



National Inventory Report for 1985-2014

Hungary

**Compiled by the
Hungarian Meteorological Service**
Unit of National Emissions Inventories

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Important notice

In 2015, Hungary made an inventory submission under UNFCCC, but not under the Kyoto Protocol because the CRF Reporter could not deliver CRF tables for Kyoto Protocol LULUCF activities without errors. The present report is the official inventory submission of Hungary for the year 2016 under the UNFCCC and for the years 2015 and 2016 under the Kyoto Protocol, in spite of the remaining deficiencies in the CRF Reporter and underlying CRF tables. Hungary should not be held liable for errors caused by the CRF Reporter in the review of the submitted information. The inventory data reported in the 2015 submission under the UNFCCC have been revised in this submission. Therefore, the 2016 submission should also be considered as a resubmission of the estimates with regard to the 2015 UNFCCC submission.

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EXECUTIVE SUMMARY

ES.1. Background information

Pursuant to the United Nations Framework Convention on Climate Change (UNFCCC), Hungary, as a Party of the Convention, has been preparing annual inventories of greenhouse gas emissions using the IPCC methodology since 1994. The aim of a greenhouse gas (GHG) inventory is to give 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 (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆), and nitrogen trifluoride (NF₃). 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. The participation of the National Food Chain Safety Office (NFCSO) together with the NARIC Forest Research Institute, the Agricultural and Rural Development Agency (ARDA) and the Hungarian Chamber of Agriculture as compilers of the whole LULUCF sector is formalized by the same governmental 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 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 1985-2014. 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.

This is the second inventory that was compiled by applying the 2006 IPCC Guidelines. For the sake of consistency, the whole time series was recalculated for the previous submission which resulted in an overall emission reduction of 3% on average. (The agriculture sector contributed the most to this decrease: the recalculated values were lower by a third. In contrast, the new emission estimates were significantly higher in the waste and industrial processes and product use sectors. However, the increase in the latter was mostly caused by reallocations from the energy sector.) This inventory contains some further refinements of our emission estimates.

ES.2. Summary of National Emissions and Removal Related Trends

In 2014, total emissions of greenhouse gases in Hungary were **57.2 million tonnes** carbon dioxide equivalents (CO₂-eq) - excluding the LULUCF sector - which is *the lowest value* in the whole time series (1985-2014). Taking into account also the mostly carbon absorbing processes in the LULUCF sector, the net emissions of Hungary were 52.6 million tonnes CO₂-eq in 2014. Being about 6 tonnes, the Hungarian per capita emissions are below the European average.

Now, our emissions are 48% 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 2014, after a period of about 14 years of relatively stagnant emission level (1992-2005), GHG emissions fell again quite significantly by 25 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 9% between 2008 and 2009, our emissions in the following five years (2009-14) remained not just the lowest in the entire time series but decreased further by 12%. In contrast, the decline in economic output stopped in the first quarter of 2010, and in 2014, Hungary has almost reached the GDP level of 2008.

From 2013 to 2014, total emissions have not changed significantly, they decreased by 0.6 per cent corresponding to 0.3 megatons in CO₂-eq. The decrease was dominated by the energy sector. Emissions from power and heat production alone dropped no less than 7% due to significantly lower electricity production from fossil fuels.

The most important greenhouse gas is carbon dioxide accounting for 76% of total GHG emissions. The main source of CO₂ emissions is burning of fossil fuels for energy purposes, including transport. CO₂ emissions have decreased by 49% since the middle of the 80's. Methane represents 13% 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. CH₄ emissions are by 40% lower than in the base year. Nitrous oxide contributes 8% to the total GHG emissions. Its main sources are agricultural soils, and manure management. N₂O emissions are 61% lower compared to base year. The total emissions of fluorinated gases amount to 3% but their steadily growing tendency seems to slowing down since 2008. However, special attention is still needed as their applications in the cooling industry and the use of SF₆ 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 CO₂-eq)

	BY	1990	1995	2000	2005	2008	2010	2012	2013	2014
CO₂	85194	73115	61354	58337	60330	57325	52109	46775	43931	43573
CH₄	12660	11967	9034	8958	8443	8251	8037	7825	7619	7614
N₂O	11404	8665	5001	5621	5982	4487	4055	4200	4599	4504
HFCs	NO	NO	42	273	804	1164	1223	1185	1280	1428
PFCs	371	376	223	283	281	5	2	2	2	2
SF₆	6	11	52	84	94	108	99	120	123	104
NF₃	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	109636	94134	75706	73557	75933	71340	65524	60107	57554	57225

Base year(BY)=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 70% to the total GHG emission in 2014. Agriculture was the second largest sector with 11% while emissions from industrial processes and product use accounted for 11% and the waste sector contributed 7%. Compared to the base year, emissions were significantly reduced in the energy (-49%), agriculture (-46%), and industrial processes and product use (-59%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+16%). The land use, land-use change and forestry (LULUCF) sector shows fluctuating behavior. Looking at the most recent trends since 2005, emissions have significantly decreased in the

energy and industrial processes sectors by 28% and 34%, respectively. The agriculture sector seems to have recovered and could show an increase of 7% since 2005. The previous growing trend turned back in the waste sector (-10%).

The **energy sector** was responsible for 70% of total GHG emissions in 2014. Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 96% to the sectoral emission. Looking at fuel combustion only, the share of CO₂ emissions was even higher (98%). Considering fuel use in combustion processes, gases had still the highest (but decreasing) proportion (44%), liquids and solids represented 31% and 13%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 11%. The most important subsector was energy industries with a proportion of 33% within the energy sector, followed by transport (28%) and other sectors (27%). Fugitive emissions from fuels played only a small role with 2% out of which 57% originate from natural gas production, processing, transmission and distribution.

The significant reduction in emissions between the base year and 1995 was mainly due to the economic transformation which caused sudden decrease in energy demand. (In this respect it is perhaps worth mentioning that the decrease in fuel consumption after 2005 was even higher!) In addition, ongoing changes in fuel-structure, i.e. gradual replacement of solid fuel by natural gas, led to further decrease of total emissions.

Overall emissions from the energy sector have decreased by 2% or 0.8 million tonnes between 2013 and 2014 (after decreases of 7% and 5% in the last two years). The transport sector surprised us with the biggest change (+12% or 1.2 million tonnes) – in the opposite direction! Especially diesel oil consumption increased significantly whereas gasoline sales remained at a quite moderate level. Still, transport related emissions were by 14% lower in 2014 than in 2007. Natural gas consumption decreased by a further 8% in the residential sector (altogether by 42% since 2005) where we have not seen such a low consumption level since the early 90's.

Gross electricity production decreased further by 3% (after a drop of 13% in 2013). The decrease in natural gas based electricity production was especially drastic (-24% in 2014 and -72% since 2008!), whereas the share of CO₂ neutral nuclear fuel grew steadily, and wind energy utilization showed a steep increase in the last few years. Currently, 53% of gross electricity production stems from nuclear energy and only 35% from classic fossil fuels. At the same time, electricity import grew significantly to a record high level of 31%.

Table ES.2 Trend of emissions and removals by sector (including LULUCF, Gg CO₂-eq)

	BY	1990	1995	2000	2005	2008	2010	2012	2013	2014
Energy	78826	68088	57017	54432	55782	52976	48644	43360	41077	40280
Ind.	15076	11712	8271	8270	9284	7458	6563	6238	5722	6129
Agri.	12051	10108	5968	6165	6128	6116	5685	5961	6386	6533
LULUCF	-1721	-2433	-5346	-215	-5079	-4758	-3710	-4075	-3098	-4594
Waste	3682	4226	4450	4690	4740	4791	4633	4548	4369	4284
Total	107915	91701	70360	73341	70855	66582	61813	56032	54456	52632

Base year (BY)=average of 1985-87

In 2014, **agriculture** was the second largest source of greenhouse gas emissions in Hungary. However its share in national total emissions was with only a few tenths of a per cent higher than the share of Industry. Emissions from agriculture include CH₄ and N₂O gases. 83 per cent of total N₂O emissions were generated in agriculture in 2014. Emissions from agriculture have decreased by 46% over the period of 1985-2014. The bulk of this reduction occurred in the years between 1985 and 1995, when

agricultural production fell by more than 30 per cent, and livestock numbers underwent a drastic decline. The contribution of agriculture to total emissions was 11% in 2014 similar to the level in the base year (BY).

Between 1996 and 2008, agricultural emissions had stagnated around 6.2 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% in the period 1995-2007 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 11 per cent decline in swine population also contributed to the downward trend. Agricultural emissions hit the lowest point in 2010. A slight increase started in 2011, due to the higher N-fertilizer use, and higher emissions from crop residues resulting from greater crop production, then in 2012 emissions remained on the level of 2011. In 2013 and 2014 the further rising fertilizer use, increasing animal livestock and relatively higher crop production resulted in growing emission levels again.

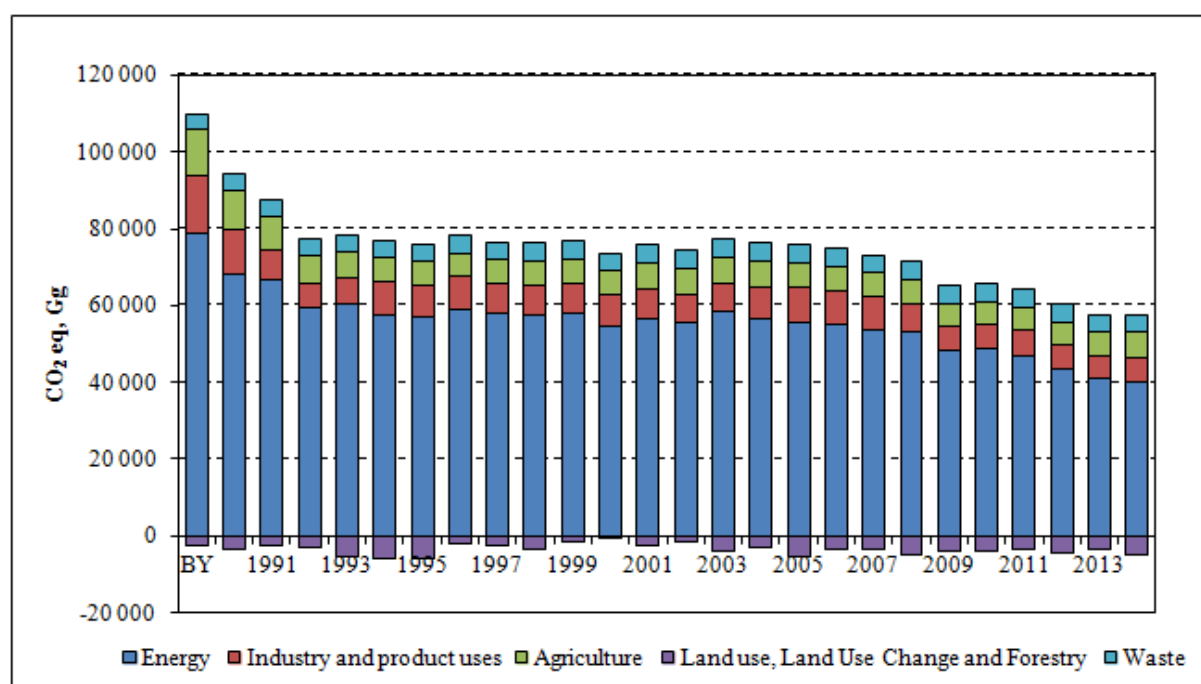
The **industrial processes** sector was the third largest sector, contributing 11% to total GHG emissions in 2014. The most important greenhouse gas was CO₂, contributing 72% to total sectoral GHG emissions, followed by F-gases with 25%. In 2014, 41% of the emissions came from chemical industry, followed by 23% from product uses as ODS substitutes, and 17% from mineral products. The contribution of iron and steel industry and other (SF₆ and N₂O containing) product uses is 15% and 3% respectively. Process related industrial emissions decreased by 59% between base year and 2014, and by 34% between 2005 and 2014.

Although emissions of F-gases represent only 3% of the total GHG emissions, their trend requires special attention. As these gases are harmless for the ozone layer, the use of HFCs in the refrigeration and air conditioning industry got widespread thus their emission steeply increased until 2008.

GHG emissions from industrial processes sector are 7% (407 Gg CO₂-eq) higher in 2014 than in 2013 after two years of decrease. There is an increase in all subsectors except for other (SF₆ and N₂O containing) product uses. The latter might be explained by the volatility of the markets, the trade and the consumption of these products. Significant increase of emissions might be observed in Iron and steel and in Chemical subsectors (cc. 200 Gg CO₂-eq in each one), while in Mineral industry the change is quite slight. The increase of emissions in Chemical subsector is mainly due to the fact that production of ammonia (for production of fertilisers) was cc.40% higher in 2014 than in 2013, while Iron and steel industry seems to recover after the drop of production in 2013.

The **waste sector** was responsible for 7% of total national GHG emissions in 2014. The largest category was solid waste disposal on land, representing 78% in 2014, followed by wastewater treatment and discharge (14%), incineration of waste (5%), and biological treatment of solid waste (3%). In contrast with other sectors, emissions from the waste sector are by 16% higher now than in the base year. However, the growth in emissions had stopped in the last decade, and a reduction of 10% could be observed between 2005 and 2014. 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 dropped significantly since 2005 (e.g. landfilled municipal waste decreased by 43%) consequently 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 2.9 million tonnes net removal, CO₂-eq net removals range from 0.04 million tonnes in 1985 to 5.6 million tonnes CO₂ in 1994. In 2014, the LULUCF sector accounted for 4.6 million tonnes carbon-dioxide removals. The net removals of forests amounted to 4.4 million tonnes CO₂.



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

Figure ES. 1 Change in greenhouse gas emissions from base year (BY, 1990-2014)

ES.4. Indirect Greenhouse Gases and SO₂

NO_x, CO and NMVOC gases are referred to as indirect gases because they (together with SO₂) 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 is required by the UNFCCC reporting guidelines. 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. Emissions are reported consistently in the above two reporting regime. The following table shows the main trends in emissions:

Table ES. 3 Emissions of indirect gases, including LULUCF (Gg)

	1990	2000	2003	2005	2006	2008	2010	2012	2013	2014
NO _x	238	177	174	166	160	154	138	122	120	120
CO	1 415	498	530	434	477	331	328	378	327	303
NMVOC	293	169	164	145	142	131	125	120	120	116
SO ₂	825	428	246	41	39	35	31	31	30	27

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 SO₂ precipitators in coal-fired power stations. Reduced carbon monoxide emissions are obviously a consequence of decreased fuel uses. The decrease in NO_x 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.

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.

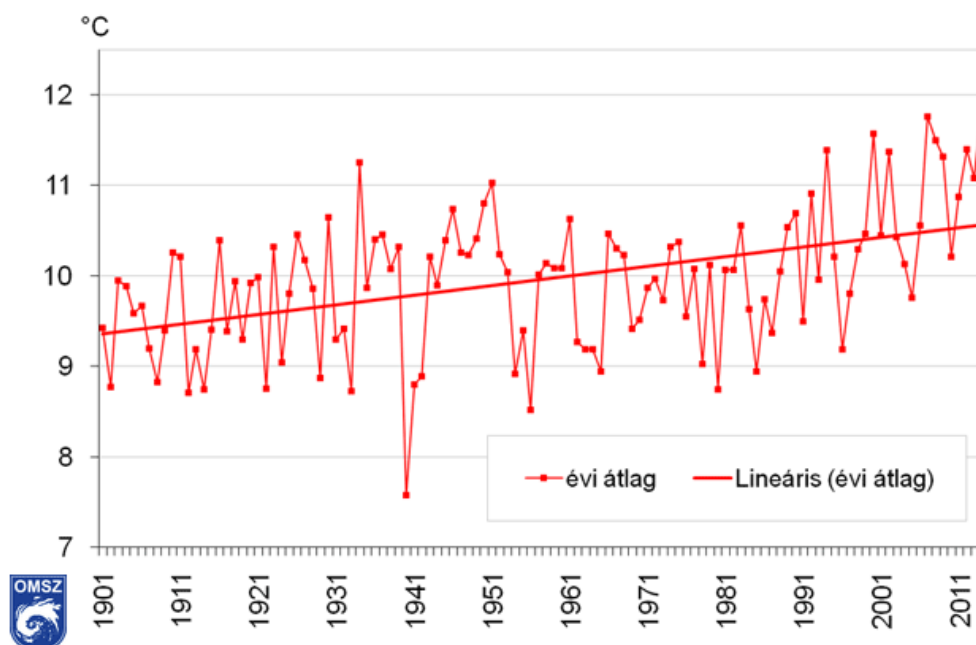


Figure 1.1 Linear trends in annual mean temperature (°C) over the period 1901-2014 in Hungary

The yearly average temperature was 11.95 °C in 2014 in Hungary. That year was the warmest among the last 114 years. This fact only would suggest a warming process which can be confirmed by a linear trend that shows a temperature increase of +1.20°C for the last 113 years. Considering the last 30

years, the temperature increase is even more pronounced with $+1.62^{\circ}\text{C}$ based on the homogenized, interpolated dataset of the Hungarian Meteorological Service (*Fig. 1.1*).

The yearly total precipitation in 2014 (739.8 mm) indicates a wetter year than a normal one. Compared to the latest years, the summer was irregularly rainy, as the rainy period was in summer. The exponential trend fitted to the 114 year-long data series shows a moderate decline by 5.6 per cent, whereas for the last 33 years a growth of 16.9% can be seen (*Fig. 1.2*), although neither of these trends are significant.

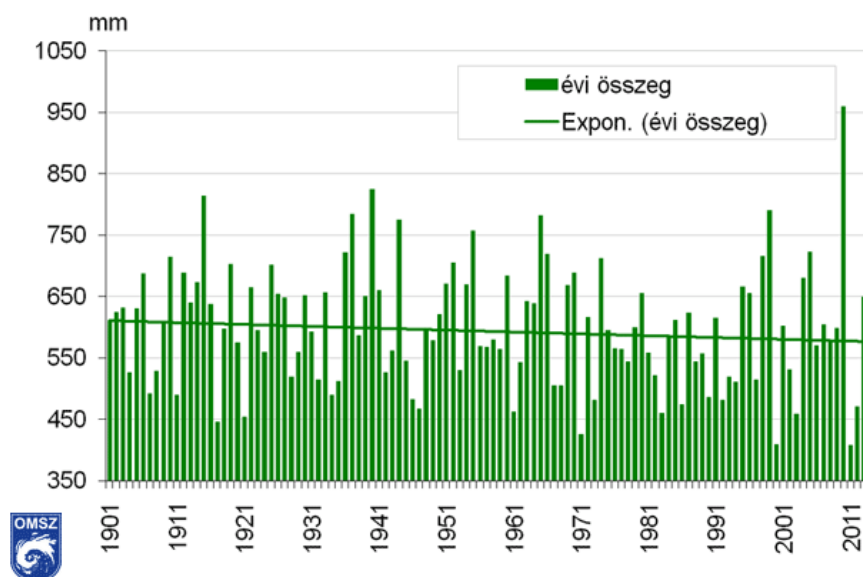


Figure 1.2 Exponential trends in annual precipitation sum (mm) over the period 1901-2014 in Hungary

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. 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 structure and duties of the ministries changed again somewhat after the elections in 2014, and the Ministry of Rural Development turned to Ministry of Agriculture which nevertheless has the same responsibilities regards environmental matters. Therefore, the designated *single national entity* is now the Ministry of Agriculture.

Contact details of the single national entity are as follows:

Ministry of Agriculture

Head office:	1055 Budapest, Kossuth Lajos tér 11.
Postal address:	1860 Budapest
Phone:	+36-1-795-2000
Fax:	+36-1-795-0200
E-mail:	info@fm.gov.hu, press@fm.gov.hu

Sándor Fazekas, Dr., Minister of Agriculture

Postal address: 1055 Budapest, Kossuth L. tér 11.
Phone: +36-1-795-3723
Fax: +36-1-795-0072
E-mail: miniszter@fm.gov.hu

See also at: <http://www.kormany.hu/en/ministry-of-agriculture/contacts>

The national system has to be operated by the minister responsible for the environment but, as prescribed by legislation, in consent and cooperation with the ministers responsible for energy policy, forest management, agricultural policy, and national budget. Within the Ministry of National Development, i.e. the ministry responsible for energy policy, a Climate Policy Department has been established that plays a 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 (HMS) for the preparation and development of the inventory. This division is responsible for most 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. In 2015, the name of the division was changed to Unit of National Emissions Inventories.

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 (NFCSO, Forestry Directorate) together with the National Agricultural Research and Innovation Centre (hereafter referred to as NARIC) Forest Research Institute was formalized by this decree. These two institutes were 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) was replaced by Govt. Decree 528/2013 (XII.30.).

1 January 2015, a new government decree 278/2014. (XI. 14) entered into force in Hungary designating the National Food Chain Safety Office (NFCSO) Plant Protection and Soil Conservation Directorate, together with the Agricultural and Rural Development Agency (ARDA) and the Hungarian Chamber of Agriculture, responsible for the development of the GHG inventory of the non-forest sectors. (This is a change from the previous system, in which the Hungarian Meteorological Service was responsible for the non-forest sectors. In order to facilitate this change, and in order to ensure a smooth transition to the application of the IPCC 2006 Guidelines, a new estimation system has been recently developed for, and together with, the NFCSO by an external expert.)

The Hungarian Meteorological Service is a central office under the control of the Ministry of Agriculture. The duties of the Service are specified in a Government Decree from 2005. The financial background of operation is determined in the Finances Act. HMS 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 Unit of National Emissions Inventories functions as part of the Department of Climate and Ambient Air. The Unit of National Emissions Inventories 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 Unit of National Emissions Inventories 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 HMS. The Head of Unit 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.

Most parts of the inventory (energy, industrial processes and product use, agriculture, and waste) are prepared by the experts of the Unit of National Emissions Inventories themselves. The whole LULUCF sector is compiled by the institutes listed in the above mentioned government decree. As before, and also complying with the decree mentioned above, the Forestry Directorate of the NFCSO is responsible for the GHG inventory of the forestry sector. Quality control for the forestry sector is provided by the NARIC Forest Research Institute. The role of the Agricultural and Rural Development Agency and the Hungarian Chamber of Agriculture in the inventory preparation is not clarified yet. Data for the estimation of non forest related emissions is also provided by the Central Statistical Office, the Hungarian Mining Authority and National Directorate General for Disaster Management. Szent István University, Gödöllő had been heavily involved in the calculations for the agriculture sector of the inventory for several years. For the calculation of emissions from agricultural soils the Karcag Research Institute of University of Debrecen (Department of Soil Utilization and Rural Development) provided inputs. The following table summarizes the institutional arrangements:

<i>Function</i>	<i>Institution</i>	<i>Responsibilities</i>
Single national entity	Ministry of Agriculture	
	(in consent and cooperation with Ministry of National Development and Ministry for National Economy)	<ul style="list-style-type: none"> • Supervision of national system • Official consideration and approval of inventory
Inventory coordination and compilation	HMS Unit of National Emissions Inventories	<ul style="list-style-type: none"> • Provision of work plan • Contracting consultants • Inventory preparation of Energy, Industry, Agriculture and Waste sectors
		<ul style="list-style-type: none"> • Compilation of the CRF and NIR • Archiving • Coordinating QA/QC activities • Reporting to UNFCCC secretariat
Inventory preparation of the LULUCF sector and LULUCF activities under the KP. (by law)	National Food Chain Safety Office (NFCSO)	
	NARIC Forest Research Institute Agricultural and Rural Development Agency (ARDA) Hungarian Chamber of Agriculture	<ul style="list-style-type: none"> • Data collection, choice of methods and EFs, inventory preparation • Compilation of the relevant parts of the CRF and NIR
Contribution to the inventory preparation of the Agriculture sector	Szent István University, Gödöllő Karcag Research Institute of University of Debrecen	<ul style="list-style-type: none"> • Data collection, choice of method, development of country specific emission factors
		<ul style="list-style-type: none"> • Background studies

1.3 Inventory preparation

The annual inventory cycle is carried out in accordance with the principles and procedures set out in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. 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 Unit of National Emissions Inventories. 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 require 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 5.

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. The Hungarian Meteorological Service funds research and development projects for the improvement of the inventory whenever possible. 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>
	Overview of sectors to identify areas for possible improvements; Data collection, choice of methodologies, Start of calculations Repeated checks	
From May to November		
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 th of April to October	Archiving, QA/QC and Development Plan	internal

A Figure presenting the inventory cycle is included in Annex 5.

To summarizing the above, the two main compiler institutes are: (1) the Hungarian Meteorological Service (HMS) and (2) the National Food Chain Safety Office, the latter is responsible for the LULUCF 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 Unit of National Emissions Inventories of the HMS or by external experts on contractual basis. The inventory report is approved by three ministers: (1) minister for national development, (2) minister for agriculture (responsible for environment and agricultural policy, and (3) minister for national economy (responsible for national budget) 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 278/2014. (XI. 14) as described below in more detail). Plant specific data are collected if possible (especially in case of power stations, heating stations and industrial technologies) but statistical databases are also heavily used as source of information. The most important statistical publications are the Statistical Yearbook of Hungary, the Environmental Statistical Yearbook of Hungary and the Environmental Report of Hungary published by the Hungarian Central Statistical Office (HCSO) and the Energy Statistical Yearbook published earlier by the Energy Efficiency, Environment and Energy Information Agency. As regards energy statistics, the practice has changed in recent years. The compiler institute relies less to classic statistical publication and more to databases sent by the Hungarian Energy and Public Utility Regulatory Authority to the IEA and Eurostat. The compiler institute receives the same completed joint questionnaires that are sent to the international organizations which ensure the consistency with data reported under Regulation (EC) No 1099/2008. Since the use of ETS data has several advantages, the inventory team was granted access (by the same gvt. decree) 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 F-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).

Data reported pursuant to Article 6(1) of Regulation (EC) No 842/2006 on F-gases (for the consistency check required by the MMR) is received from Hungarian contact point responsible for the reporting under 842/2006/EC. This data provision is also included in Govt. Decree 278/2014. (XI. 14). 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 Agriculture 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 278/2014. (XI. 14) 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 5.

All the collected data, where relevant, are also used for the elaboration of the air pollutant emission inventories (NFR). Therefore the consistency with the reporting of air pollutant emission inventories under Directive 81/2001 and the Convention on Long-range, Transboundary Air Pollution (CLRTAP) is ensured.

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 Unit of National Emissions Inventories 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 Agriculture
- 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 Agriculture.

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 Unit of National Emissions Inventories. 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 Unit of National Emissions Inventories. 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 Unit of National Emissions Inventories;
- 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 Unit of National Emissions Inventories.

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 Unit of National Emissions Inventories are stored

have access protection, so they are available only for the staff of the Unit 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 Unit of National Emissions Inventories 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 Unit of National Emissions Inventories 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 Unit of National Emissions Inventories. 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 CO₂/TJ and 107.9 t CO₂/TJ, respectively; the importance of the mix of fuels used to produce energy becomes apparent at a glance.

Emission factors are usually dependent on several other factors, used technologies etc. which leads us to the concept of tiers. A tier represents a level of methodological complexity. In the Guidelines usually three tiers are provided. Tier 1 is the basic method, where activity data are usually aggregated national statistics and the emission factors are default values representing typical process conditions. Higher tier methodologies are more demanding in terms of complexity and data requirements as they require country-specific information on the used technologies, facility level data whenever possible, or use of complex models. For key categories, i.e. categories that have a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals, it is required to apply higher tier methods. Accordingly, the compilers of the Hungarian inventory aim at taking into account the technologies available in Hungary to the extent possible. For example, the emission trading system of the European Union makes possible to have access to facility level activity and verified emission data.

Although this basic equation can widely be used, in some source categories other approaches are used. For example, mass balance method is used for estimating the change in carbon content of living biomass in forests, or in case of solid waste disposal sites, a calculation method is applied which assumes that the degradable organic component in waste decays slowly throughout a few decades.

To ensure that the national inventory fulfils its main purpose, namely monitoring the country's compliance with its commitments, it has to meet certain quality standards, in other words it has to be accurate, complete, consistent, comparable and transparent (ACCCT). The first two requirements need no special explanation: an inventory is accurate, if it has no systematic bias towards under- or overestimations, whereas a complete inventory covers all relevant sources and sinks, and gases within the borders of the country. The next two 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 2006 IPCC guidelines.

More detailed source specific information on used data and methodologies can be found in Chapters 3-9 in this inventory report.

1.6 Key source categories

Key categories have been identified based on the IPCC Tier 1 methodology. As the same Tier1 key category analysis was performed, it is possible to identify changes compared to last year, however there are only few ones:

- In Level assessment:

CO₂ emissions from *1A1 Energy Industries - Other fossil fuels* and *4G Harvested Wood Products* falls below the threshold this year.

N₂O emission from *2G Other Product Manufacture and Use* is not identified as key category thanks to its significant decrease, opposite process can be observed in case of CO₂ emission from *1A2 Manufacturing industries - Solid fuels*.

CO₂ emission from *4E2 Land Converted to Settlements* and N₂O emission from *5D Wastewater Treatment and Discharge* are now above the threshold.

- In Trend assessment:

CH₄ emission from *1A4 Other sectors – Biomass* falls below the threshold this year.

N₂O emission from *2G Other Product Manufacture and Use* is not identified as key category thanks to its significant decrease.

CO₂ emissions from *1B2c Venting and flaring* and *4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils* are now above the threshold.

CO₂ emission from *2B1 Ammonia Production* is now key category thanks to its significant increase.

Table 1.6.1 Number of identified Key categories

	TIER 1 (excluding LULUCF) Number of key category / number of categories	TIER 1 (including LULUCF) Number of key category / number of categories
LEVEL	25/142	31/169
TREND	27/142	34/169

Table 1.6.2. Key category analysis summary

KEY CATEGORIES OF EMISSIONS AND REMOVALS	Gas	Criteria used for key source identification			
1A1 Energy Industries - Gaseous fuels	CO ₂	L incL	L excL	T incL	T excL
1A1 Energy Industries - Liquid fuels	CO ₂	L incL	L excL	T incL	T excL
1A1 Energy Industries - Other fossil fuels	CO ₂			T incL	T excL
1A1 Energy Industries - Solid fuels	CO ₂	L incL	L excL	T incL	T excL
1A2 Manufacturing industries - Gaseous fuels	CO ₂	L incL	L excL	T incL	T excL
1A2 Manufacturing industries - Liquid fuels	CO ₂	L incL	L excL	T incL	T excL
1A2 Manufacturing industries - Solid fuels	CO ₂	L incL	L excL	T incL	T excL
1A3b Road transport - All Fuels	CO ₂	L incL	L excL	T incL	T excL
1A3c Railways - All Fuels	CO ₂			T incL	T excL
1A3d Domestic navigation - All Liquid fuels	CO ₂				T excL
1A4 Other sectors - Biomass	CH ₄	L incL	L excL		

KEY CATEGORIES OF EMISSIONS AND REMOVALS	Gas	Criteria used for key source identification			
1A4 Other sectors - Gaseous fuels	CO ₂	L incL	L excL	T incL	T excL
1A4 Other sectors - Liquid fuels	CO ₂	L incL	L excL	T incL	T excL
1A4 Other sectors - Solid fuels	CH ₄			T incL	T excL
1A4 Other sectors - Solid fuels	CO ₂	L incL	L excL	T incL	T excL
1B1 Solid fuels	CH ₄			T incL	T excL
1B2b Natural Gas	CH ₄	L incL	L excL		
1B2c Venting and flaring	CO ₂			T incL	T excL
2A1 Cement Production	CO ₂	L incL	L excL	T incL	T excL
2A2 Lime Production	CO ₂			T incL	T excL
2A4 Other Process Uses of Carbonates	CO ₂	L incL	L excL		
2B1 Ammonia Production	CO ₂	L incL	L excL	T incL	T excL
2B2 Nitric Acid Production	N ₂ O			T incL	T excL
2B8 Petrochemical and carbon black production	CO ₂	L incL	L excL	T incL	T excL
2C1 Iron and Steel Production	CO ₂	L incL	L excL	T incL	T excL
2C3 Aluminium Production	PFC			T incL	T excL
2F1 Refrigeration and Air Conditioning Equipment - HFC+PFC	Aggregate F-gases	L incL	L excL	T incL	T excL
3A Enteric Fermentation	CH ₄	L incL	L excL	T incL	T excL
3B Manure Management	CH ₄	L incL	L excL		
3B Manure Management	N ₂ O	L incL	L excL		
3D Agricultural Soils	N ₂ O	L incL	L excL	T incL	T excL
4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO ₂			T incL	
4A1 Forest Land Remaining Forest Land	CO ₂	L incL		T incL	
4A2 Land Converted to Forest Land	CO ₂	L incL		T incL	
4B1 Cropland Remaining Cropland	CO ₂	L incL		T incL	
4B2 Land Converted to Cropland	CO ₂	L incL		T incL	
4C2 Land Converted to Grassland	CO ₂	L incL		T incL	
4E2 Land Converted to Settlements	CO ₂	L incL		T incL	
4G Harvested Wood Products	CO ₂			T incL	
5A Solid waste disposal	CH ₄	L incL	L excL	T incL	T excL
5D Wastewater Treatment and Discharge	CH ₄	L incL	L excL		
5D Wastewater Treatment and Discharge	N ₂ O	L incL	L excL		

Note: L = Level assessment; T = Trend assessment.

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. The QA/QC Plan was updated again and entered into force in the beginning of 2016 in order to follow the changes of legislation and the Guidebook, and the change of the name and acronym (from “UHG” to “NELO”) of the Unit of National Emissions Inventories.

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 Unit of National Emissions Inventories 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/minosegiranyitas/>

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. ISO document No.: ELFO_UHG_401.01 entered into force on 4th January 2013 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. On 21 May 2014 an update of the QA/QC Plan (No.: ELFO_UHG_401.02) entered into force in order to insert the recommendation of the review of the year before regarding the documentation of QA activities. The update of the QA/QC Plan (No.: ELFO_NELO_401.01) that entered into force in the beginning of 2016 did not contain significant changes, mainly changes of names and references to legislation and the Guidebook are reflected. The records and their functions are the following at the moment:

- NELO01: 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;
- NELO02: Data quality check: to be filled in case of data providers and external experts on data quality;
- NELO03: 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;
- NELO04: Responsibility: for the specification of the sectoral responsibilities of the core team and the QA/QC coordinator
- NELO05: Data source logbook: for the standardized documentation of data sources;
- NELO06: Uncertainty and NELO07: Key category analysis; for the standardized documentation of uncertainty and key category analysis.
- NELO08: QA activities logbook: record for the documentation of QA activities.

The records and the English translation of the QA/QC Plan are presented in the Annex 5 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_NELO_401.01 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_NELO_401.01 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 Agriculture. 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_NELO_401.01.

- 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. NELO02 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 and in January 2015 and 2016 as well. On the 5th April 2013 and on the 12th December 2014 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. Starting with the data reported for the year 2013, the European Commission will conduct an annual review of the national inventory data submitted by Member States. We believe that this process contribute significantly to the quality assurance procedures.

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

- Several consistency checks as detailed in chapter 1.10.
- 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)*”

In November 2015, Hungary took part in an informal review organized by the EU, where all the sectors had been thoroughly reviewed by international experts. Several recommendations have been formulated and some of them are already implemented in the present submission.

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.NELO04. 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 NELO02 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 is under review in order to implement all changes required by the EU Monitoring Mechanism Regulation and implementation of the 2006 IPCC Guidelines.

1.8 Uncertainty

The reliability of the data for individual source categories was estimated on the basis of the 2006 IPCC Guidelines but information from the industry and expert estimates was also used. On the basis of Table 3.3 and Table 4.1 of the 2006 IPCC Guidelines we have determined the total uncertainty according to the Tier 1 method. Accordingly, the combined uncertainty as % of total national emissions (in the year 2014) is 11% (excluding LULUCF) and the uncertainty introduced in trend in national emissions is 2%.

The uncertainty values have been determined by gas as well:

% SUM Uncertainty excluding LULUCF	
CO ₂	3
CH ₄	25
N ₂ O	136
F-gases	13

Estimation of the uncertainties including LULUCF is a planned improvement. Please find the detailed Tables presenting the whole calculation in chapter 2 of Annex 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 1986–2014. 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.

1.10 Consistency checks

Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change requires to report the results of the checks performed on the consistency of the emissions reported or of the data used to estimate emissions in preparation of the greenhouse gas inventories. The results of the consistency checks are summarized below.

Consistency with the verified emissions reported under Directive 2003/87/EC

ETS data is essential in inventory compilation, especially to derive country specific emission factors. Information on consistency is provided in a separate Annex submitted to the EU.

Consistency of the data used to estimate emissions in preparation of the greenhouse gas inventories with the data used to prepare inventories of air pollutants under Directive 2001/81/EC

As basically the same team has prepared both inventories, the consistency of the used data is safeguarded. Consistently, the emissions estimates of carbon monoxide (CO), sulphur dioxide (SO₂), nitrogen oxides (NO_x) and volatile organic compounds, in inventories submitted by the Member State under Directive 2001/81/EC of the European Parliament and of the Council and under the UNECE Convention on Long-range Transboundary Air Pollution are consistent with the corresponding emission estimates in greenhouse gas inventories. The difference between the total emissions of any of the above pollutants reported in both inventories is well below 5% as it is demonstrated in the table below. (The relatively larger differences in CO emissions are mainly due to emissions reported in the LULUCF sector.)

			1990	1995	2000	2005	2008	2010	2012	2013	2014
CRF	NO _x	kt	238	184	177	166	154	138	122	120	120
	CO	kt	1415	911	498	434	331	328	378	327	303
	NMVOC	kt	293	203	169	145	131	125	120	120	116
	SO ₂	kt	825	616	428	41	35	31	31	30	27
NFR	NO _x	kt	238	184	177	167	154	139	121	121	120
	CO	kt	1399	897	475	414	322	322	344	319	289
	NMVOC	kt	293	203	168	145	130	124	120	120	116
	SO _x (as SO ₂)	kt	825	616	428	41	35	31	31	30	27
	NH ₃	kt	159	93	96	89	82	79	78	83	84
Difference%	NO _x	%	0.2%	0.1%	-0.1%	0.0%	0.3%	0.4%	-0.7%	0.4%	0.4%
	CO	%	-1.1%	-1.5%	-4.7%	-4.7%	-2.9%	-1.8%	-9.0%	-2.5%	-4.5%
	NMVOC	%	0.0%	0.0%	-0.2%	-0.3%	-0.3%	-0.3%	-0.3%	-0.2%	-0.3%
	SO _x (as SO ₂)	%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%

Consistency of the data used to estimate emissions in preparation of the greenhouse gas inventories with the data reported pursuant to Article 6(1) of Regulation (EC) No 842/2006

In the case of 842/2006/EC only companies importing and exporting across the EU border are required to report. However, thanks to the Hungarian F-gas regulations, data is available also on import/export of F-gases within the EU for the preparation of the inventory. Thus the data used for the preparation of the inventory is significantly wider than the data reported based on 842/2006/EC. Please find the comparison of data reported for inventory preparation purposes and the quantities that were reported within the scope of 842/2006/EC to the European Environment Agency (EEA). The difference is due to the quantities imported/exported within the EU as mentioned before.

	SUM quantity used for preparation of the inventory		<i>Data reported pursuant to Article 6(1) of Regulation (EC) No 842/2006</i>	
	Import	Export	<i>Import</i>	<i>Export</i>
R134a (t)	436.8	67.6	39.9	0.3
R404A (t)	280.4	101.7	7.3	0.0
R407C (t)	54.9	7.8	16.2	0.0
R410A (t)	47.2	4.6	14.8	0.0

The reporting requirements under the 'new' F-Gas Regulation will cover solely reporting on 2014 activities of companies.

For the year 2014 unfortunately no data is yet available for the HMS on the quantities reported pursuant to EU F-gas Regulation by Hungarian companies.

Consistency of the data used to estimate emissions in preparation of the greenhouse gas inventories with the energy data reported pursuant to Article 4 of, and Annex B to, Regulation (EC) No 1099/2008

The IEA/Eurostat joint questionnaires serve as basis of emission calculation in the energy sector and as regards non-energy use of fuels partly also in the industrial processes sector. Consistency is further enhanced by our practice that emission calculation files access directly the joint questionnaires. Where ETS data are taken into account, there might, however, be some minor differences with the energy statistics (e.g. industrial waste consumption in cement production). Nevertheless, these differences are well below 2%.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

In the United Nations Framework Convention on Climate Changes, Hungary undertook to keep its CO₂ emissions in 2000 at or below the 1990 level. In the first commitment period of 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	1990	1995	2000	2005	2008	2010	2012	2013	2014
Total (incl.LULUCF)	107,915	91,701	70,360	73,341	70,855	66,582	61,813	56,032	54,456	52,632
Total (excl.LULUCF)	109,636	94,134	75,706	73,557	75,933	71,340	65,524	60,107	57,554	57,225

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.

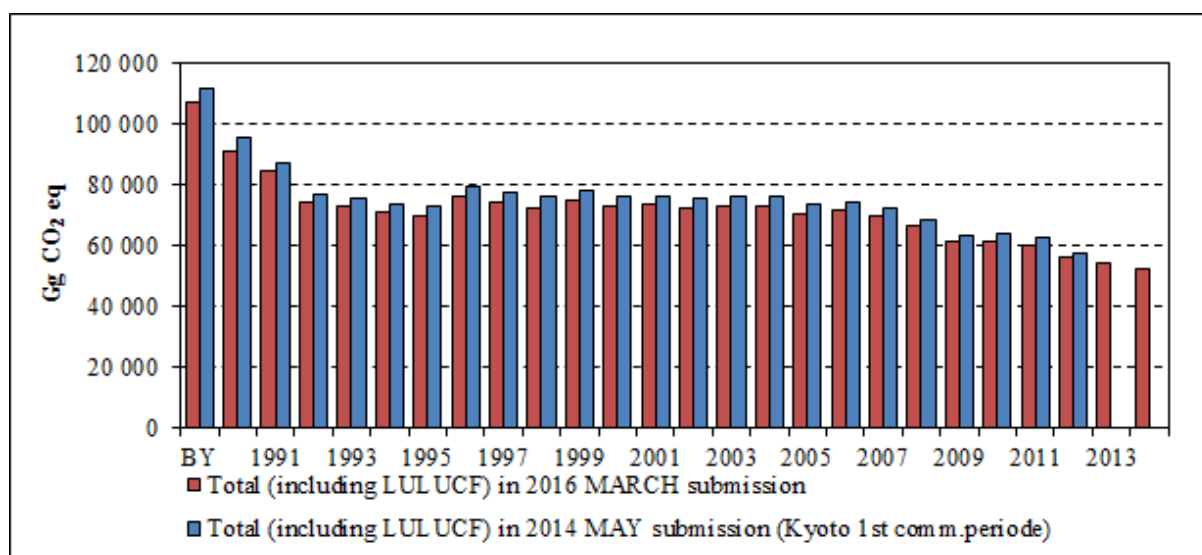


Figure 2.1 Total emission (including net CO₂ from LULUCF) between 1985 and 2014

Compared to the base year, emissions were significantly reduced in the energy (-49%), agriculture (-46%) and industrial processes and product use (-59%) sectors. In contrast, emissions in the waste sector have increased since 1985-87 (+16%). Land use, land-use change and forestry (LULUCF) sector shows a 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.

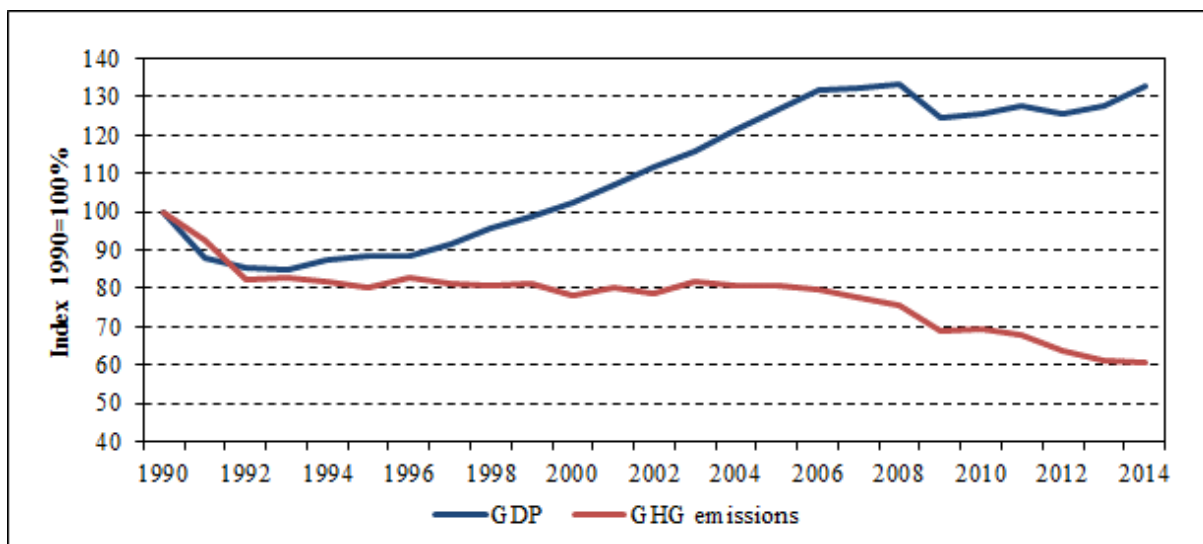


Figure 2.2 Comparison of trends in GDP and GHG emissions

In the third period, after 2005, Hungary experienced an emission reduction of 25%, out of which 6% occurred in the first three 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, not just remained at a relatively low level but decreased again quite significantly by 13%.

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 34 million tonnes CO₂ equivalent. Between the mid 80's and the mid 90's emissions fell back in the *energy* sector by around 27%, and even more, by around 45-50% 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;
- Aluminum: 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 11% to 8%.

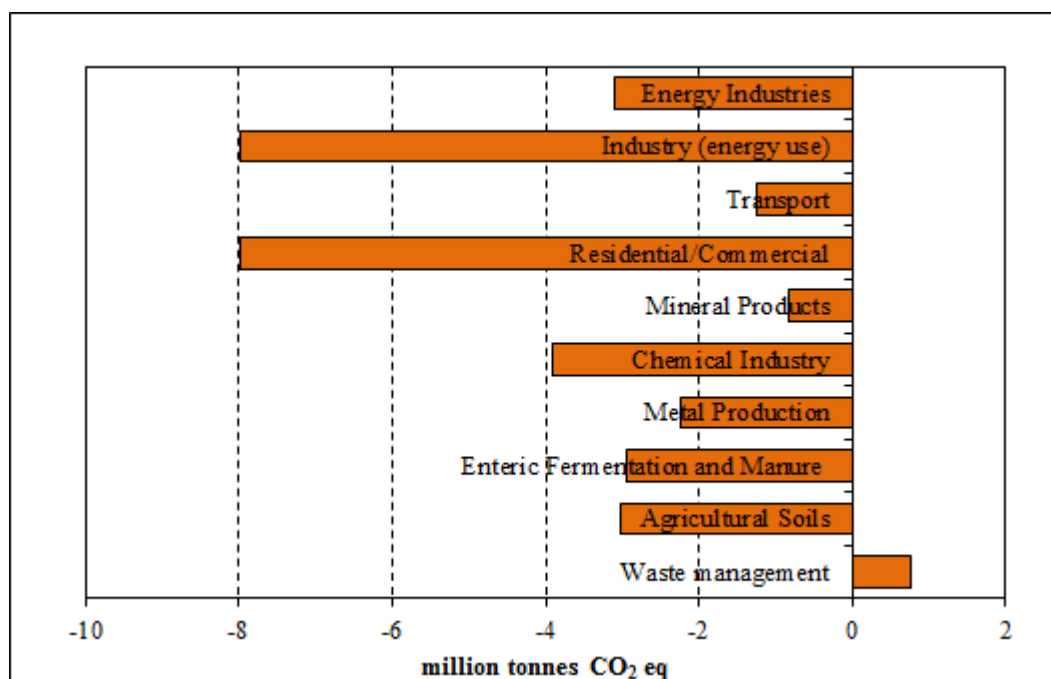


Figure 2.3 Changes in emissions due to regime change, Y1995-BY, million tonnes CO₂-eq

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

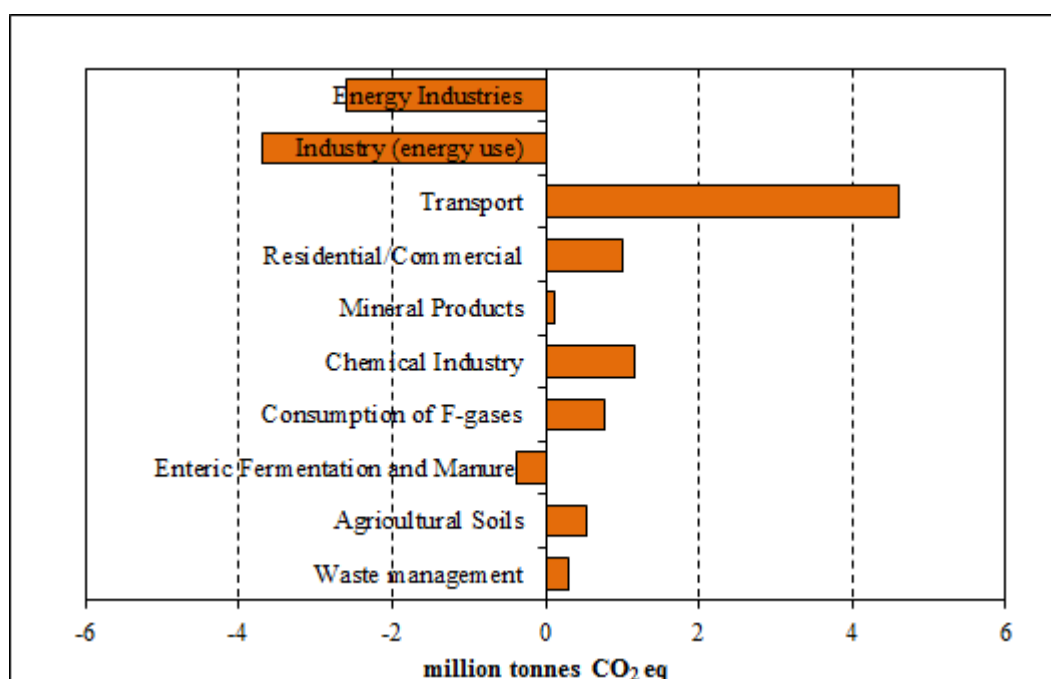


Figure 2.4 Changes in emissions between 1995 and 2005, million tonnes CO₂-eq

After the mid 90's, emissions seemed to have stabilized around 75-76 million tonnes CO₂ 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 which led to about 6% share only in GHG emissions. In contrast, emissions from transport increased significantly by almost 5 million tonnes CO₂ equivalent which represented a growth of 64%.

In the third period, after 2005, emissions fell by 18.7 million tonnes or 25%. About a quarter 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 about 17% (including a 33% drop in solid fuel and 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 45%. 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 9% (-6.3 million tonnes) between 2008 and 2009. In comparison with 2008, emissions in 2009 were lower in all major sectors. The highest relative reduction (-14%) occurred in the industrial processes and product use sector mainly due to lower production volumes especially in mineral product manufacturing (-27%). Parallel to that, also energy use decreased in manufacturing industries and construction, consequently GHG emission fell by 28% here. Regarding absolute changes in emissions, out of the 6.3 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.

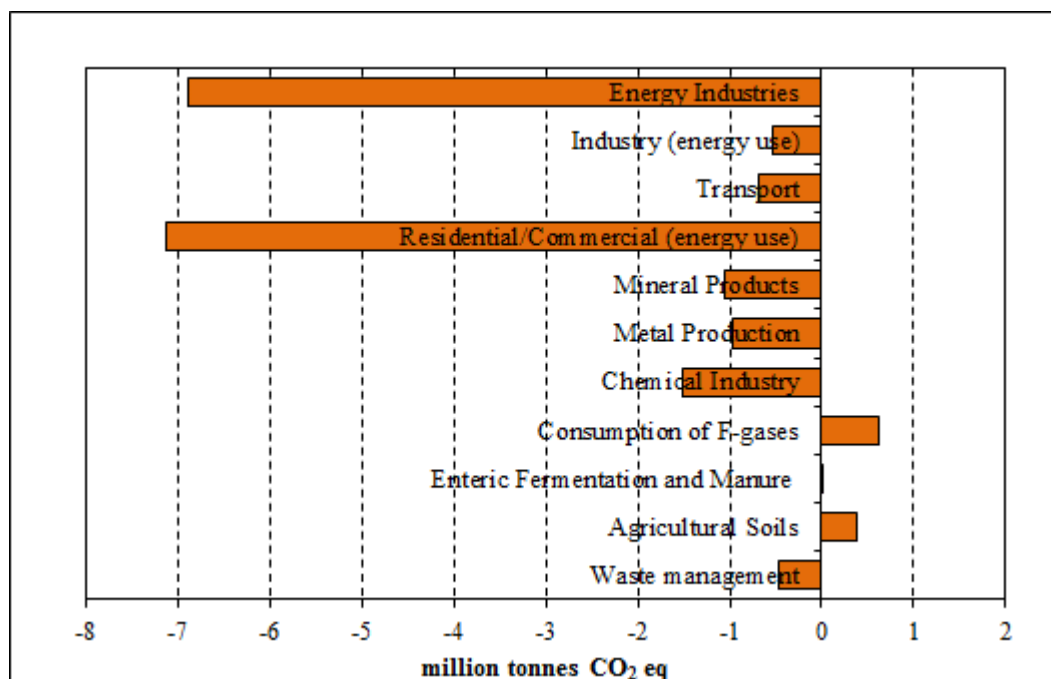


Figure 2.5 Changes in emissions between 2005 and 2014, million tonnes CO₂-eq

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 0.8% in 2010. The change in GHG emissions was about the same. And that was the last year with (slightly) increased emissions. In the next four years, emissions decreased altogether by 13%.

In 2011, we could see decreases in many areas but especially in the energy sector. Electricity production had decreased by 4% which resulted in a similar fall in GHG emissions. Natural gas consumption of the residential sector dropped by 9%. Transport emissions fell by 5%, mineral production by a further 15%. In this overall decreasing trend, agricultural soils were the 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. The decrease of 3.7 million tonnes (or -6%) can almost be explained by processes in the energy sector alone (e.g. further decrease in electricity production, a 14% drop in natural gas consumption in “other sectors”) as it will be elaborated more in chapter 2.3.

2013 was not an exception in the decreasing trend, either. Total emissions have decreased by 4% corresponding to 2.6 megatons in CO₂-eq. The decrease was dominated again by the energy sector. Emissions from power and heat production alone dropped no less than 2.6 Mt CO₂-eq due to significantly lower electricity production from fossil fuels.

Total emissions have not change much in 2014; they decreased slightly by about half percent. In the energy sector we could observe some counterbalancing processes. After several years of decreasing emissions, the transport sector started to show some growth. Nevertheless, the diminishing fossil fuel based electricity production, and the lower and lower energy consumption in the residential sector led to an overall decrease of emissions.

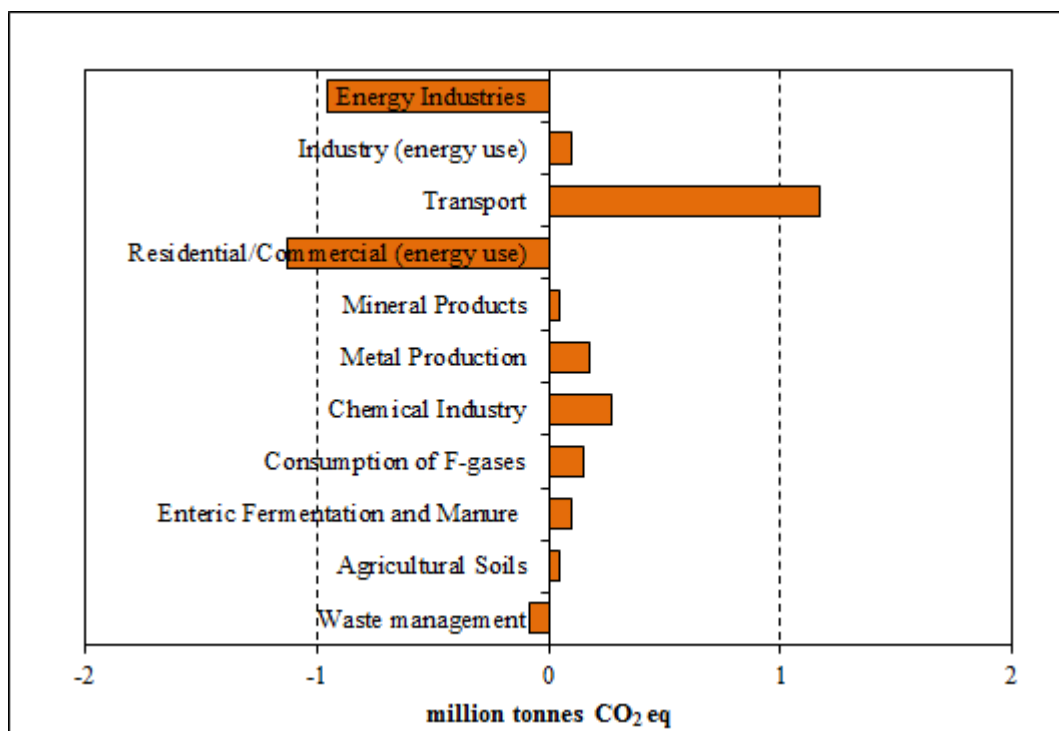


Figure 2.6 Changes in emissions between 2013 and 2014

2.2 Description and interpretation of emission trends by gas

The following table shows the emission data for each greenhouse gas (Gg CO₂ equivalent):

Table 2.2 Trends in emissions of greenhouse gases in Hungary
(excluding LULUCF Gg CO₂-eq)

	BY	1990	1995	2000	2005	2008	2010	2012	2013	2014
CO₂	85194	73115	61354	58337	60330	57325	52109	46775	43931	43573
CH₄	12660	11967	9034	8958	8443	8251	8037	7825	7619	7614
N₂O	11404	8665	5001	5621	5982	4487	4055	4200	4599	4504
HFCs	NO	NO	42	273	804	1164	1223	1185	1280	1428
PFCs	371	376	223	283	281	5	2	2	2	2
SF₆	6	11	52	84	94	108	99	120	123	104
Total	109636	94134	75706	73557	75933	71340	65524	60107	57554	57225

Base year (BY)=average of 1985-87

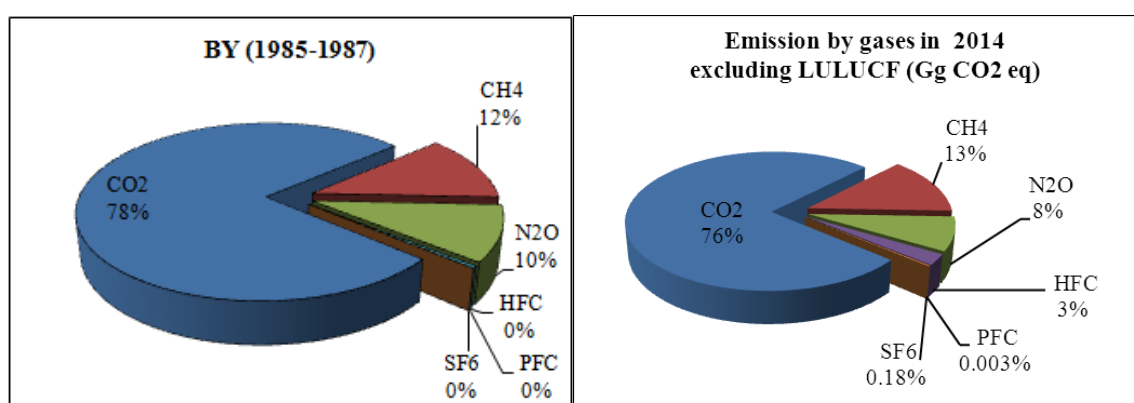


Figure 2.7 Shares of emissions of greenhouse gases in the base year (BY) and in 2014

The drop in CO₂ 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, CO₂ emissions decreased by 28 per cent which is about the same as the decrease during the regime change around 1990. The drop of emission accelerated after 2008 mainly driven by the global economic crisis, and the reduced fossil fuel based electricity production.

As regards CH₄ emissions, agriculture, fugitive emissions, and waste management are the trend setting sectors. Most importantly, reductions in the livestock resulted in lower emissions. Besides, emissions from waste disposal had grown until 2008, 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 N₂O emissions decreased significantly 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.

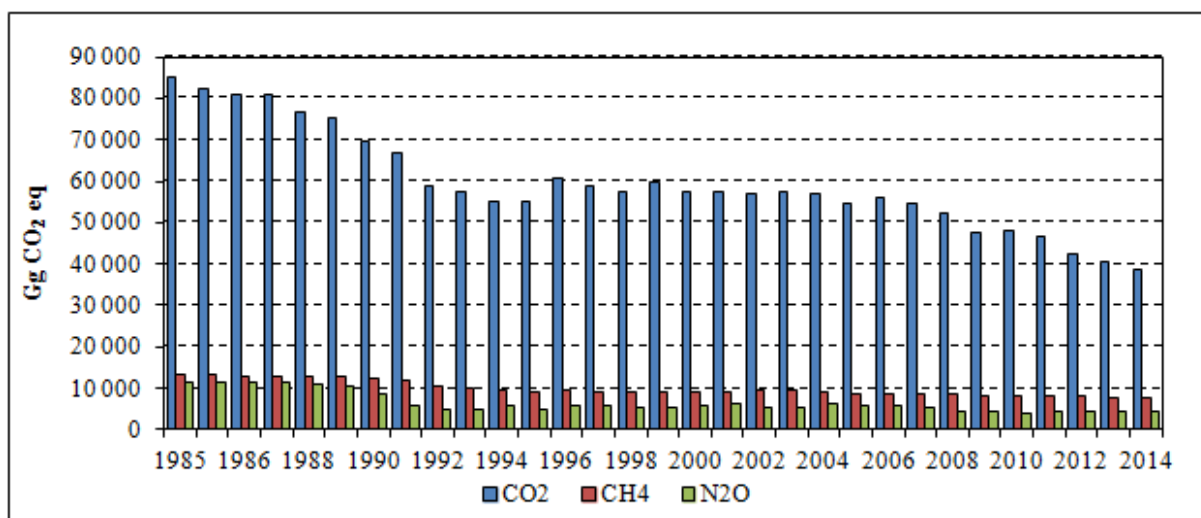


Figure 2.8 Trend of emissions by gases, including LULUCF, Gg CO₂-eq

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 slow down 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.

SF₆ 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 SF₆, however the tendencies vary according to the manufacturing/application needs and the steep increase seems to be stopped in the recent years in SF₆ emissions too.

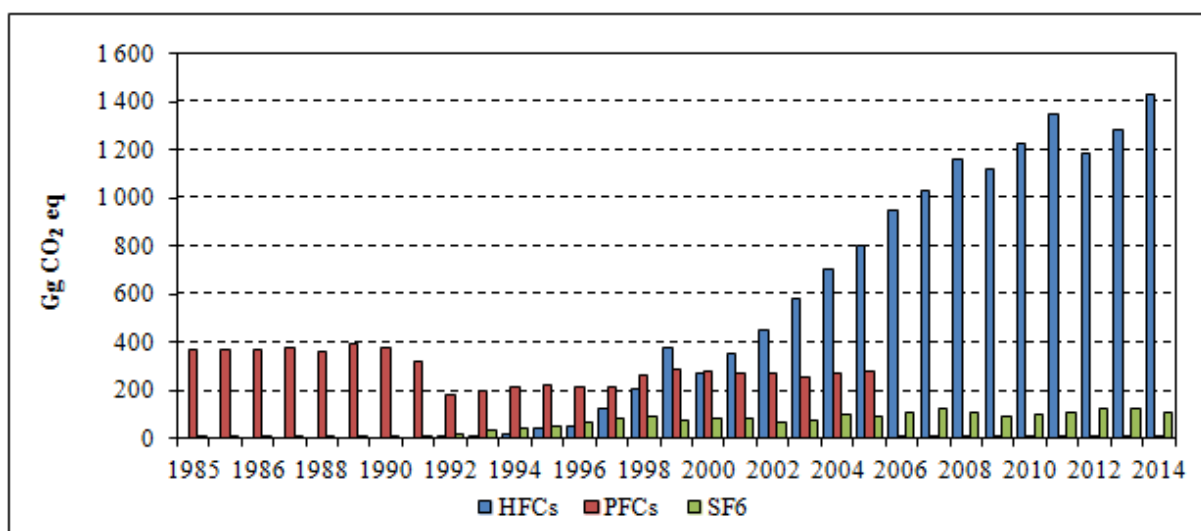


Figure 2.9 F-gases trend (1985-2014), Gg CO₂-eq

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 70% to the total GHG emission in 2014. Agriculture was the second largest sector with 11% but only slightly larger than emissions from industrial processes and product use that accounted for 11% too. The waste sector contributed 8%. Compared to the base year, emissions were significantly reduced in the energy (-49%), agriculture (-46%), and industrial processes and product use (-59%) sectors. In contrast, emissions in the waste sector have increased since 1985-87 (+16%). Land use, land-use change and forestry (LULUCF) sector shows fluctuating behavior.

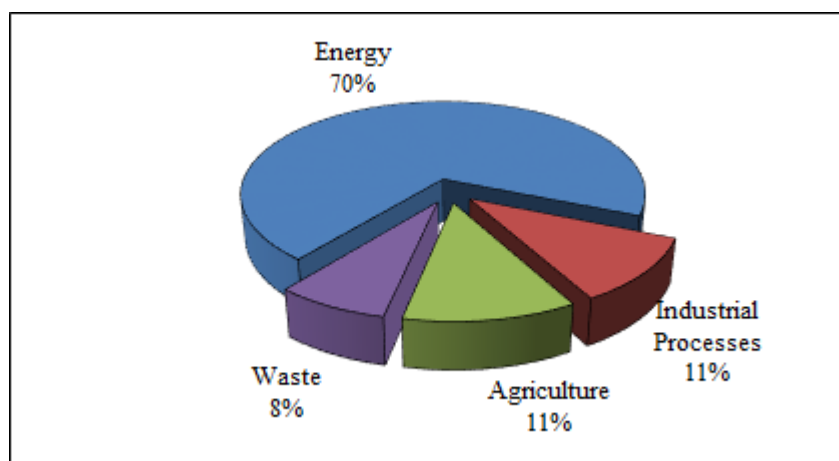


Figure 2.10 Shares of sectors in 2014

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 the drastic reductions in the residential sector and manufacturing industries. And then the economic crisis came.

The **energy sector** was responsible for 70% of total GHG emissions in 2014. Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 96% to the sectoral emission. Looking at fuel combustion only, the share of CO₂ emissions was even higher (98%). Considering fuel use in combustion processes, gases had still the highest (but decreasing) proportion (44%), liquids and solids represented 31% and 13%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 11%. The most important subsector was energy industries with a proportion of 33% within the energy sector, followed by transport (28%) and other sectors (27%). Fugitive emissions from fuels played only a small role with 2% out of which 57% originate from natural gas production, processing, transmission and distribution. Emission in subsector *1.B.1 – Fugitive emissions from solid fuels* are 95% 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 72% decrease compared to the base year.

The significant reduction in emissions between the base year and 1995 was mainly due to the economic transformation which caused sudden decrease in energy demand. (In this respect it is perhaps worth mentioning that the decrease in fuel consumption after 2005 was even higher!) In addition, ongoing changes in fuel-structure, i.e. gradual replacement of solid fuel by natural gas, led to further decrease of total emissions.

Overall emissions from the energy sector have decreased by 2% or 0.8 million tonnes between 2013 and 2014 (after decreases of 7% and 5% in the last two years). The transport sector surprised us with the biggest change (+12% or 1.2 million tonnes) – in the opposite direction! Especially diesel oil consumption increased significantly whereas gasoline sales remained at a quite moderate level. Still, transport related emissions were by 14% lower in 2014 than in 2007. Natural gas consumption decreased by a further 8% in the residential sector (altogether by 42% since 2005) where we have not seen such a low consumption level since the early 90's.

Gross electricity production decreased further by 3% (after a drop of 13% in 2013). The decrease in natural gas based electricity production was especially drastic (-24% in 2014 and -72% since 2008!), whereas the share of CO₂ neutral nuclear fuel grew steadily, and wind energy utilization showed a steep increase in the last few years. Currently, 53% of gross electricity production stems from nuclear energy and only 35% from classic fossil fuels. At the same time, electricity import grew significantly to a record high level of 31%.

In 2014, **agriculture** was the second largest source of greenhouse gas emissions in Hungary. However its share in national total emissions was with only a few tenths of a per cent higher than the share of Industry. Emissions from agriculture include CH₄ and N₂O gases. 83 per cent of total N₂O emissions were generated in agriculture in 2014. Emissions from agriculture have decreased by 46% over the period of 1985-2014. The bulk of this reduction occurred in the years between 1985 and 1995, when agricultural production fell by more than 30 per cent, and livestock numbers underwent a drastic decline. The contribution of agriculture to total emissions was 11% in 2014 similar to the level in the base year (BY).

Between 1996 and 2008, agricultural emissions had stagnated around 6.2 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% in the period 1995-2007 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 11 per cent decline in swine population also contributed to the downward trend. Agricultural emissions hit the lowest point in 2010. A slight increase started in 2011, due to the higher N-fertilizer use, and higher emissions from crop residues resulting from greater crop production, then in 2012 emissions remained on the level of 2011. In 2013 and 2014 the further rising fertilizer use, increasing animal livestock and relatively higher crop production resulted in growing emission levels again.

The **industrial processes** sector was the third largest sector, contributing 11% to total GHG emissions in 2014. The most important greenhouse gas was CO₂, contributing 72% to total sectoral GHG emissions, followed by F-gases with 25%. In 2014, 41% of the emissions came from chemical industry, followed by 23% from product uses as ODS substitutes, and 17% from mineral products. The contribution of iron and steel industry and other (SF₆ and N₂O containing) product uses is 15% and 3% respectively. Process related industrial emissions decreased by 59% between base year and 2014, and by 34% between 2005 and 2014.

Although emissions of F-gases represent only 3% of the total GHG emissions, their trend requires special attention. As these gases are harmless for the ozone layer, the use of HFCs in the refrigeration and air conditioning industry got widespread thus their emission steeply increased until 2008.

GHG emissions from industrial processes sector are 7% (407 Gg CO₂-eq) higher in 2014 than in 2013 after two years of decrease. There is an increase in all subsectors except for other (SF₆ and N₂O containing) product uses. The latter might be explained by the volatility of the markets, the trade and the consumption of these products. Significant increase of emissions might be observed in Iron and steel and in Chemical subsectors (cc. 200 Gg CO₂-eq in each one), while in Mineral industry the change is quite slight. The increase of emissions in Chemical subsector is mainly due to the fact that

production of ammonia (for production of fertilisers) was cc.40% higher in 2014 than in 2013, while Iron and steel industry seems to recover after the drop of production in 2013.

The **waste sector** was responsible for 7% of total national GHG emissions in 2014. The largest category was solid waste disposal on land, representing 78% in 2014, followed by wastewater treatment and discharge (14%), incineration of waste (5%), and biological treatment of solid waste (3%). In contrast with other sectors, emissions from the waste sector are by 16% higher now than in the base year. However, the growth in emissions had stopped in the last decade, and a reduction of 10% could be observed between 2005 and 2014. 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 dropped significantly since 2005 (e.g. landfilled municipal waste decreased by 43%) consequently 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 2.9 million tonnes removal, CO₂-eq net removals range from 0.04 million tonnes in 1985 to 5.6 million tonnes CO₂ in 1994. In 2014, the LULUCF sector accounted for 4.6 million tonnes carbon dioxide net removals. The net removals of forests amounted to 4.4 million tonnes CO₂.

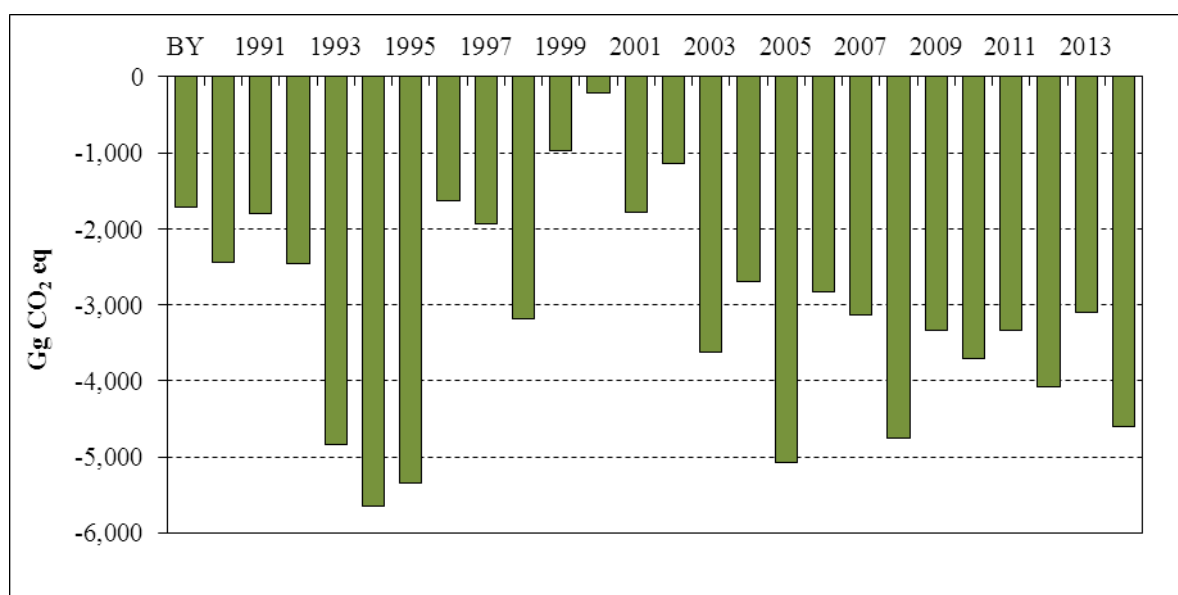


Figure 2.11 Sinks of LULUCF, Gg CO₂-eq

2.4 Trends of indirect gases and SO₂

NO_x, CO and NMVOC gases are referred to as indirect gases because they (together with SO₂) 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 is required by the UNFCCC reporting guidelines. 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. Emissions are reported consistently in the above two reporting regime.

The following table shows the main trends in emissions:

Table 2.3 Trends in emissions of indirect greenhouse gases and SO₂ including LULUCF (Gg)

	1990	2000	2003	2005	2006	2008	2010	2012	2013	2014
NO_x	238	177	174	166	160	154	138	122	120	120
CO	1 415	498	530	434	477	331	328	378	327	303
NMVOC	293	169	164	145	142	131	125	120	120	116
SO₂	825	428	246	41	39	35	31	31	30	27

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 SO₂ precipitators in coal-fired power stations. Reduced carbon monoxide emissions are obviously a consequence of decreased fuel uses. The decrease in NO_x 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 28 per cent lower than in 2005;
- Emissions from the energy sector have decreased by 2% or 0.8 million tonnes between 2013 and 2014 (after a 5% decrease previous year);
- Gross electricity production decreased further by 3% (after a drop of 13% in 2013). The decrease in natural gas based electricity production was especially drastic (-24% in 2014 and -72% since 2008!). At the same time, electricity import grew significantly to a record high level of 31%;
- Natural gas consumption decreased by a further 8% in the residential sector (altogether by 42% since 2005) where we have not seen such a low consumption level since the early 90's;
- In contrast, after six years of decreasing emissions, the transport sector showed quite significant increase (+12% or +1.2 million tonnes).

Major changes compared to previous submission:

- No methodological change has been made for this submission;
- Nevertheless, activity data has been updated (e.g. the latest version of the Annual IEA/Eurostat Questionnaires has been used that contained amendments back to 2010. Also the most up-to-date database received from Eurocontrol has been taken into account).

3.1 Overview of sector

Emitted gases: CO₂, CH₄, N₂O

Methods: T1, T2, T3

Emission factors: D, CS, PS

This sector covers emissions from combustion processes and fuel-related fugitive emissions from exploration, transmission, distribution and conversion of primary energy sources.

For a better understanding of the principal drivers behind fossil fuel related emission trends and variations, the main characteristics of the Hungarian Energy System will be described shortly in the following. First of all, not enough, cheap and clean domestic energy resources of good quality are available in Hungary, therefore the energy demand has to be met by import to a great extent. In 2014, primary energy production amounted to 422.9 PJ which was by 31 per cent less than in 1990 and the lowest value in the whole time series (1990-2014). Most importantly, uneconomical deep coal mines were closed down, but also crude oil and natural gas production decreased. In contrast, energy import increased by 37 per cent between 1990 and 2005, and after drop of about 21 per cent until 2012, it grew again by 11 per cent until it reached its current level of 803 PJ. Thus our import dependency is quite significant.

The primary energy use of Hungary was 961.6 PJ in 2014 which was about half per cent above the 2013 figure.

In 2014, final domestic electricity use amounted to 35,866 GWh, which was by 1% lower compared to the previous year and at about the same level as the average of 2003-2013. The market penetration of the nuclear electricity started in 1983 in Hungary when the first 440 MW block of the Nuclear Power

Plant in Paks was put into service. Recently, 53 per cent of the domestic generated electricity is produced by nuclear energy whereas the share of fossil fuels decreased to 35% in 2014 from 67% in 2003. The share of gas-engines, wind-turbines, and biomass in electricity generation increased in the last decade, however, the use of gas engines decreased in recent years.

Also wind power production decreased somewhat in the last two years, still 657 GWh was produced in 2014 which is a great increase after 10 GWh in 2005. Altogether, electricity produced from all renewables (including part of municipal waste) accounted for 11% of total electricity generation after 5% in 2005 and 8% in 2010, so the growing tendency seems obvious.

Figure 3.1.1 shows the emission trends in the sector compared to the total.

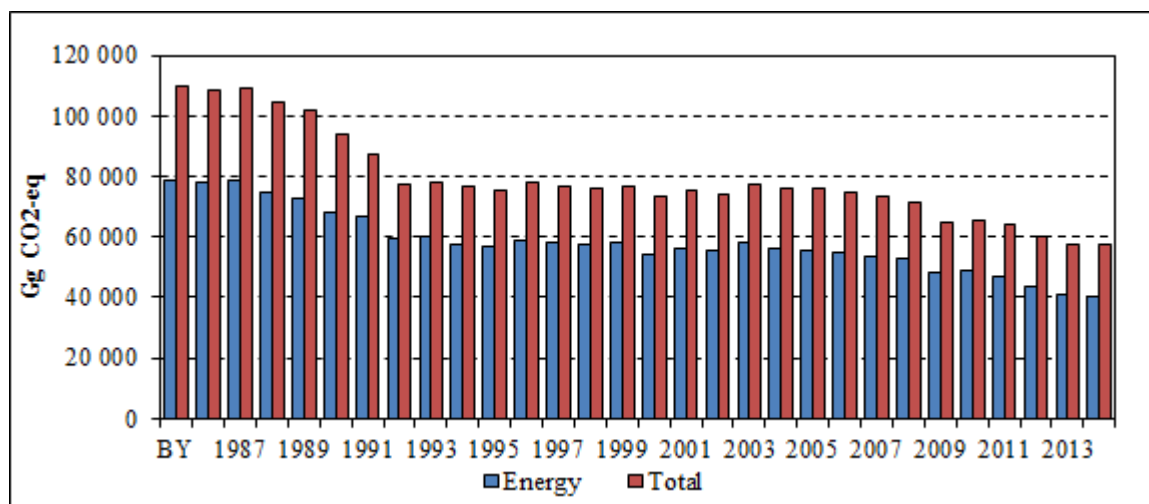


Figure 3.1.1 GHG emissions of the Energy sector compared to total (BY-2014)

As the figure above demonstrates, the biggest emitting sector by far is the energy sector contributing 70% to the total GHG emission in 2014.

The significant reduction in emissions between the base year and 1995 was mainly due to the economic transformation which caused sudden decrease in energy demand. (In this respect it is perhaps worth mentioning that the decrease in fuel consumption after 2005 was even higher!) In addition, ongoing changes in fuel-structure, i.e. gradual replacement of solid fuel by natural gas, led to further decrease of total emissions. Some classical types of fossil fuels have disappeared or their use decreased significantly, e.g. city-gas, heavy fuel oil (by destructive technologies it has been transformed to motor fuels and partly petrol-coke is produced from it). At the same time, the market penetration of new fuel types became significant e.g. petrol-coke, bio-ethanol, LPG and compressed natural-gas (CNG) for cars and buses, biomass for firing in power plants, biogas produced by fermentation of sludge and animal carcasses etc. All these changes were taken into consideration in our emission calculations.

In the last 10 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 the next four years, however, 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 2% or 0.8 million tonnes between 2013 and 2014 (after decreases of 7% and 5% in the last two years). The transport sector surprised us with the biggest change (+12% or 1.2 million tonnes) – in the opposite direction! Especially diesel oil

consumption increased significantly whereas gasoline sales remained at a quite moderate level. Still, transport related emissions were by 14% lower in 2014 than in 2007. Natural gas consumption decreased by a further 8% in the residential sector (altogether by 42% since 2005) where we have not seen such a low consumption level since the early 90's.

Gross electricity production decreased further by 3% (after a drop of 13% in 2013). The decrease in natural gas based electricity production was especially drastic (-24% in 2014 and -72% since 2008!), whereas the share of CO₂ neutral nuclear fuel grew steadily, and wind energy utilization showed a steep increase in the last few years. Currently, 53% of gross electricity production stems from nuclear energy and only 35% from classic fossil fuels. At the same time, electricity import grew significantly to a record high level of 31%.

Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 96% to the sectoral emission. Looking at fuel combustion only, the share of CO₂ emissions was even higher (98%). Among all sectors, the energy sector contributes the most to the total CO₂ emissions as well (89% in 2014).

As regards methane emission, its contribution is 3% and 2% to the energy sector's emissions and to the total greenhouse gas emission (without LULUCF), respectively. 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 14% (waste and agriculture sectors dominate here, see *Fig. 3.1.2*).

Considering nitrous oxide emission, this sector represents 1% (without LULUCF) of the total greenhouse gas emission. Among nitrous oxide emitters, its proportion is 9% which represents though the second highest emission compared to other sectors but it is still far behind agriculture and about the same level with IPPU and waste sectors.

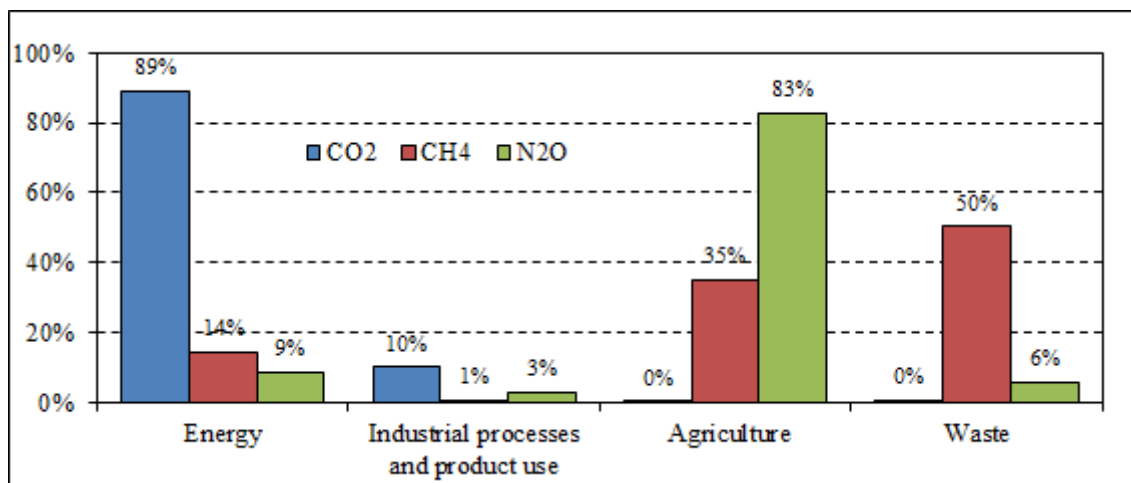


Figure 3.1.2 Sectoral contributions to the total emissions of the main GHG gases (2014)

The most important subsector was energy industries with a proportion of 33% within the energy sector, followed by transport (28%) and other sectors (27%). In *Fig. 3.1.3* we can observe some changes in the relative contributions of the different subsectors, most notably the growing share of transport emissions (from 11% in the base year to 28% in 2014) and the diminishing share of manufacturing industries (from 21% in the base year to 7% in 2009 or 11% in 2014).

Fugitive emissions from fuels played only a small role with 2% out of which 57% originate from natural gas production, processing, transmission and distribution. Emission in subsector 1.B.1 – Fugitive emissions from solid fuels are 95% 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

72% decrease compared to the base year.

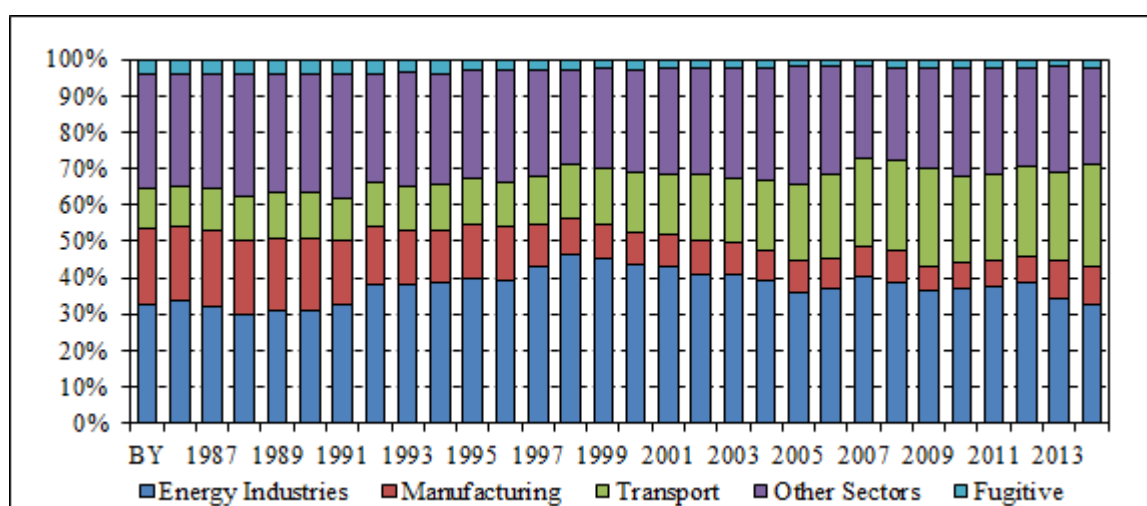


Figure 3.1.3 Changing shares of the different subsectors (BY-2014)

3.2 Fuel combustion (CRF 1.A)

The principal driver of emissions in the energy sector is fuel consumption, therefore emissions of the sector strongly depend on the amount of combusted fuel. The use of combustible fuels decreased quite considerably, by 38% between the base year and 2014. Two periods need to be emphasized in this respect. The regime change around 1990 had the first significant effect: the fuel use in 1995 was by a fifth less than in the base year. The decrease in energy use after 2005 was even more significant (-26%) where the global economic crisis must have played a role.

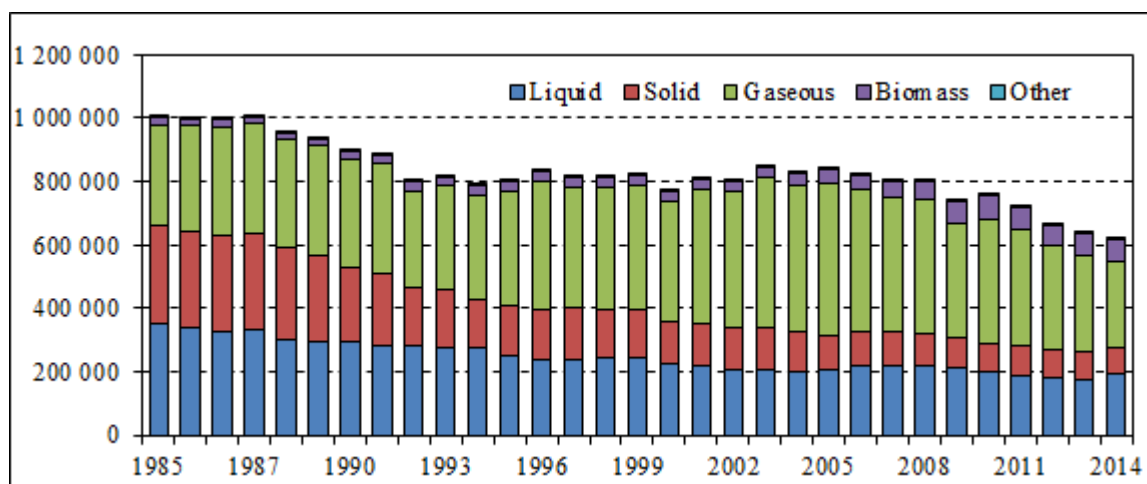


Figure 3.2.1 Fuel consumption by main fuel types (1985-2014)

Beside the amount, also the type of the used fuels has a great influence on the emission levels. Considering fuel use in combustion processes, gases had the highest proportion (44%) in 2014, liquids and solids represented 31% and 13%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 11%. Especially solid fuels lost their importance: their share in the fuel mix was around 30% in the base year.

Figure 3.2.2 presents the proportion of combusted fuel types in the base year and in 2013.

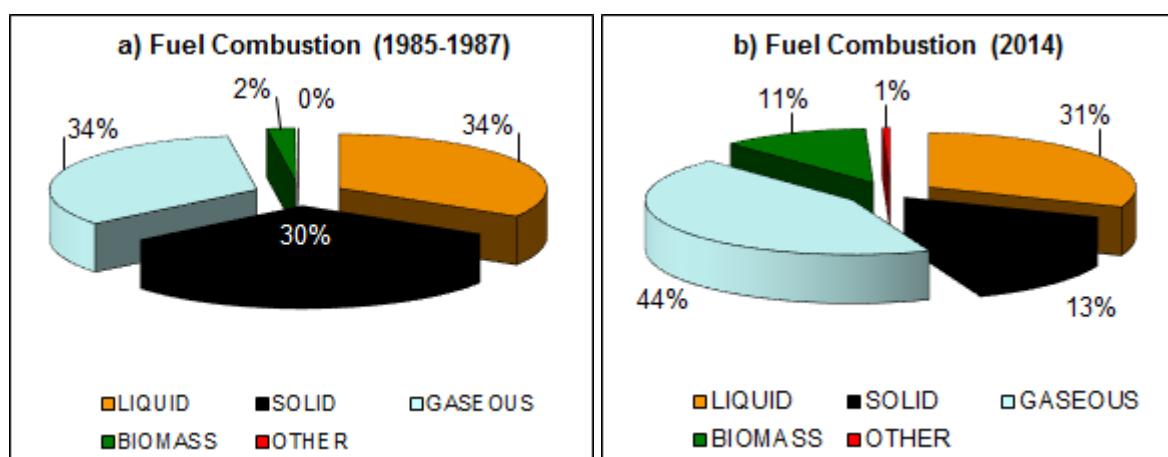


Figure 3.2.2 The used fuel mix in the base year and in 2014

In Fig. 3.2.3 the share of energy consumption among subsectors is illustrated (a) together with the subsectoral proportion of the combustion related GHG emissions in the energy sector (b). The most important subsector within the energy sector (fuel combustion only) is energy industries (1A1) with a proportion of 33%, followed by transport (1A3) and other sectors (1A4) representing 28% each. Following the trend of previous years, the least contribution to the emission from fuel combustion has manufacturing industries and construction (1A2) with 11%.

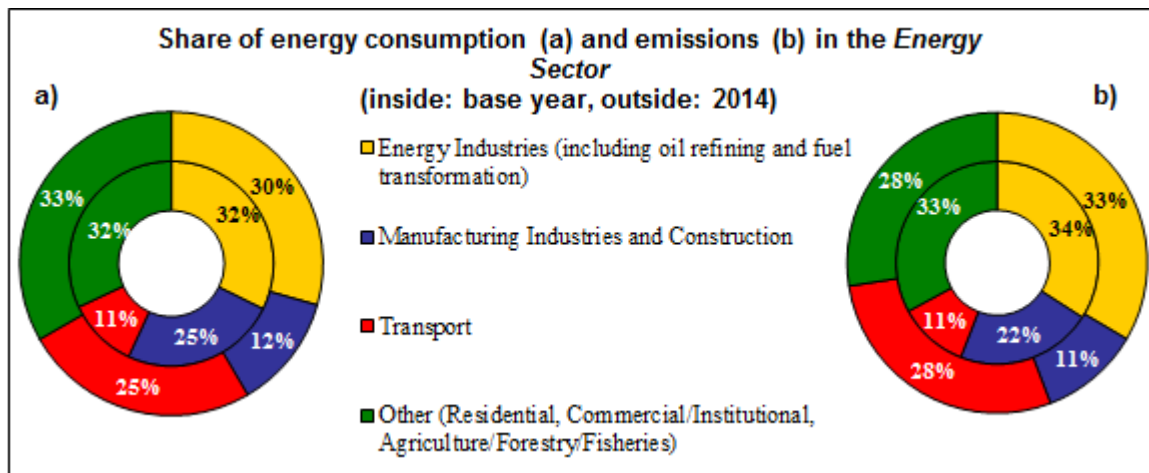


Figure 3.2.3 Proportions of energy consumption and emissions in the base year and 2014

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 compiled by the Hungarian Energy and Public Utility Regulatory Authority are used dominantly. After discussion with the energy statistics provider and following their recommendation, it was decided that starting with the 2014 submission, the basis of the inventories would be on the IEA/Eurostat Questionnaires. (Previously, 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.)

To increase consistency of the time series, we had to make some minor amendments of the allocation of fuel consumption compared to the IEA annual questionnaires, as follows:

- Based on 2013-2014 data allocations and value added volumes for previous years, some gasoil consumption have been reallocated from road transport to construction, mining (1A2gvii), and minerals (1A2f);
- The time series of gasoil use in navigation has been improved by interpolation where the missing amounts were taken again from road transport;
- Some natural gas use have been reallocated between petroleum refining (1A1b) and commercial/institutional: stationary (1A4a) to increase consistency with fuel consumption reported by the refinery under the ETS;
- Further natural gas consumption has been reallocated between other energy industries (1A1c) and commercial/institutional (1A4a) to reflect fuel consumption in oil and gas extraction. Data on natural gas production served as basis of extrapolation here;

The fuel use and emissions of autoproducer plants (that generate electricity or heat, wholly or partly for their own use as an activity which supports their primary activity) are accounted for in this inventory mostly under other stationary combustion (1A2g) which means not under the relevant economic sector and not in energy industries. (The only differences are coke oven gas and blast furnace gas that are reallocated from autoproducers to iron and steel, and to manufacture of solid fuels, and some industrial waste incineration that are reallocated to energy industries.) Knowing the order of magnitudes, this might not have led to large allocation errors, since in 2014 only 4 PJ of fuel

combustion was allocated to autoproducer use compared to 155 PJ energy use by public power plants.

The problem of the network losses in the natural-gas transmission and distribution system should be also mentioned here. These losses are not technical ones in the reality, but the result of accounting. After discussing the situation with the experts of the natural gas industry, only about one third of the losses reported in statistical publications was taken into consideration as real loss (i.e. that is emitted into the atmosphere as methane), while the remaining two-third was assumed to be fired. This one-third figure was more or less in line with our fugitive methane emission estimate from transportation and distribution of natural gas reported to the UNFCCC. Thus the natural gas consumption in the residential sector is not the same as reported in the IEA natural gas annual questionnaire because 50 per cent of the network losses are added to it. As recent information from the energy statistics provider indicated that natural gas used on compressor stations was allocated to distribution losses for previous years therefore we reallocated about 1-2 PJ natural gas consumption to pipeline transport based on IEA data of total consumption.

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. LPG and petroleum coke was taken into account as liquid fuels which had significant influence on the IEF value of this fuel type.

3.2.1 Comparison of the sectoral approach with the reference approach

The quantity of CO₂ from energy consumption was determined both on national level (reference approach) and on sectoral level (sectoral approach). 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 2014 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 CO₂ 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 CO₂ emissions from energy use of fossil fuels.

Emissions from feedstocks and non-energy use of fuels are taken into account in the IPPU 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.

Since the 2015 submission, more fuel has been removed from the reference approach than in previous submissions (see also Table 3.2.3):

- All coke related emissions (including blast furnace gas) in the iron and steel industry are allocated to the IPPU sector;
- More natural gas consumption in the chemical sector is allocated to the IPPU sector.

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. 3.2.4). The remaining differences – after extracting the feedstock and non-energy use of fuels – are basically statistical differences, fugitive emissions and transformation losses which are occurring during coking, briquetting or oil refining.

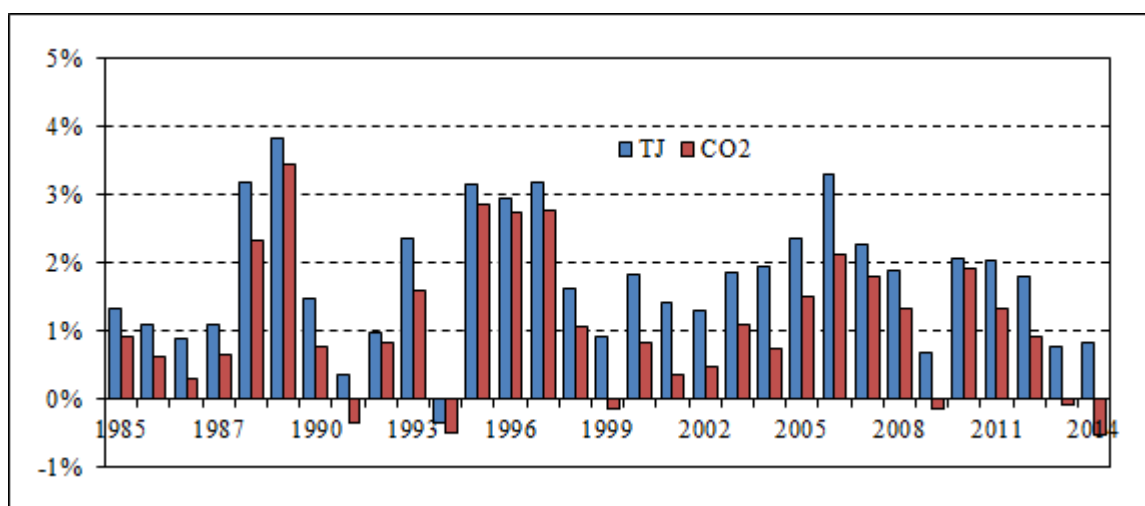


Figure 3.2.4 Differences between the reference and the sectoral approach as regards fuel consumption and CO₂ emissions

In 2014, comparing the two approaches the difference was 0.8% in energy consumption and -0.5% as regards CO₂ emission (Fig. 3.2.4). The ranges of differences are between -0.3% (1994) and 3.8% (1989) with a 1.8% mean value as regards the fuel consumptions, and -0.5% (1994) and 3.5% (1989) with a 1.1% mean value as regards the CO₂ emissions.

It has to be noted that the traditional Hungarian coal terminology as published in the Energy Statistical Yearbooks differs from that of the IPCC. The partitioning was created according to the age of coal; Table 3.2.1 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 anthracite, 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, as our reporting is based on the IEA statistics, the reported fuel data follow the IPCC categories consistently.

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. (Until the 2014 submission, the following constant values had been 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 103.0 and 108.6 t CO₂/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 CO₂/TJ, OX=0.974. As for Hungarian brown coal EF=100.8 t CO₂/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, the IPCC default values are used.

Table 3.2.1 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 reporting 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 CO₂ 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 3.2.2 which shows the air travelling/transport performance of the past years.

Table 3.2.2 Air travelling and transport performance in Hungary since 2000 in selected years

	2000	2005	2008	2009	2010	2011	2012	2013	2014
Passengers (thousands)	2476	3785	4340	4573	4512	4875	2106	2270	2967
Transported goods (kt)	22	16	14	16	16	12	7	8	8
Kerosene use (TJ)	9408	10962	11298	9660	9618	9660	6972	6804	7148

Consumption in international navigation was not considered, because separate data on the uses for international navigation are not included in the national statistics.

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

3.2.3 Feedstocks and non-energy use of fuels

The 2006 IPCC Guidelines introduced significant changes regarding feedstocks and non-energy use of fuels. It is good practice now to report all the feedstock and non-energy use of fuels in the *IPPU Sector* within the source category in which the process occurs (and not in 2G source category as in the case of previous inventory submissions of Hungary).

In addition, also chapter 1.2 of Volume 2 states: “Combustion emissions from fuels obtained directly or indirectly from the feedstock for an IPPU process will normally be allocated to the part of the source

category in which the process occurs. These source categories are normally 2B and 2C.”

So, in present submission all the fuels regarded as NEU in IEA Energy Statistics are allocated into IPPU sectors and also some amount from the quantities regarded as energy use in order to follow the suggestion of IPCC2006. This is the case by Natural Gas use in sector 2B1 – Ammonia, Naphtha use in 2.B.8 Petrochemical and the Coke used in 2C1 – Iron and steel.

Therefore the Fuel quantities for NEU reported in CRF Table 1.A.(d) and QA/QC check Table for NEU included in Annex of the NIR are higher than the actual quantity reported in IEA Energy Statistics. However the differences are well-known and documented.

Table 3.2.3 Allocation of feedstocks and non-energy use of fuels

Fuel type	Allocated under IPCC sector...
Other kerosene	2.B.8 -Petrochemical and Carbon Black Production
Gas/diesel oil	2.B.8 -Petrochemical and Carbon Black Production
Liquefied petroleum gases (LPG)	2.B.8 -Petrochemical and Carbon Black Production
Naphtha	2.B.8 -Petrochemical and Carbon Black Production
Bitumen	2.D Non-energy Products - Other (<i>no CO₂</i>)
Lubricants	2.D.1 - Lubricant Use
Other oil	2.D.2 - Paraffin Wax Use 2.B.8 - Petrochemical and Carbon Black Production
Coking coal	2.C.1 -Iron and Steel Production
Coke oven/gas coke	2.C.1 -Iron and Steel Production
Natural gas	2.B.1 -Ammonia Production 2.C.1 - Iron and Steel Production 2.B.8 - Petrochemical and Carbon Black Production

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 calculation of emission in the IPPU sector is not based on a default carbon-stored approach, but usually plant-specific (EU ETS) data, except for Lubricant and Paraffin wax use source categories.

3.2.4 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 3.2.4. Fuel uses in energy statistics and ETS are compared also to see whether the fuel use in a given category is fully covered by ETS plants or not. Fuel consumption data are compared both in natural units and in energy units to reveal any possible differences in net calorific values. Should such difference occur, emission factors need to be amended to achieve consistency in energy balance and verified emissions since national energy data serve always as activity data. It is also checked whether the oxidation factor used by the facilities is included in their EFs. Measured oxidation factors, especially in case of coal firing plants, are always taken into account.

Table 3.2.4 Country specific emission factors derived from the EU ETS database

	Default	2008	2010	2011	2012	2013	2014
Gasoil	74.1	74.1	82.6	75.4	75.2	74.1	74.1
Heavy fuel oil	77.4	82.0	77.4	78.4	78.6	77.4	77.4
Other oil	73.3	80.1	80.1	80.2	80.1	-	-
Lignite*	101.0	106.1	107.9	107.5	107.8	107.9	108.5
Blast furnace gas	260.0	255.7	243.4	254.2	260.0	252.6	244.9
Coal/petroleum coke	-	94.1	93.3	93.5	92.4	93.0	92.8
Natural gas	56.1	-	55.3	55.6	55.6	55.9	56.1

**including the oxidation factor*

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

3.2.5 Energy Industries (CRF sector 1A1)

Emitted gases: CO₂, CH₄, N₂O

Methods: T1, T2, T3

Emission factors: D, CS, PS

Key sources:

1A1 Fuel combustion - Energy Industries - Liquid Fuels – CO₂ – L, T

1A1 Fuel combustion - Energy Industries - Solid Fuels – CO₂ – L, T

1A1 Fuel combustion - Energy Industries - Gaseous Fuels – CO₂ – T

1A1 Fuel combustion - Energy Industries - Other Fossil Fuels – CO₂ – L, T

3.2.5.1 Category description

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.

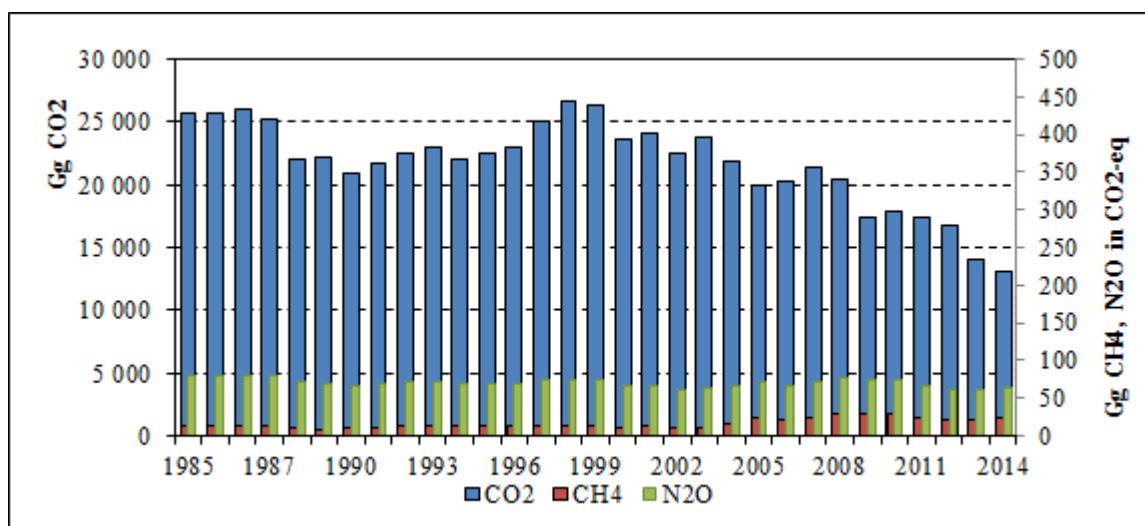


Figure 3.2.5 Trends of CO₂, CH₄ and N₂O emissions in the Energy Industries (1985-2014)

Public Electricity and Heat Production was responsible for about 85% of fuel use in energy industries. Based on a publication of the Hungarian Energy and Public Utility Regulatory Authority (“Statistical Data of the Hungarian Power System 2014”), for electricity production 326 PJ energy was used which is 34% of total domestic consumption. The energy source consumption of power plants was 2% less than in previous year. 52.4% of consumed energy sources was nuclear fuel 14.6% was natural gas and 19.8% was coal in 2014. The waste and renewable energy sources used in power plants gave 10.3% of total energy source consumption of power plants.

Domestic electricity production showed an overall increasing trend up till 2008; even during the years of the regime change around 1990, whereas import suffered a more severe drop from 28% to 10%. In addition to the effects of the financial crisis, 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 the oil fired power plants. After 2010, domestic electricity production decreased every year, and it has dropped quite substantially in 2013 by 12.5%. The share of import is a highly variable figure: in

the last decade it changed between 8% (2001) and 18% (2004). After 2010, however, it grew constantly and has reached a share of 31% in 2014.

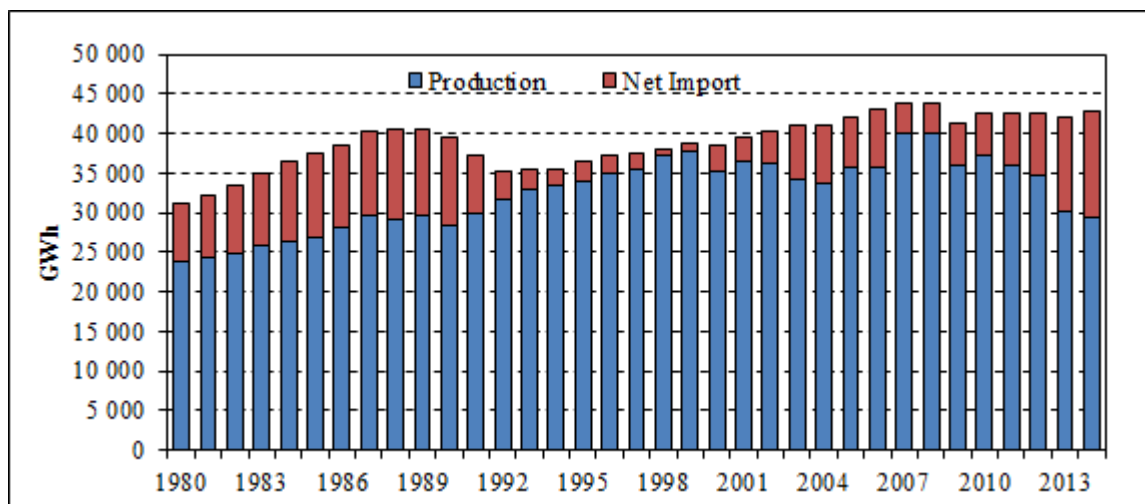


Figure 3.2.6 Domestic Electricity Production and Net Import (1980-2014)

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 the 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 3.2.7.

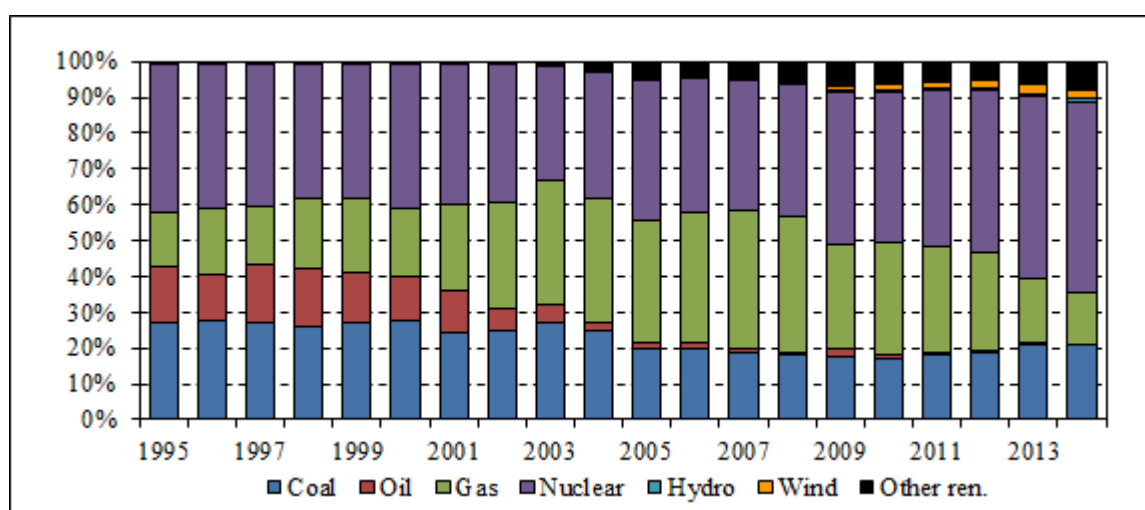


Figure 3.2.7 Share of produced electricity by fuel (1995-2014)

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)

The above words taken from the last year's edition from the already referenced Statistical Data of the Hungarian Power System 2012 seem to be valid also for 2013-2014. There were no further large power generating units connected to the Hungarian Electricity System either in 2013 or in 2014. At the same time, the gas and oil powered AES Tisza II. Power Plant (900 MW) initiated the suspension of its generation. The constant non-operational status of Tiszapalkonya Power Plant (200 MW) permanently ceased on 1 June 2014. After having been in constant non-operational status from 1 January 2014, Unit XIII of Dunamenti Power Plant was removed, upon the initiation of the power plant, from the electricity system with its total installed capacity on 1 January 2015. Borsod Power Plant (137 MW), which was in constant non-operational status as well, has also been excluded from total installed capacity of the Hungarian electricity system since 1 January 2015. In addition, referring to unfavourable market conditions, E.ON Hungaria group initiated the suspension of the Generation Licence of Debrecen Combined Cycle Power Plant (95 MW). Furthermore, EON initiated the suspension of operation of Nyíregyháza Combined Cycle Power Plant (49 MW). The Power Plants intends to suspend its operation until 30 June 2016. The operation of Gönyű (433 MW) and Dunamenti G3 (407.7 MW) Power Plants is uncertain due to the market environment. The low load factor of the two most state-of-the-art power plants in the Hungarian electricity system has a considerable negative impact on balancing possibilities. Gönyű and Dunamenti G3, the new large power plants, were operating only in 27% and 4.2%, respectively (in 2013 the annual load factors were 18.4% and 2.6%). This anticipates, depending on future market conditions, the possibility of a 'constant non-operational state' of these power plants. The generation licence of Vértessomló Power Plant will expire on 31 December 2020, however, it is planned to be available only until 31 December 2015 based on the data provided via long term capacity planning. In order to sustain urban area heating, the duration of its availability may be temporarily extended. In year 2013 the Combined Heat and Power (CHP) generating units of the Budapest Power Plant also considered their shutdown from the end of 2015. According to our current information, the generation of these power plants might become uncertain in the near future. (Source: Statistical Data of the Hungarian Power System 2013 and 2014).

3.2.5.2 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 3.2.8, total fuel consumption (without nuclear energy) in the energy

industries sector shows strong fluctuations. After a significant decrease around the political and economic regime change in 1990, we could experience some increase till 1998, then a slight decrease till 2005 and a more pronounced drop after 2008 due to the global financial crisis. After 2010, fuel consumption has reached record low values every year. Within the inventory period, the consumption of liquid and solid fuels decreased significantly. In contrast, the consumption of natural gas increased until 2007 to a great extent then it shrunk substantially afterwards. The biomass use due to burning or co-burning in power plants became 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, this is also illustrated on Figure 3.2.8. In 2007 the produced electricity increased by more than 11%, in parallel the fuel consumption (mainly natural gas) increased only by 9%, because the efficiency of natural gas combustion is better than that of the others. Biomass burning in power plants became again popular on favorable terms, which was induced by the EU carbon trading. In 2008, the produced electricity from fossil fuels and also the fossil fuel consumption of this sector decreased again, but the total generated electricity – including nuclear, waste and renewable sources – was a bit higher than in the previous year. In 2009, the electricity generation in Hungary was by 10% less than in 2008. The generation decrease of power plants of 50 MW and higher capacity was 11.6% while it was 2.8% in case of small power plants. The fuel-mix also changed in 2009: coal and natural gas consumption decreased, however liquid fuel use increased, but its contribution to total fuel consumption is very low. Use of nuclear, waste and renewable sources continued to increase. In 2010 domestic electricity production increased again by 4%.

In 2011, electricity production fell back by 4% 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 emission irrelevant nuclear fuel use.

In 2012, gross electricity production fell back by a further 4%. Moreover, the decrease in natural gas based electricity production was the most pronounced (-12.5%), whereas the share of air pollutant 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.

This trend continued and even intensified in 2013. Domestic electricity production has dropped by a further 13 per cent. At the same time net import grew by 49 per cent!

The overall picture did not change in 2014, either. We experienced decreasing production levels (-3%) and increasing import (+13%). In fact, net import was never higher in the whole period (1980-2014) than in 2014, and electricity production was never lower since 1990 (see Fig. 3.2.6).

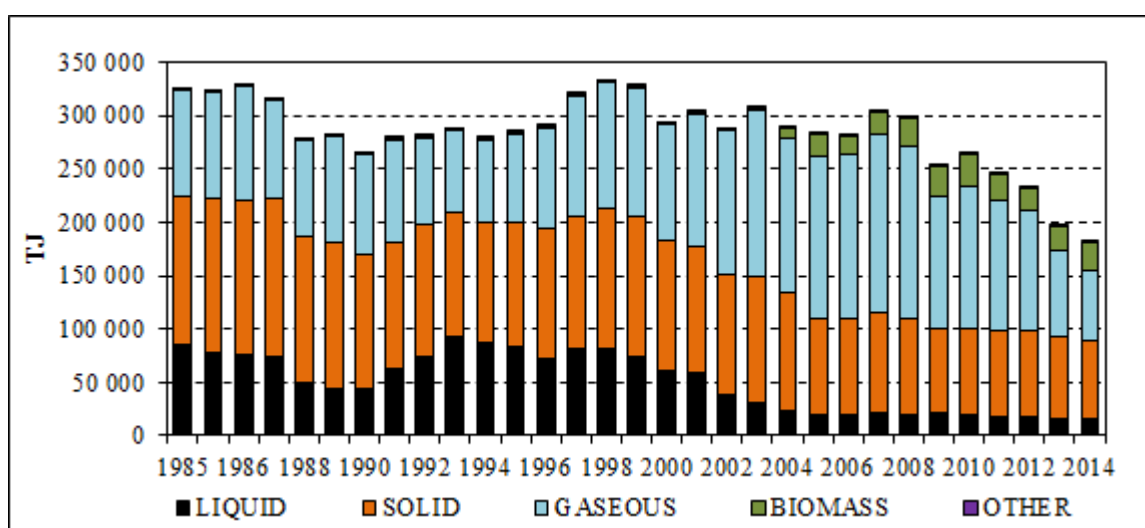


Figure 3.2.8 Fuel combustion in the Energy Industries Sector (1985-2014)

The fuel consumption of oil refining showed a pronounced drop around 2000 but remained more or less at the same level afterwards. Currently its share is about 10%. Even less significant is manufacture of solid fuels and other energy industries with a portion of 2-4% within energy industries.

Going into more detail regarding fuel use, it can be seen that domestically produced lignite is the dominant fuel among solid fuels (Fig. 3.2.9). In energy industries, solid and gaseous fuels are dominant representing together around 80% of all fuel use. In contrast, liquid fuel use became almost negligible in electricity and heat generation. At the same time, refinery gas used in oil refinery became the most important liquid fuel type whereas the formerly dominant fuel oil almost disappeared (Fig. 3.2.10).

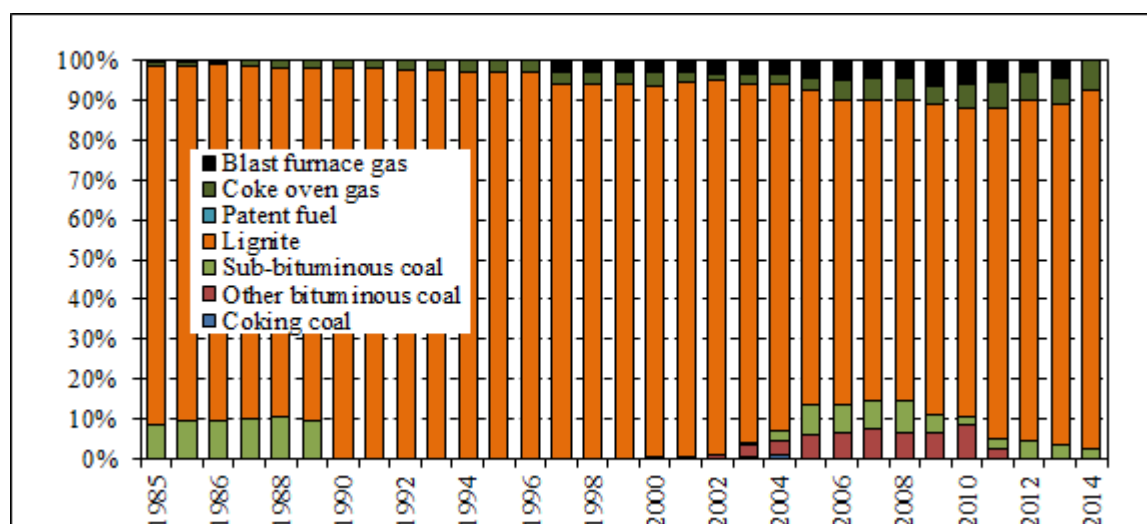


Figure 3.2.9 Share of different solid fuels used by energy industries (1985-2013)

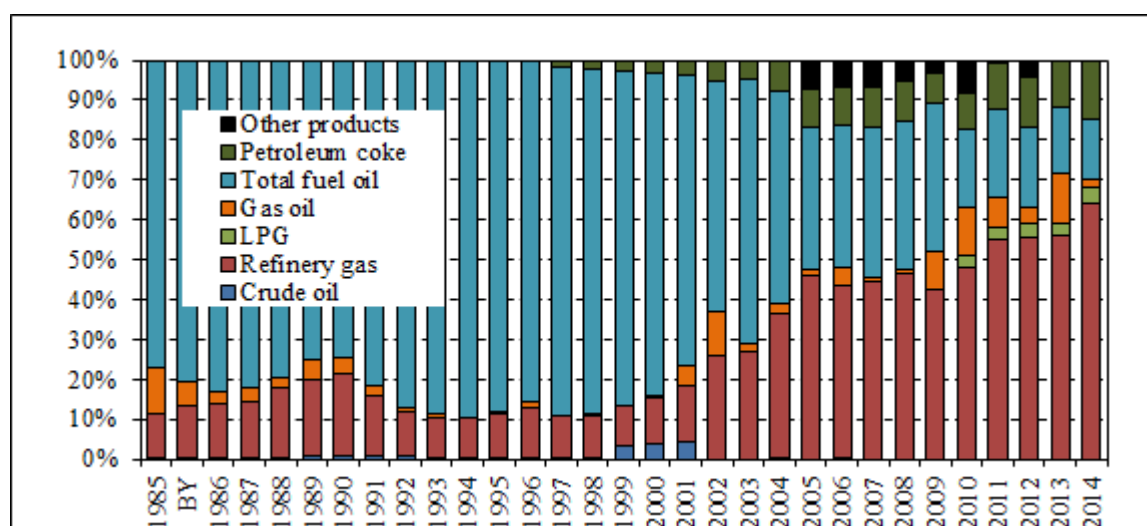


Figure 3.2.10 Share of different liquid fuels used by energy industries (2005-2013)

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 2008-2014, “real” heavy fuel oil burned by the refinery has a net calorific value between 39.8 TJ/kt to 40.5 TJ/kt and a CO₂ emission factor between 79.3 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 65.9 TJ/kt with corresponding CO₂ emission factors between 33.0 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 CO₂ 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 3.2.5 Country specific parameters used in the category petroleum refining

Period	Fuel	Avg. NCV [TJ/kt]	EF [t CO ₂ /TJ]	Comment
2008-2014	refinery gas	49.2-52.4	48.6-51.8	ETS data
2008-2014	other liquid fuel	40.0-40.4	78.9-82.7	ETS data
2001-2007	mixed fuel	50.0	58.7	country specific
1985-2000	refinery gas	49.5	51.3	country specific
1985-2014	petroleum coke	29.4	117.3	EF based on mass

Emission factors

Carbon dioxide emissions were calculated in accordance with the 2006 IPCC 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 3.2.6.

Table 3.2.6 CO₂ emission factors used in energy industries in the 2014 inventory year

Fuel type	Emission factor (CO ₂ t/TJ)	Oxidation factor
Coking coal	94.6	1.0
Other Bituminous Coal	94.6	1.0
Sub-Bituminous Coal	95.8	0.976
Lignite (domestic brown coal)	104.9	0.959
Lignite (domestic lignite)	112.4	0.973
Coke Oven Gas	44.4	1.0
COG in coking plant (IEF)	70,8	1.0
Blast Furnace Gas	244.9	1.0
Gas/Diesel Oil	74.1	1.0
Residual Fuel Oil	77.4	1.0
RFO in refinery	79.3	0.995
Refinery gases	37-57	0.995
Petroleum Coke	97.5	1.0
Natural Gas (in PPs)	56.1	1.0
NG in coking plant	56.3	1.0
NG in the refinery	55.7	1.0
Biomass (Solid)	112.0	1.0
Biogases	56.6	1.0
Waste	86.9	1.0

(Source: 2006 IPCC Guidelines; in bold and italics – EU ETS database of Hungary)

*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.

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. For methane and nitrous oxide, default emission factors were used generally.

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 serves as basis of calculations. For our calculations three main activity data sources were used: data from the Waste Incineration Works (FKF) of Budapest (1985-2014), the Hungarian Waste Management Information System (2004-2014), the IEA Renewable Questionnaire, and the ETS data (2006-2014). 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).

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 (mostly) not used for CO₂ emission estimations therefore the resulting IEF values have little significance.

As only CO₂ emissions resulting from incineration of carbon in waste of fossil origin should be included in the national CO₂ 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 grew from 5% in 1990 to 17% around 2010 and decreased to 13% in 2014. CO₂ 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 CO₂ emissions were taken over.

In addition, there is a relatively small amount classified as industrial waste (45 TJ in 2014) reported in the IEA questionnaire for which the default emission factor was applied (143.0 t CO₂/TJ).

All in all, waste incineration contributed around 215 Gg CO₂ to GHG emissions in this category in 2014.

Also CH₄ 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 N₂O emissions that were estimated the same way with the default emission factor of 4 kg/TJ.

3.2.5.3 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 $\pm 1\%$ (for biomass 5%). 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 CO₂ is 2-5%. The uncertainty of the methane factor is significantly higher (50-150%), while that of N₂O may be of an order of magnitude. The time series can be regarded as consistent.

3.2.5.4 Category-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 in the IEA/Eurostat questionnaires.

Verified energy use from EU ETS was compared to 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. Since the energy consumption in sectoral approach should be compared with those of reference approach, we kept the NCVs of the energy statistics, however the emission factors of coals were corrected for some years to achieve consistency in energy balance and verified emissions. Measured oxidation factor was also applied in the calculation for the above mentioned reason. (As the fuel amounts in the ETS database and in the energy statistics shows good agreement, this means in practice that CO₂ emissions from solid fuel use reported under the ETS could be used directly.)

In previous inventories, 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 CO₂ emissions with default parameters and compared our results with the reported CO₂ 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. To be more consistent with the emissions reported under the ETS regime, we have switched to country specific emission factors for 2010-2013.

A comparison between the ETS data (based on mass balance methodology) and calculations based on fuel use was also made for the coking plant. The difference was higher here: CO₂ emissions from solid fuels differed from ETS data by between -4% (2011) to 17% (2010). Emission calculations showed a better agreement for 2012 though: CO₂ emissions calculated on the basis of fuel use were by only 2% higher than in the ETS database. These smaller differences allowed us to base our emission estimates on the ETS data for the years 2011-2013 to reach a greater consistency with the ETS database. In 2014, the difference became greater again (the ETS data is significantly higher) which led to an unusual high IEF based on coke oven gas reported as activity data here.

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.

3.2.5.5 Category-specific recalculations

No methodological changes have been undertaken. However, there were minor changes in the energy

statistics regarding oil products use for the years 2012-13 which were taken into account. The resulting change in CO₂ emission was an increase of only 0.3% in 2013. (Emissions in the base year remained unchanged.)

3.2.5.6 Category-specific planned improvements

The different oxidation factors used by ETS facilities will be analyzed.

3.2.6 Manufacturing Industries and Construction (CRF sector 1A2)

3.2.6.1 Source category description

Emitted gases: CO₂, CH₄, N₂O

Methods: T1, T2, T3

Emission factors: D, CS, PS

Key sources:

1A2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels - CO₂ – L, T

1A2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels - CO₂ – T

1A2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels - CO₂ – L, T

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 (previously used) energy statistical yearbooks is that the industrial sectors in the questionnaires and in the CRF tables can be more easily harmonized. Emissions from autoproducers have generally been included under *1A2gviii Other*. Emissions from off-road vehicles and other machinery are reported as a separate category (1.A.2.g.vii).

Emissions in the Manufacturing Industries and Construction Sector:

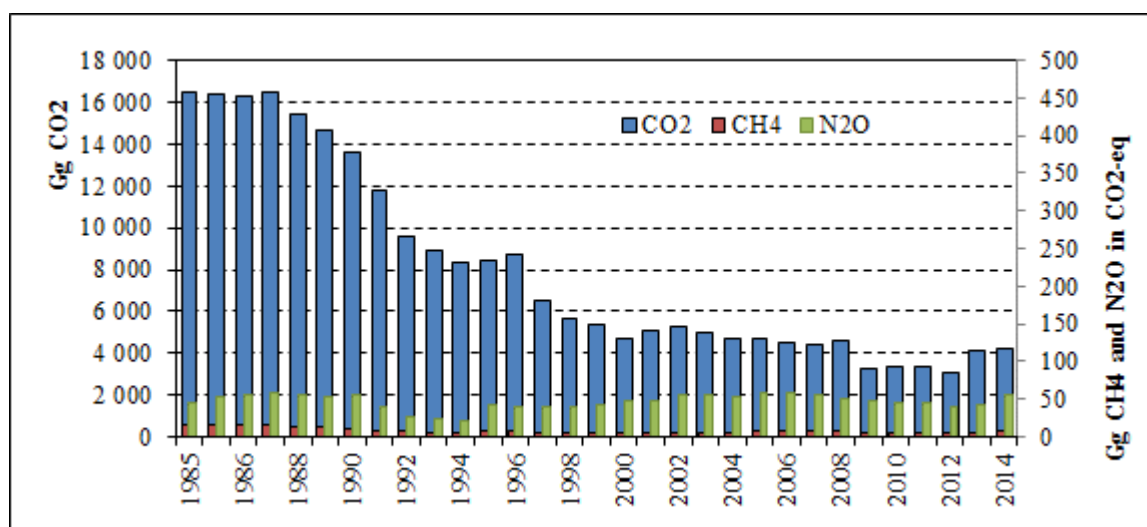


Figure 3.2.11 Trends of CO₂, CH₄ and N₂O emissions in the Manufacturing Industries and Construction Sector (1985-2014)

3.2.6.2 Methodological issues

The energy consumption data have been taken from the IEA/Eurostat questionnaires. All feedstock and non-energy use were removed from the chemicals subsector for the entire time-series, and all relating CO₂ emission originating from non-combustion processes can be found in the Industrial Processes Sector.

Part of the emissions from waste incineration for energy purposes was allocated to this source category. Activity data in energy units were taken directly from the IEA Renewable questionnaire/ETS database with preference to ETS data in case of differences. 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: 85.5 tonne CO₂/TJ waste. This EF was used for the years 2004-2007 in case of fossil wastes. From 2008 on, ETS data (fuel consumption and emission) of the cement factories were used directly. It could be seen that the other industrial facilities incinerate predominantly waste of biogenic origin, mostly wood waste, therefore their CO₂ emissions did not contribute to the national total. The insignificant CH₄ and N₂O 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 3.2.12 illustrates the energy consumption of the sector. After 1990, following the economic changes, fuel use decreased significantly. The underlying reasons are clearly illustrated by the decreasing production data presented in the IPPU sector (Chapter 4).

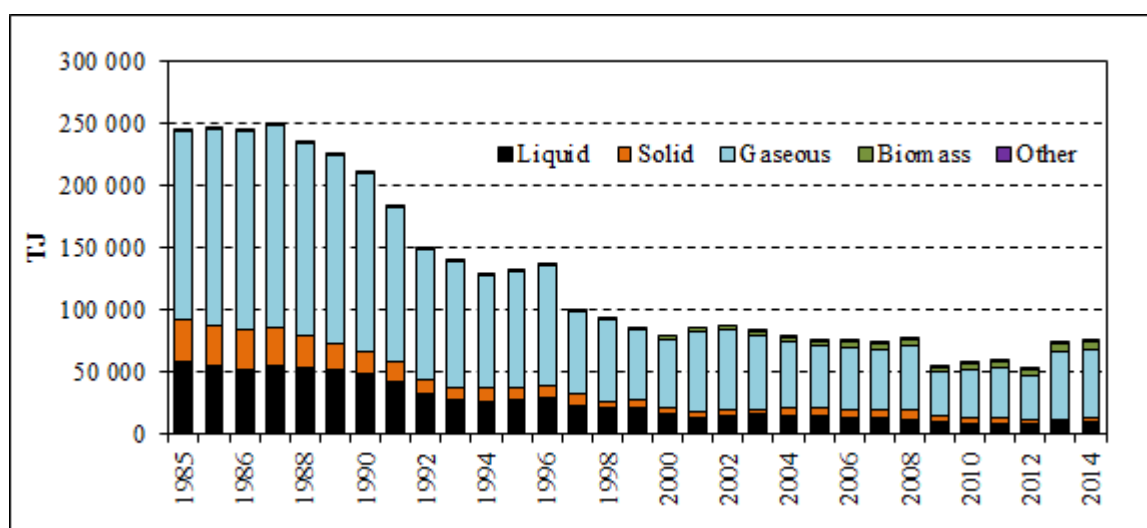


Figure 3.2.12 Fuel combustion in the Manufacturing Industries and Construction Sector (1985-2014)

In 2009 the global economic crisis caused a drop of fuel consumption by more than 25% 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. In 2013, however, fuel consumption returned to the level of the years before the economic crisis.

Fig. 3.2.12 clearly demonstrates the dominance of natural gas (71% in 2014). Biomass use became popular especially in the last decade. (As a consequence, the relative share of methane and nitrous oxide emissions increased.) Combustion of oil products continues to lose its importance among fossil fuels. Liquid fuels represented 14% in 2014 out of which gas oil seems to be the most important (see Fig. 3.2.13).

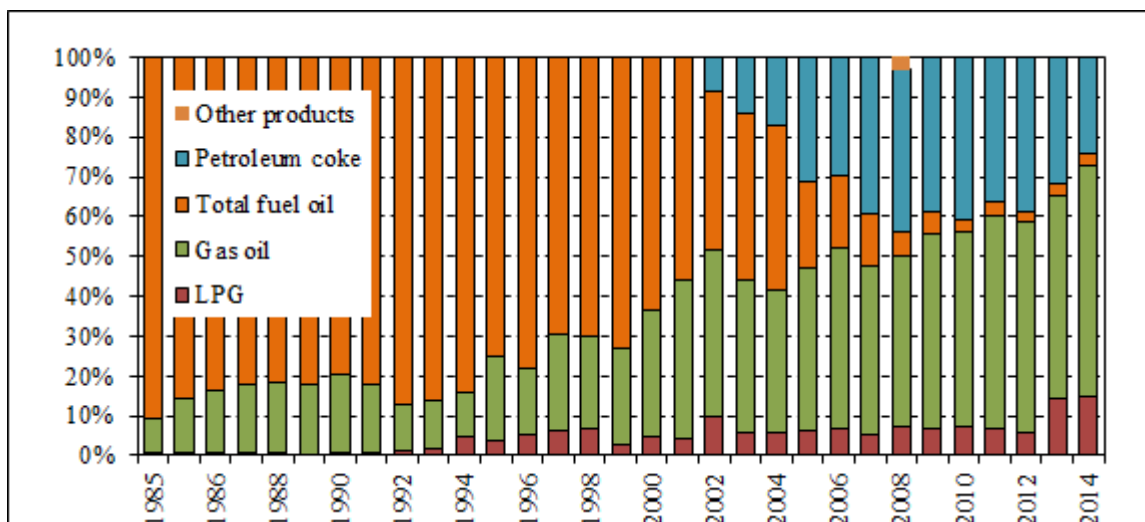


Figure 3.2.13 Share of different liquid fuels used by manufacturing industries (1985-2014)

The share of solid fuels became quite low (5% in 2014). Also the fuel mix has been changing as demonstrated by Fig. 3.2.14. The growing relative share of coke oven gas define the CO₂ IEF in the iron and steel category since coke oven gas has a very low (44.4 t/TJ) CO₂ 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 almost exclusively) coke was used as solid fuel by this industry.

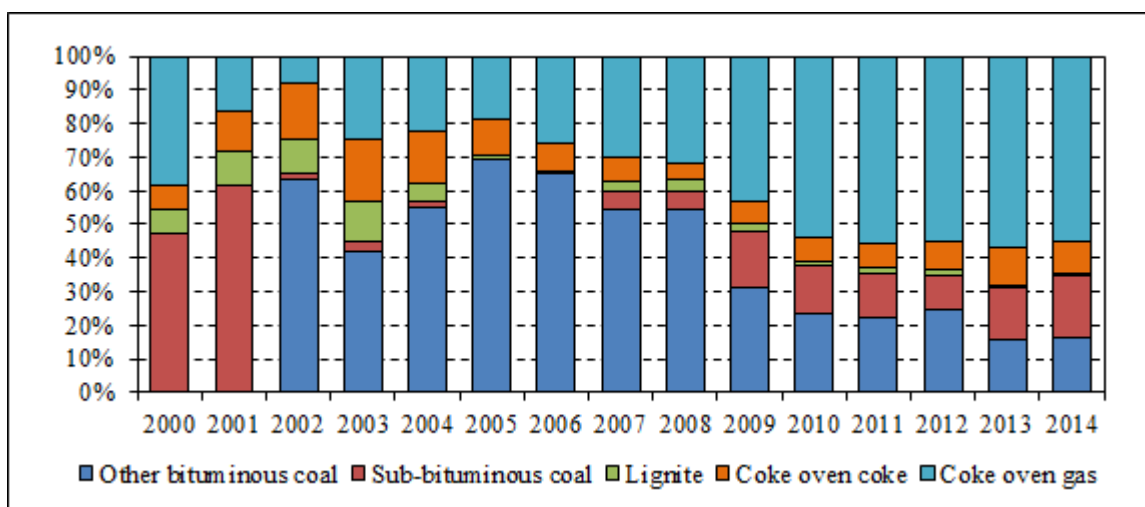


Figure 3.2.14 Share of different solid fuels used by manufacturing industries (2005-2014)

Biomass cannot be considered as the most important fuel but its contribution grew slowly to 8 per cent. Within this 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 CO₂ factors are used in this sector with some exceptions. Country specific emission factors are applied for example in the non-metallic minerals category (based on ETS information). The situation is somewhat complicated here as the cement factories often use mixed fuels. The applied country specific CO₂ emission factors for petroleum coke/coal mix are varying between 92.4 t/TJ and 95.0 t/TJ for the period 2008-2014.

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 5% in consideration of the fact that uses are less easy traceable due to the high number of users.

The estimated specific uncertainty for CO₂ is 2-5%. The uncertainty of the methane factor is significantly higher (50-150%), while that of N₂O may be of an order of magnitude.

3.2.6.4 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.

Non-energy use of fuels was cross-checked with the Industrial Processes sector.

3.2.6.5 Source-specific recalculations

No methodological change occurred. All changes in this subsector were due to changes in activity data as:

- The energy statistics provider made some revisions back to 2010;
- In light of the latest energy statistics, smaller amount of gasoil is now reallocated from road transport to manufacturing industry (e.g. it seems now not necessary anymore to reallocate fuel consumption data to machinery).
- All gasoil consumption is allocated now to off-road vehicles and other machinery (to be consistent with the CLRTP reporting).

The new CO₂ emission estimates are lower by 160 kt in 2013 that corresponds to a 3.7% reduction. Base year emissions are affected by less than 0.5 kt.

3.2.6.6 Source-specific planned improvements

None.

3.2.7 Transport (CRF sector 1A3)

3.2.7.1 Source category description

Emitted gases: CO₂, CH₄, N₂O

Methods: T1, T2, T3

Emission factors: D, CS, M

Key sources:

1A3b Road Transportation – CO₂ - L, T;

1A3c Railways – CO₂ – T

1A3d Domestic Navigation - Liquid Fuels – CO₂ – T (only excl. LULUCF)

This sector covers all the emissions from fuels used for transportation purposes. International aviation and navigation are 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 68%, followed by rail (18%), pipeline (10%) and waterway (3%). In 1990 we saw a completely different picture with railway and waterway being the dominant mode of transport representing 40% and 34%, respectively. The share of road transportation was 15% about 25 years ago.

Passenger transport also underwent considerable changes. The stock of passenger cars had more than doubled since 1985, and increased by 60% since 1990. Within this increase, the proportion of Eastern European cars characterized by high fuel consumption and obsolete technology decreased; for example currently about 56% of the passenger cars complies with at least the Euro 3 emission standards. At the same time, the average age of the car fleet has increased again in recent years to 13.5 years in 2014. Figure 3.2.15 summarizes the above mentioned developments.

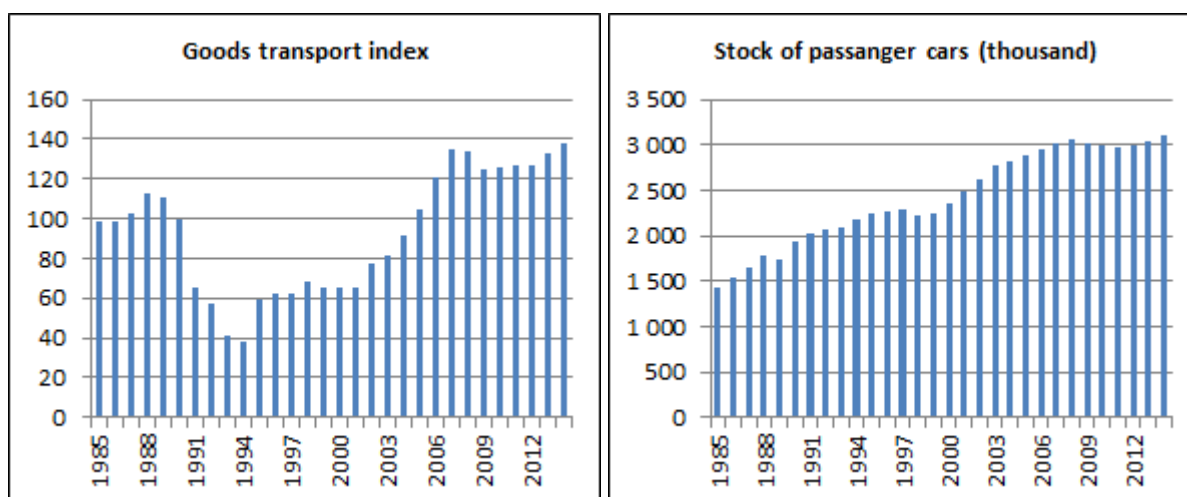


Figure 3.2.15 General changes in the transport sector

Electrification of the railways in Hungary eliminated mostly decreased the solid fuel consumption. (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 79% between the base year and 2014.

Emissions were calculated generally from the national fuel consumption data from the IEA/Eurostat annual questionnaires. However, 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). Fuel consumption data (i.e. both aviation gasoline and jet kerosene) of domestic aviation are taken from the Eurocontrol database that contains data on IFR flights. Some aviation gasoline consumption (for VFR flights) is most probably included under road transport.

Based on information received from the energy statistics provider, natural gas use related to natural gas transport was previously included under distribution losses. Since the last submission, however, a complete time series of emissions from pipeline transport has been included separately.

Figures below illustrate the fuel consumption of the sector:

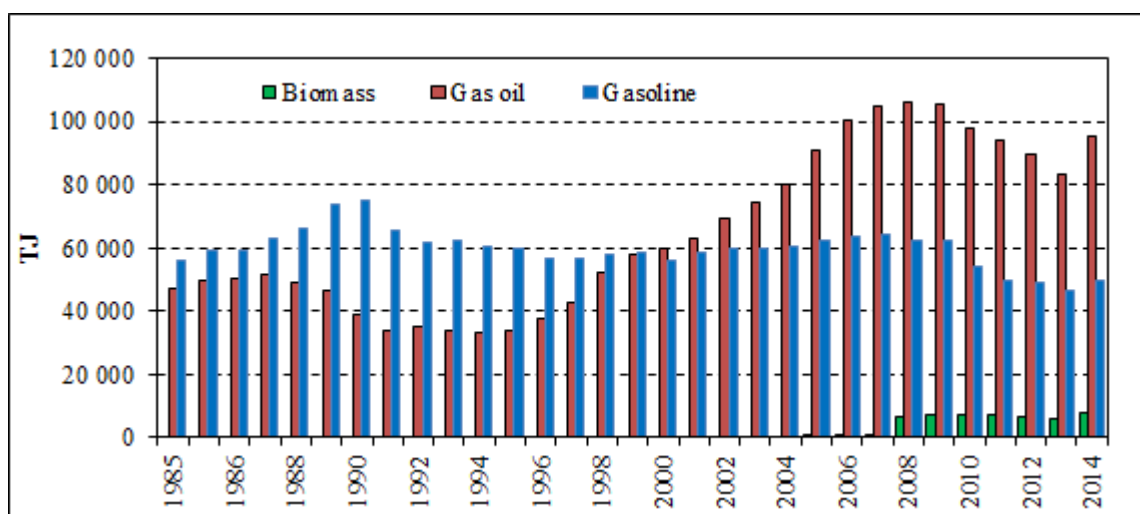


Figure 3.2.16 Gasoline, diesel and biomass consumption in the Transport Sector (1985-2014)

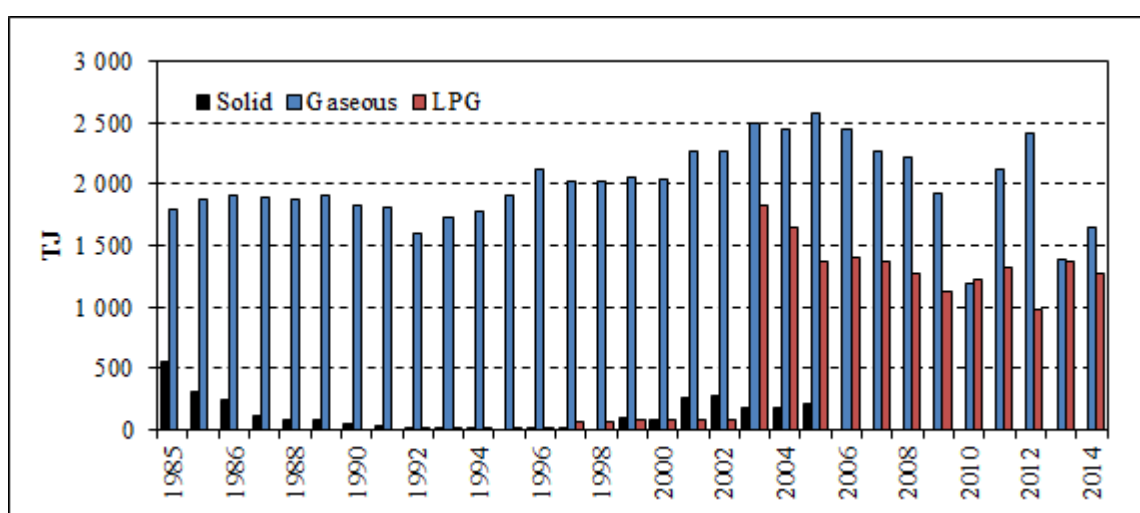


Figure 3.2.17 LPG, natural gas and solid fuel combustion in the Transport Sector (1985-2014)

Figure 3.2.18 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. Both fuel consumption and mileage of vehicles (km/year)

increased until 2009 and started decreasing afterwards. The increasing fuel prices (up to 2012) could also be one of the reasons of a record low gasoline consumption in the transport sector. It is worth mentioning that the mass of domestically transported goods via road transport decreased by 44% between 2008 and 2012. However, the decreasing trend stopped, fuel consumption started to grow again and goods transport increased by 18% since 2012.

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. 3.2.16.

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

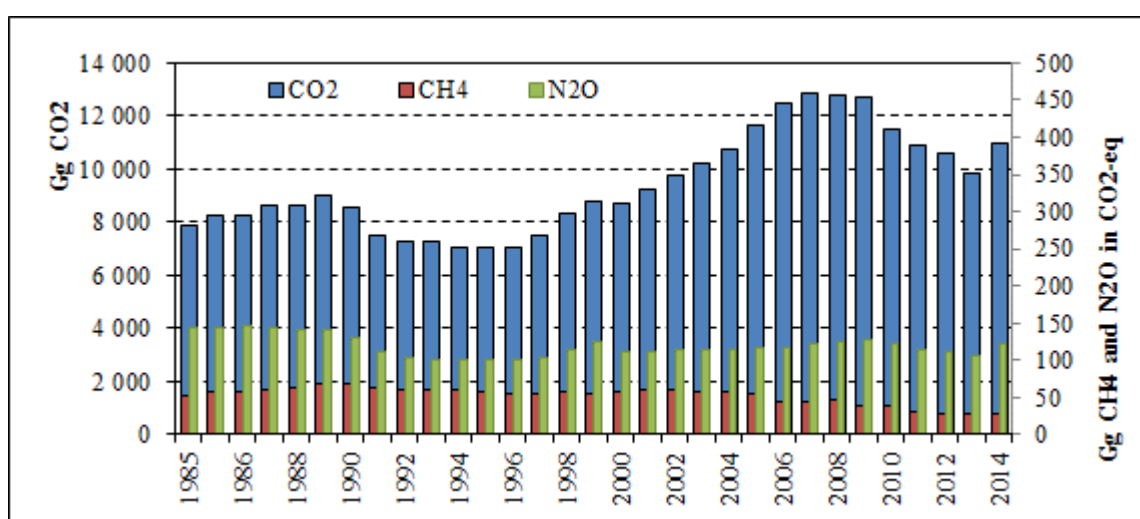


Figure 3.2.18 Trends of CO₂, CH₄ and N₂O emissions in the Transport Sector (1985-2013)

3.2.7.2 Methodological issues

CO₂ emission from transport was previously calculated 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 (see Table 3.2.9). From the 2014 submission, activity data are basically taken from the IEA/Eurostat joint questionnaires with a few modifications.

For non-CO₂ emissions, the COPERT-4 (Computer Programme to Calculate Emission from Road Transport) model, specifically version 11.1, was used consistently for the period 1985-2013, and the latest version (v11.3) for 2014. The transition to the COPERT-4 model for the whole time series was a necessary step in the area of national road transport emission calculations, since most countries use this model, and our previous approach (i.e. using COPERT for the period 2005-2012 and a different method for the preceding years) led to significant inconsistencies in the time series.

The COPERT model requires quite detailed background information. To produce input data for the

model for the whole time series, basically three data sources were used:

1./ The compiler institute received the COPERT input/output data from the Institute for Transport Sciences for the years 2006, 2007, 2009, 2011, 2012, 2013, and 2014. The structure of the input data was produced in a way which fully complies with that described in the software requirement.

Generally, the input data required by COPERT-4 are as follows:

- vehicle stock data
- emission categorization
- mileage data
- traffic situations, average speed values
- fuel used
- country-specific data.

As the above data were not obtained from the same source and were not always suitable for direct use. The largest bulk of work was processing the vehicle stock data, since this data ensures the basis for emission calculations performed by COPERT-4. Thus, with respect to the vehicle stock it was crucial to perform work of the utmost precision, therefore, in the course of the work, the vehicle stock related data of the Central Statistical Office (CSO) were used. At the request of the Institute for Transport Sciences, vehicle data tables required to perform the task were extracted from the CSO database. The vehicle stock classifications and emission categorizations for the year 2014 were prepared with the use of these data tables.

The data on traffic situations, that is, the percentage of runtime distribution within individual road categories by vehicle category, and, within road categories, the average speed values also by vehicle category were included based on emissions defined in the previous years. These earlier data were based on the results of previous research carried out by the Institute for Transport Sciences. The mileage data were specified based on previous emission calculations with the use of the research outcomes of the Institute for Transport Sciences, as well as based on the annual emission calculation for the year 2009 provided by the Ministry of Environment from the extract of the Regular Environmental Audits database, subsequently corrected based on the annual fuel consumption. The source of the "amount of fuel used" data was the official energy statistics.

The country-specific data was taken partly from the Hungarian Meteorological Service (HMS) (average maximum and minimum temperatures by month), partly from the Hungarian fuel standards (Reid vapor pressure RVP).

In case of larger differences between the calculated fuel consumption and the fuel sold statistics, the input mileage data (km/year) were slightly modified.

2./ For all the years in the period 2000-2014 for which no domestic data were provided by the Institute for Transport Sciences, data purchased from Emisia SA, developer of the COPERT model, were used as inputs. As claimed by the data provider, *"the vehicle fleet and activity data provided by EMISIA SA for the compilation of national emission inventories with use of the COPERT model reflect our best knowledge of national situation in each country until 2013. These data have been updated using the road transport dataset and methodology of the TRACCS research project. More specifically, TRACCS dataset of the period 2005-2010 has been combined with the previous FLEETS research project dataset (2000-2005) and with latest official statistics available (2011-2013) to produce aligned and up to date time series for the period 2000-2013 (no projection included). The quality, completeness, and consistency of these two projects datasets, which have been extensively reviewed and cross-checked, ensure that the compiled countries data are also of good quality."*

Again, whenever necessary, the mileage data were slightly modified to reflect better the domestic statistics on fuel sold.

3./ The compiler institute produced input data for the remaining years (i.e. 1985-1999). Quantification

of the stock of each road vehicle type was based on Statistical yearbooks of Hungary and annual reports of Ministry of Economy and Transport about the Hungarian vehicle fleet. Also personal communications with experts took place. 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.

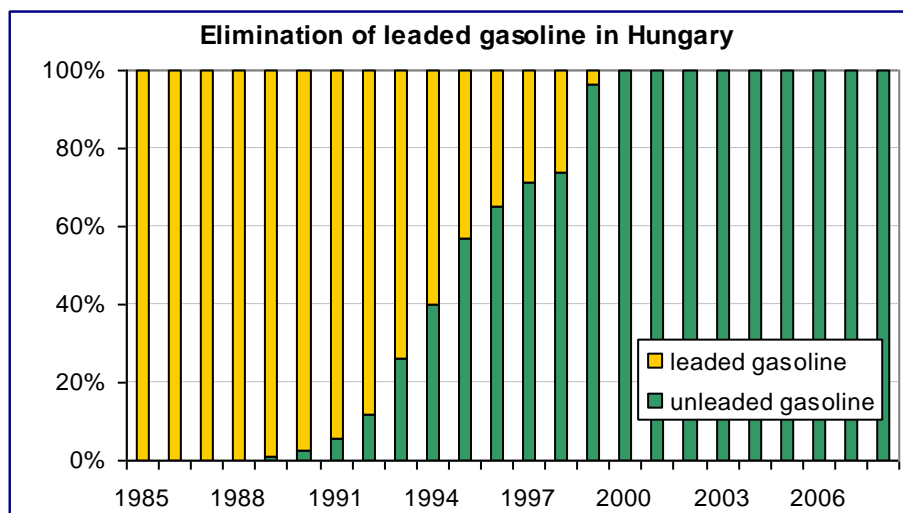


Figure 3.2.19 Elimination of leaded gasoline in Hungary
(Source: Hungarian Petroleum Association (MÁSZ), Annual Reports 1996-2008)

Compared to recent years where about 200 vehicle categories were taken into account, the input database for the earlier part of the time series is less detailed containing 35 vehicle categories, and it probably has a higher uncertainty.

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 were calculated together with road traffic gasoline.

Upon receiving data from Eurocontrol, the above approach was slightly modified. Although there are no scheduled commercial domestic flights in Hungary, Eurocontrol data for the period 2005-2013 suggested that about 0.23 per cent of total jet kerosene and some minimal amount of aviation gasoline is used for domestic flights. Using the same share back to 1985, some kerosene and aviation gasoline use is now allocated to domestic aviation. The resulting CO₂ emission is 2 Gg on average.

The annual total emissions of the national railway were determined as an exhaust gas component based on the data received from the national energy statistics provide, the Hungarian Energy and Public Utility Regulatory Authority which calculated the quantity of the fuel used in the national railway transport. Railway transport emissions are affected by many factors. However, since the currently used method of calculation is based on the fuel consumption of the rail traction, the factors described below do not have a direct influence on the calculation.

The total length of railway lines has not changed in recent years. The number of locomotives dropped only minimally. The total volume of passenger transport in terms of the number of persons transported has decreased since 2001 by about 11 percent. As far as the railways are concerned, although the decrease was a significant one but compared to the total volume changes, the decrease was a little smaller (-10%). However, expressed in passenger kilometers, the decrease was more pronounced (-23%). Considering transport of goods, rail transport is showing some sign of growth, especially domestically.

Table 3.2.7 Interurban passenger transportation (2001–2014)

Year	Total number of transported passengers (in millions)	Of these trains (in millions)	Total passenger-kilometers	Of these trains
2001	755.9	161.7	25,546	10,005
2002	755.9	164.6	26,102	10,531
2003	743.7	159.9	26,418	10,286
2004	737.3	162.7	27,217	10,544
2005	720.1	156.4	26,736	9,880
2006	721.7	156.8	27,733	9,584
2007	682.3	149.8	26,885	8,752
2008	691.1	144.9	25,989	8,293
2009	650.8	142.8	24,881	8,073
2010	652.8	140.5	25,059	7,692
2011	665.9	145.7	25,979	7,806
2012	669.3	147.8	23,285	7,806
2013	671.0	148,5	23,701	7,842
2014	671.9	146.1	25,056	7,738

Table 3.2.8 Domestic freight transport (2001–2014)

Year	Weight of transported goods, thousand tons	Of these, by railway	Freight ton-kilometers in millions	Of these, by railway
2001	152,552	17,824	9,766	1,967
2002	237,732	16,560	13,413	1,788
2003	230,961	14,592	13,224	1,593
2004	228,019	15,217	13,692	1,725
2005	238,233	13,440	14,031	1,645
2006	253,388	12,078	14,928	1,491
2007	237,823	10,834	15,629	1,289
2008	251,666	11,198	15,495	1,374
2009	222,568	12,362	14,448	1,268
2010	190,635	11,398	13,667	1,341
2011	176,031	10,763	12,844	1,169
2012	156,503	11,556	12,411	1,423
2013	158,213	12,461	12,504	1,606
2014	184,218	15,020	13,559	2,049

Emissions from pipeline transport are reported separately since the last submission. The calculations are based on (amended) energy statistical data and default emission factors. The IEA Annual Gas Questionnaire contains fuel consumption data only for the period 2010-2014. Therefore, backward extrapolation was carried out using total natural gas consumption as proxy information.

Emission factors

Carbon dioxide emissions were calculated using country-specific emission factors for gasoline and diesel in road transportation, otherwise default factors were applied as summarized in Table 3.2.9 below.

Table 3.2.9 Some CO₂ emission factors in the Transport Sector

Fuel type	Emission factor (kt CO₂/TJ)	Source of EFs
Gasoline	69.3	2006 IPCC Guidelines
in road transport	73.4	Refinery
Gas/Diesel Oil	74.1	2006 IPCC Guidelines
in road transport	75.3	Refinery
LPG	63.1	2006 IPCC Guidelines
Residual fuel oil	77.4	2006 IPCC Guidelines
Natural Gas	56.1	2006 IPCC Guidelines

It has to be noted that the cited CO₂ 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: that 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 the oxidation factor was changed to the new default value of 1.0.

As discussed above, CH₄ and N₂O emissions were calculated using the COPERT model (COPERT 4, version 11.1 and 11.3) for the whole inventory period for gasoline and diesel. Otherwise, the default IPCC emission factors were applied.

3.2.7.3 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 CO₂ is $\pm 1-5\%$. It should be noted, that in the 2006 IPCC Guidelines the

uncertainty for default methane and nitrous oxide factors is much higher (200-300%).

3.2.7.4 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 CO₂ from gasoline that is representative for gasoline used in Hungary and to revise data accordingly.

3.2.7.5 Source-specific recalculations

No methodological change has occurred. All changes in this subsector were due to changes in activity data as:

- The energy statistics provider made some revisions back to 2010;
- In light of the latest energy statistics, smaller amount of gasoil is now reallocated from road transport to manufacturing industry;
- Updated energy statistics had (a minimal) effect on the extrapolated activity data for pipeline transport;
- EUROCONTROL provided updated data for the period 2005-2013.

The total difference in CO₂ emission is basically negligible for the base year (+14 kt which is less than 0.2%). The changes are a bit higher for 2013 (-79 kt or -0.8%) but are still not significant.

3.2.7.6 Source-specific planned improvements

It is planned using the latest version of the COPERT model for the whole time series.

3.2.8 Other Sectors (CRF sector 1A4)

3.2.8.1 Source category description

Emitted gases: CO₂, CH₄, N₂O

Methods: T1, T2

Emission factors: D, CS

Key sources:

1A4 Other Sectors - Liquid Fuels – CO₂ – L, T;

1A4 Other Sectors - Solid Fuels – CO₂ – L, T;

1A4 Other Sectors - Solid Fuels – CH₄ - T

1A4 Other Sectors - Gaseous Fuels – CO₂ – L, T;

1A4 Other Sectors - Biomass – CH₄ – L

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

Emissions in the Other Sectors:

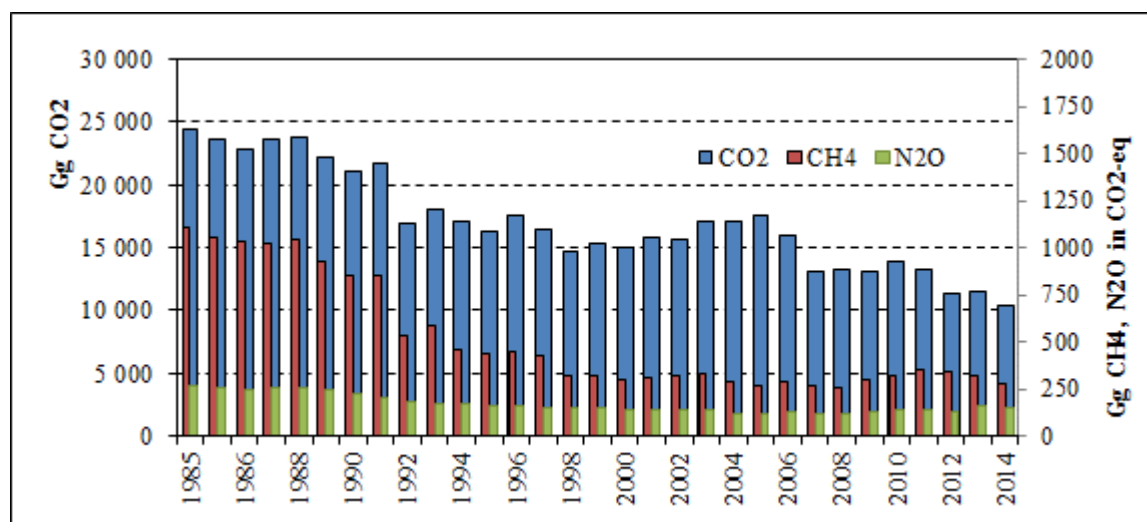


Figure 3.2.20 Trends of CO₂, CH₄ and N₂O emissions in the Other Sector (1985-2013)

3.2.8.2 Methodological issues

Activity data

Activity data was obtained from the IEA/Eurostat questionnaires as described in the introduction section of the chapter. Figure 3.2.21 illustrates the fuel consumption of the sector by fuel types.

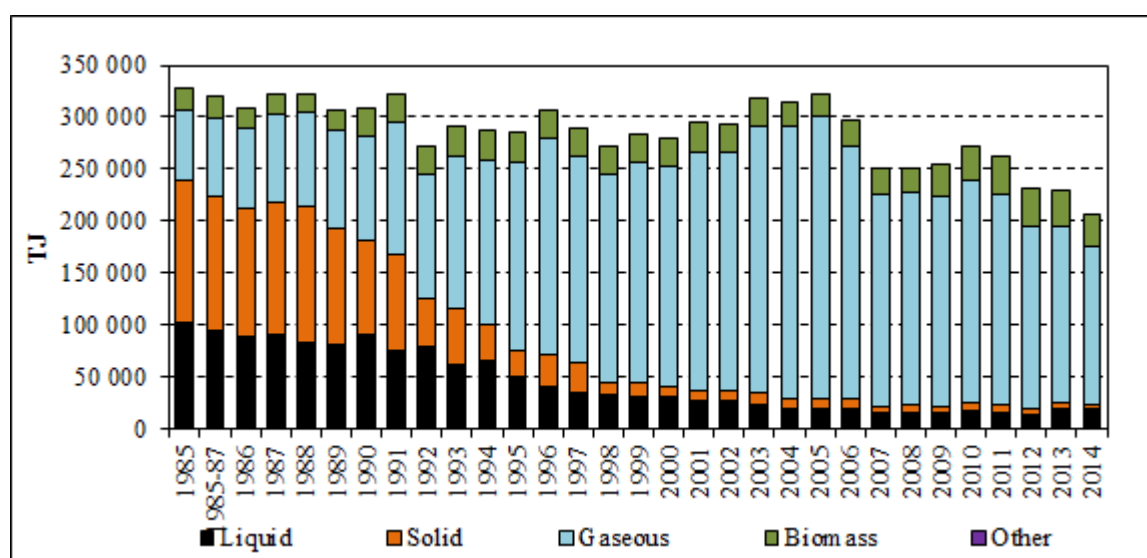


Figure 3.2.21 Share of different combusted fuel types in the Other Sectors (1985-2014)

Since about two third of the fuel consumption is related to the residential category, the fuel structure is influenced principally by changes in this sector (see Fig. 3.2.22.)

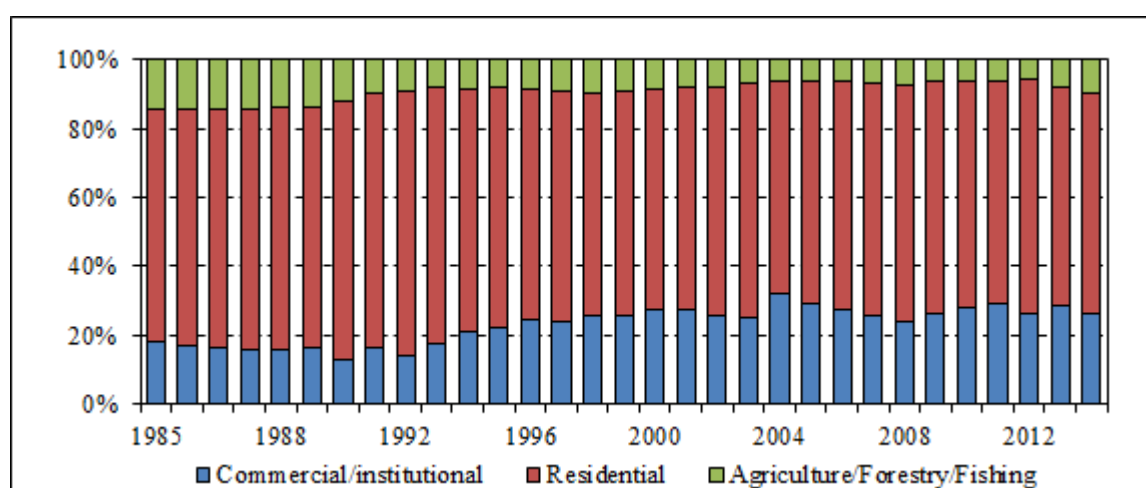


Figure 3.2.22 Fuel combustion in the subsectors of the Other Sector (1985-2014)

Generally, in contrast with the significant reduction of coal and oil consumption, natural gas consumption has increased significantly. The population switched from coal to natural gas combustion. Household heating oil was completely replaced by LPG (see Table 3.2.10).

Table 3.2.10 Oil and LPG consumption in the Commercial/Institutional and Residential Sectors in selected years after 2000

		2000	2005	2008	2009	2010	2011	2012	2013	2014
Commercial/ Institutional	Oil	1246	373	0	0	0	0	493	245	581
	LPG	2209	1,081	799	799	893	752	705	517	564
Residential	Oil	1092	84	0	0	0	0	0	40	40
	LPG	12,079	7802	4418	4465	5640	4371	3290	3525	2538

During the period 1990-2014 natural gas transmission pipelines length had increased from 3544 km to 5783 km. The number of households supplied with natural gas increased in the last decade from 2.8 to 3.4 million but decreased a little to 3.2 million since 2010. Residential consumption represented 39% of total piped gas supply in 2014. 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 598 thousand with hot water. Most of this heat (78%) is generated from natural gas use; however, the resulting emission was not accounted for here but under the Energy industries subsector.

Natural gas consumption can be influenced by several factors. One of these factors might be the weather and the resulting heating demand. 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 3.2.23 illustrates the relationship between residential fuel consumption and HDD. The figure demonstrates that increased fuel use can often be explained by increased HDD values and vice versa.

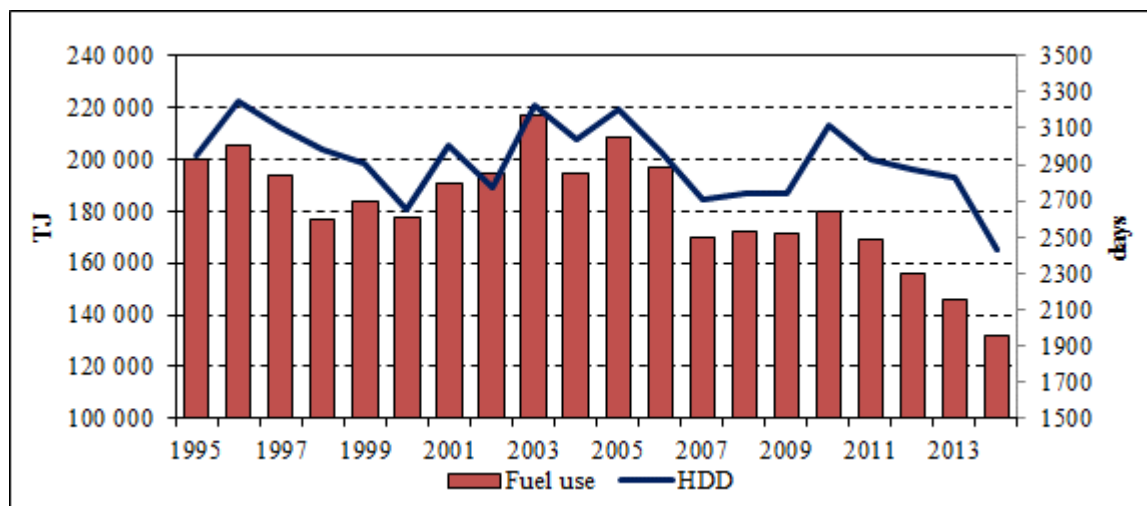


Figure 3.2.23 Comparison of residential fuel consumption and HDD between 1995 and 2014

Another factor is definitely the price. The (nominal) price of pipelined gas increased from 325 to 1360 Ft/10 m³ between 2000 and 2012. This price increase might have led to increased biomass use as a substitute fuel in the residential sector. However, the above-mentioned trends have changed in recent years. Gas prices have dropped by 24% since 2012 (but are still more than double as high as in 2005). Biomass consumption has also decreased in the same period by 15% (but this decrease was probably due to favorable weather conditions).

All in all, the monthly average natural gas consumption of a household user decreased from 125.4 m³ in 2003 to 69.5 m³ in 2014. In this significant decreasing trend - beside the higher energy prices – most probably also the more energy-conscious approach of the population plays a role and is definitely greatly affected by the weather.

In the Agriculture category the significant growth in biogas use might deserve our attention as its share within biomass can be as high as 30 per cent.

In order to report separate emissions for the source category “Agriculture/Forestry/Fishing: Off-road vehicles and other machinery”, diesel oil consumption had to be split between stationary and mobile combustion. The Energy Statistical Yearbooks published around 1990 contained separate data for

gasoil used in tractors and harvesters. Based on this information, a bit more than 60% could be allocated to mobile consumption in the early period of the time series. Considering the generally diminishing role of liquid fuels in stationary combustion, it is assumed that after 2001 all gasoil allocated to agriculture in the energy statistics has been used for mobile off-road machinery.

Emission factors

Default emission factors for CO₂ 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 (almost) 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 CO₂ is very low.

For non-CO₂ emissions, default emission factors were applied.

3.2.8.3 Uncertainties and time-series consistency

We assume that the uncertainty of the fuel consumption data, especially biomass, in 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 ± 5 -20%.

The estimated specific uncertainty for CO₂ is 2-7%. The uncertainty of the methane factor is significantly higher (50-150%), while that of N₂O may be of an order of magnitude.

3.2.8.4 Source-specific QA/QC and verification

Comparing residential coal consumption data in the Hungarian Energy Statistical Yearbook and the IEA/Eurostat statistics, a 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.

3.2.8.5 Source-specific recalculations

No methodological change took place. However, the latest IEA/Eurostat annual questionnaires were used for this submission therefore all updates in the energy statistics were taken into account. In addition, as regards industrial waste incineration double counting was detected with the category 5C Incineration and Open Burning of Waste therefore the corresponding emissions were removed from 1A4a for the years 2012-2013.

All values for the base year remained the same, whereas CO₂ emissions increased by 152.6 kt (+1.3%) in 2013.

3.2.8.6 Source-specific planned improvements

None.

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

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

3.3.1.1 Source category description

Emitted gas: CH₄, CO₂

Category *1B1a* includes fugitive CH₄ 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.

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.

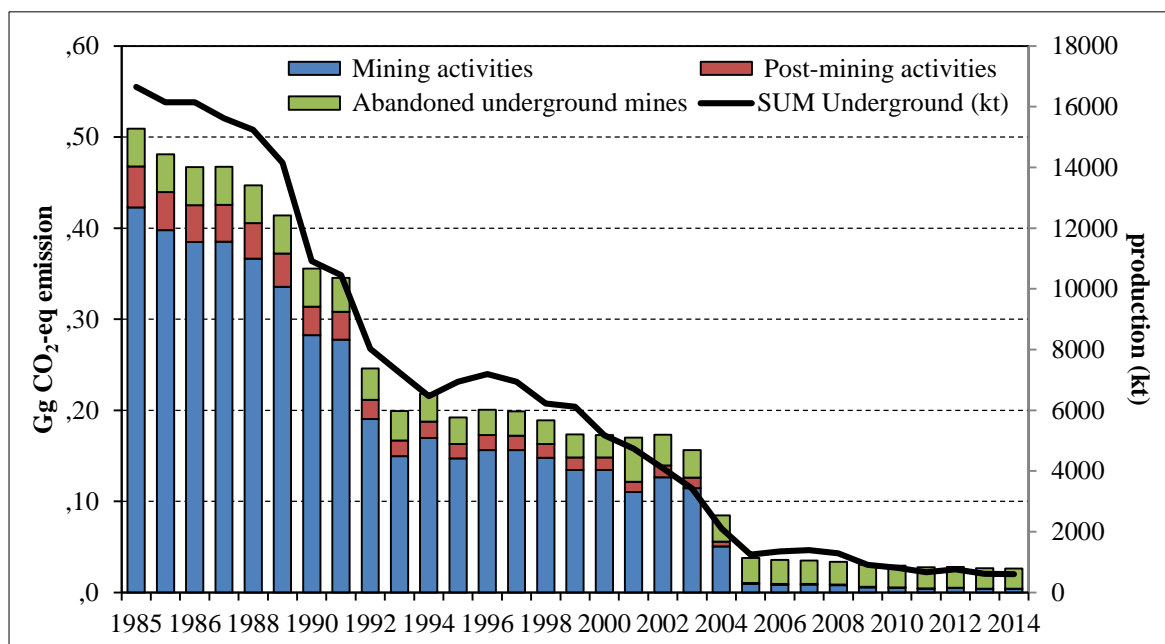


Figure 3.3.1 Trend of emissions from solid fuels and underground production of coal

Please note, that “old” coal classification of Hungary used before 2015 inventory submission has been changed into the coal classification used by IPCC and IEA in present submission. So, all the coal mined in Hungary is classified now as lignite (except for very small amounts of sub-bituminous and

coking coal in years 1990-1991).

3.3.1.2 Methodological issues

Activity data

Production data were taken from the IEA Coal statistics, where both coal types and underground and surface productions are distinguished. Due to IEA Coal classification, all the coal mined in Hungary is classified as Lignite, (except for very small amounts of sub-bituminous and coking coal in the years 1990-91). Mine and coal basin level data are received from the Mining Bureau of Hungary.

Table 3.3.1 *Underground and surface coal production in Hungary*

Year	SUM Production (kt)	SUM Surface production (kt)	SUM Underground production (kt)	out of which: Mecsek basin production (kt)
1985	24042	7387	16655	2639
1985-87	23338	7198	16141	2441
1986	23129	6983	16146	2325
1987	22844	7223	15621	2360
1988	20875	5634	15241	2255
1989	20030	5883	14147	2127
1990	17830	6919	10911	1819
1991	17135	6680	10455	1760
1992	15844	7815	8029	1210
1993	14832	7588	7244	950
1994	14084	7622	6462	1030
1995	14772	7834	6938	856
1996	15259	8067	7192	882
1997	15764	8828	6936	854
1998	14668	8445	6223	813
1999	14547	8425	6122	716
2000	14033	8848	5185	753
2001	13914	9174	4740	573
2002	13027	8929	4098	726
2003	13301	9871	3430	667
2004	11242	9135	2107	259
2005	9570	8321	1249	0
2006	9952	8601	1351	0
2007	9818	8421	1397	0
2008	9404	8118	1286	0
2009	8986	8078	908	0

Year	SUM Production (kt)	SUM Surface production (kt)	SUM Underground production (kt)	out of which: Mecsek basin production (kt)
2010	9113	8301	812	0
2011	9555	8890	665	0
2012	9290	8527	763	0
2013	9558	8941	617	0
2014	9551	8950	601	0.011*

* Surface production in Mecsek basin

Emission factors

Table 3.2.2 shows the measured methane content of coal for the mines operating since 1985 in Hungary together with the emission factors applied and defaults of the 2006 IPCC Guidelines. Data on in-situ methane content of mines in Hungary 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. 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 m³ methane/ t coal value. Based on the above mentioned references, two different emission factors are applied for underground mines - the same as in case of previous inventory submissions. One is applied for coals from Mecsek coal basin and the other for all other underground production. The former is within the range of default average emission factor from 2006 IPCC Guidelines, the latter is well below but the difference might be explained by country specific properties.

Table 3.3.2 In-situ CH₄ content in Hungarian mines, the emission factors used and default emission factors from 2006 IPCC Guidelines

Coal basin	Mine	In-situ CH ₄ content (m ³ /t)	
		mine-specific value	average in basin
Mecsek coal basin	Pécsbánya – Karolina	18.26	19.5
	Vasas – Észak	20.75	
Other underground coal mines	Balinka	1.29	1.00
	Lencsehegy	0.00	
	Mány I/a	0.98	
	Márkushegy*	0.93*	
	Bükkábrány	0.00	
Surface coal mines	Visonta	0.00	0.00
defaults from 2006 IPCC Guidelines	Low	10	
	Average	18	

*single underground coal mine still working in Hungary

Generally no emissions occur in Hungary in case of surface mining based on the above mentioned references. The reason is that the mined Hungarian lignite is relatively young in the coalification (NCV is under 10 MJ/kg). At the end of 2014 an old surface mine in the Mecsek basin was re-opened with relative high (20.75 m³ CH₄/t coal) in-situ methane content, but the amount of mined coal was almost negligible, however emission was reported together with emissions from underground mines.

Please note that the implied emission factor is changing because the activity data in CRF is the SUM coal produced underground while the emissions are mainly related to the production in Mecsek basin where also some recovery activity occurred. Between 2005 and 2013 there is only one operating underground mine, so implied emission factor ($0.623+0.0623=0.68541$ please see above) becomes steady.

Recovery

In 1.B.1.a Underground coal mining category, CO₂ emissions are reported from CH₄ recovery for the years 1985-1996. In this case CO₂ emissions are not direct emissions, but it is calculated from the amount of recovered CH₄ (CH₄ burned for energy use) as follows:

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

$$(\text{M}_{\text{CO}_2} = 44 \text{ g/mol}; \text{M}_{\text{CH}_4} = 16 \text{ g/mol})$$

The yearly amount of recovered CH₄ 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).

Post-mining

For post-mining activities the same activity data and 10% of the mining emission factor is used the same as in the case of previous inventory submissions, which is in line with the suggestion for mines using pre-drainage of 2006 IPCC Guidelines chapter 4.1.3.2.

Abandoned underground mines

It is very hard to collect detailed data on activities performed more than 50 years before that is required by the method of 2006 IPCC Guidelines, so several assumptions are applied. Chapter 4.1.5.2 of the guidelines states that "Abandoned mines that were considered non-gassy when they were actively mined are presumed to have negligible emissions" and no emissions are to be reported from flooded mines.

So, emissions from this subsector are not significant in Hungary as coal mines are anyway "non-gassy" (please see Table 3.2.2 above) except for Mecsek basin. In addition abandoned mines are usually flooded with water in Hungary.

Based on a study of the Hungarian Geological Service (please see References) there are 104 coal mines closed in Hungary. However most of them are flooded with water and had not been gassy, except for the Mecsek basin, so this number is extrapolated using coal production data in Mecsek basin (see Table 3.2.1 above) as surrogate data.

Table 3.3.3 Activity data used in 1B1a – Abandoned coal mines

	Mines closed	<i>out of which gassy and unflooded (extrapolated data)</i>
SUM	104	8
2001-	8	1
1976-2000	34	3
1951-1975	31	2
1926-1950	16	1
1901-1925	16	1

Numbers in blue are estimated values.

3.3.1.3 Set of Tier 1 emission factors from 2006 IPCC Guidelines Table 4.1.6 and Equation 4.1.11 is used for the calculation of emissions. Uncertainties and time-series consistency

Uncertainty of activity data is estimated based on chapter 4.1.3.6 of 2006 IPCC Guidelines. Consistency with the value used as uncertainty of activity data in other subsectors in *Energy* is also taken into account where usually also IEA Energy Statistics are applied as activity data.

Unfortunately no uncertainty is provided for measurement data used for emission factors applied in mining subsector and Tier 1 approach is used in post-mining and abandoned coal mined subsectors. So, the uncertainty of emission factor in *IB1* is estimated to be „factor of 2” based on Table 4.1.2 of 2006 IPCC Guidelines.

	AD	EF	Combined
1B1 Solid fuels (uncertainty +/-%)	5.00	200	200.06

3.3.1.4 Source-specific QA/QC and verification

General QA/QC procedures apply.

Activity data is compared with old time-series used in previous inventory submissions (data from the Mining Bureau of Hungary) and the differences are cc.1%.

Country specific emission factors are compared to defaults of 2006 IPCC Guidelines as it is presented in Table 3.2.2 above.

3.3.1.5 Source-specific recalculations

None.

3.3.1.6 Source-specific planned improvements

Since we have not enough information about all abandoned mines back to 1901, default method with default emissions are presented for the entire time-series as first guess. It is planned to revise these methane emissions, because this calculation cannot take account of national features. In recent years after the closure of all underground mines in several coal basin the mine drainage is not pumped anymore that induces the water-table rise and the mine flooding, Research from 2003 (Nyers, 2003) prognosticates that all mines in Mecsek basin will be flooded in 2014.

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: CO₂, CH₄, N₂O

In *IB2* category fugitive emissions arising during exploration, production, processing, transmission and distribution and storage of oil (*IB2a*) and natural gas (*IB2b*) are reported and in a separate subcategory also GHG emissions from Venting and Flaring activities connected to the operations mentioned before (*IB2c*). In subcategory *IB2d - Other* Hungary reports fugitive CH₄ emitted during extraction of thermal water and gas and fugitive CO₂ from mining of natural CO₂ occurrence.

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. However in recent years, the increase of natural gas consumption has also been stopped.

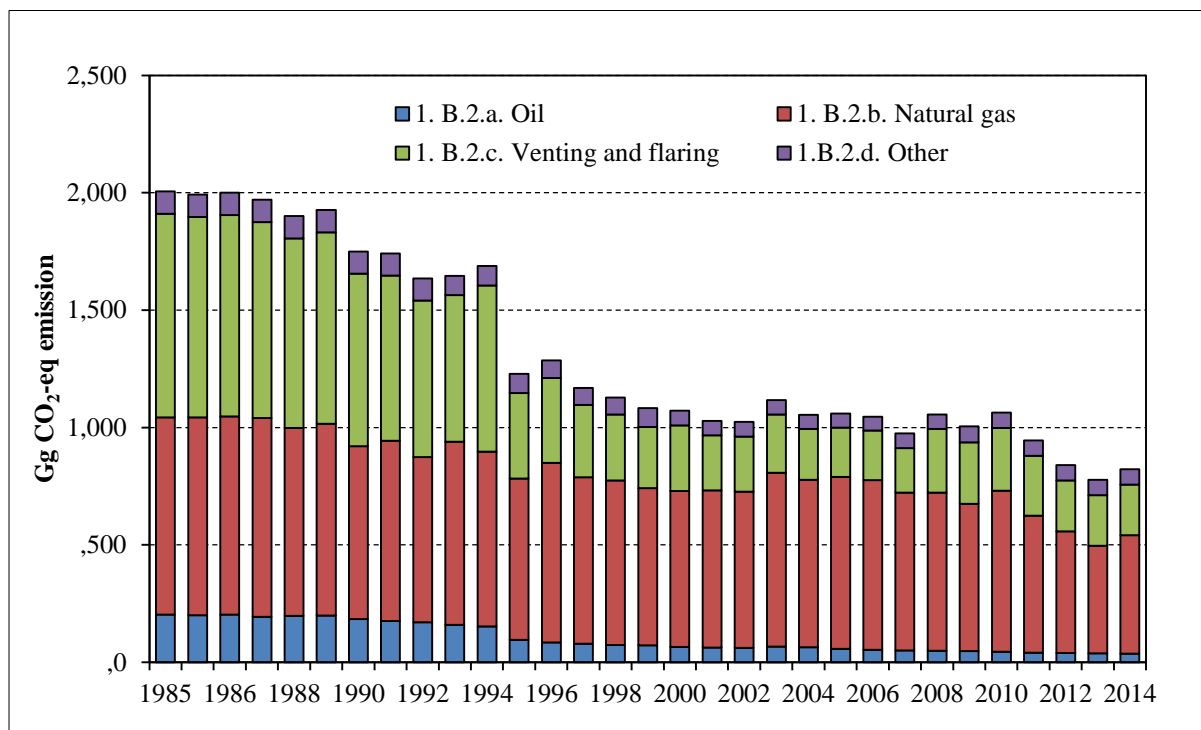


Figure 3.3.2 Trends of emissions in CO₂-eq from 1.B.2 by subsector (Gg CO₂-eq emissions)

The reason of significant interannual change between 1994 and 1995 is explained in the chapter on emission factors below.

3.3.2.2 Methodological issues

Activity data

Activity data is taken from IEA Energy Statistics. Data that is not included in IEA Energy Statistics has been provided by individual companies. In Hungary the number of companies present in oil and gas sector is very limited, so the coverage might be assured. In subsector 1.B.2.c.i - Oil Flaring, plant specific (EU ETS) data is also used, as very detailed verified data is available on flaring in oil refineries.

Emission factors

Default emission factors from 2006 IPCC Guidelines are applied. Chapter 4.2.2.3 of Vol2 contains one set of emission factors (Table 4.2.4) for “Developed Countries” and another Table (Table 4.2.5) for “Developing Countries And Countries With Economies In Transition”.

However Hungary was regarded as a country with economy in transition in the beginning of the 1990's, the economy underwent significant changes since then. Hungary is now part of the European

Union, and there is a great change regarding the application of state-of-the-art technologies and environmental investments as well.

So, in order to reflect more the real trend, emission factors from Table 4.2.5 have been applied for the years 1985-1994 and emission factors from Table 4.2.4 have been applied from the year 1995.

EU ETS data in 1.B.2.c.i – Oil Refinery Flaring

CO₂ emissions from oil refineries of Hungary are taken from EU ETS annual emission reports and oil refinery flaring data is 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.

1.B.2.d Other Fugitive emissions

Within this subsector fugitive CH₄ from groundwater extraction and fugitive CO₂ emissions from CO₂ mining is reported. No method is available in 2006 IPCC Guidelines for these activities, so country specific data has to be applied.

In the case of groundwater extraction, Geological and Geophysical Institute of Hungary provided expert estimate for the first time in 2015 based on 278/2015 Govt.Decree on data provision of Inventory preparation. This Institute is responsible for the monitoring, authorization and research of underground waters. They provided two set of data for the years 2004-2006 and noted that one method probably underestimates CH₄ emissions, while the other overestimates them.

So, the average of the two datasets has been applied and data have been extrapolated using Annual Groundwater extraction data from EuroStat (available at: <http://ec.europa.eu/eurostat/web/environment/water/database>) as surrogate data.

In the case of CO₂ mining, activity data (million m³ CO₂ mined/year) is available from the Hungarian Office for Mining and Geology (MBFH) from 1987. For the years 1985 and 1986 the data from 1987 is applied as extrapolation. Due to lack of emission factor, the EFs for fugitive emissions from natural gas production (extraction) from Table 4.2.4 (from 1995) and 4.2.5 (between 1985 and 1994 as described above) have been applied.

3.3.2.3 Uncertainties and time-series consistency

Uncertainty values from Table 4.2.4 have been aggregated using error propagation rule for the determination of emission factor uncertainty. For the uncertainty of AD the same value is included as in other parts of the inventory for IEA Energy Statistics.

	AD	EF	Combined
1B2aOil – CH ₄	5.00	83	83.32
1B2aOil – CO ₂	5.00	44	44.43
1B2b Natural Gas – CH ₄	5.00	282	281.97
1B2b Natural Gas – CO ₂	5.00	296	296.18
1B2c Venting and flaring – CH ₄	5.00	56	56.15
1B2c Venting and flaring – CO ₂	5.00	529	528.69
1B2c Venting and flaring – N ₂ O	5.00	567	566.72
1B2d Other - CH ₄	5.00	200	200.06
1B2d Other - CO ₂	5.00	200	200.06

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

. Some activity data were revised by IEA last year in case of oil, so fugitive emissions were recalculated in the following sectors and years:

- 1.B.2.a.3 Transport; 2010-2013
- 1.B.2.a.4 Refining / Storage; 2012-2013

CO₂ emissions from oil refineries of Hungary are taken from EU ETS annual emission reports and oil refinery flaring data is extrapolated for the years before 2005 using the amount of “Refinery intake” as surrogate data.

3.3.2.6 Source-specific planned improvements

Informal review organised by the EU in November 2015 suggested improvements as follows:

Two type of default emission factors are used to calculate fugitive emissions from oil and gas, namely the set of emission factors for “Developed Countries” (lower) and another for “Developing Countries And Countries With Economies In Transition” (higher). However Hungary was regarded as a country with economy in transition in the beginning of the 1990’s, the economy underwent significant changes since then. Hungary is now part of the European Union, and there is a great change regarding the application of state-of-the-art technologies and environmental investments as well. So, higher emission factors have been applied for the years 1985-1994 and lower from the year 1995, which causes significant jump in emissions. It was highly recommend to further investigate how to generate smooth transition between the two kind of emission factors considering the application’s year of new technologies in each category.

3.4 CO₂ transport and storage (CRF 1.C)

Not applicable.

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Available online: <http://www.ombkenet.hu/index.php/bkl-banyaszat?id=92>

4. INDUSTRIAL PROCESSES (CRF sector 2.)

Major changes compared to previous submission:

- 2A3 Glass - Recalculation due to the inclusion of +10% CO₂ emission covering the potential glass manufacturers not included in EU ETS as recommended by the informal review organized by the EU in November 2015.
- 2A4d Waste gas scrubbing - During the informal review organized by the EU in November 2015, it was noted that an installation is also included where there the waste gas scrubbing technology do not result CO₂ emissions. The data of this installation is now eliminated and time-series are therefore recalculated.
- 2D1-2 Lubricants and Paraffin wax use - Activity data of the year 2013 has been changed in the case of use of Lubricants as it was recommended by the informal review organized by the EU in November 2015.
- 2D3 Other – Indirect CO₂ emissions from solvent and other product uses – Activity data and emissions are reported again as it was recommended by the informal review organized by the EU in November 2015.
- 2F1 RACHP - The sum of emissions did not change, but the division of emissions within the 6 subsectors have slightly been changed as it was recommended by the informal review organized by the EU in November 2015. In MAC subsector solely HFC-134a is now reported and other HFCs are allocated into other subsectors within 2F1.
- 2F3 Fire - A mistype error has been corrected affecting solely year 2012 and 2013 that caused less than 1 Gg increase of emissions.
- 2F4 – Emissions are not changed but rows “filled into new products” within 2F4 sector have also been filled in within CRF as it was recommended by the informal review organized by the EU in November 2015.

4.1 Overview of sector

Industrial Processes sector includes emissions generated by non-combustion processes related to industrial production. Emissions from the industrial processes are the third largest following the energy and agriculture sectors (see 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.),
- Non-energy Products from Fuels and Solvent use (CRF 2.D.),
- Electronics Industry (2.E),
- Consumption of Halocarbons and SF₆ (CRF 2.F.) and
- Other Product Manufacture and Use (CRF 2.G).

Under Mineral Products Hungary reports the emissions from cement production (CO₂), lime production (CO₂), limestone glass (CO₂), and other mineral products including bricks and ceramics production, mineral wool production, waste gas scrubbing and soda ash use (CO₂).

Under Chemical Industry emissions from ammonia (CO₂), nitric acid (N₂O), and Petrochemical and Carbon Black Production (CO₂, CH₄).

Under Metal Industry emissions from pig iron (CO₂, CH₄), steel (CO₂, CH₄) ferroalloys (CO₂), aluminium (CO₂, CF₄, C₂F₆) are taken into account. Consumption of halocarbons and SF₆ means

emissions from different source, for example: refrigeration, air conditioning equipment, foam blowing, aerosols, electrical equipment. The 2.G sector contains emissions from manufacturing and use of electrical equipment and SF₆ and N₂O use in other products (SF₆ and N₂O).

Indirect GHGs are reported in an aggregated way, but the time-series are fully consistent with CLRTAP Air Pollutants Emission Inventory reporting of Hungary.

The base year is the average of 1985–1987 for CO₂, CH₄ and N₂O, and 1995 for HFCs, PFCs and SF₆. *Figure 4.1.1* shows the main sources of greenhouse gas emissions in the base year and in 2014.

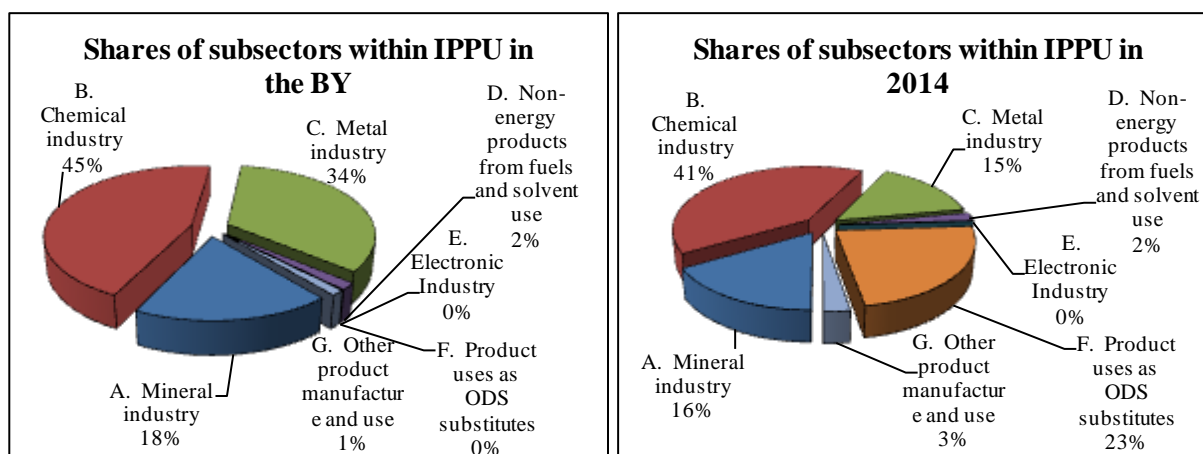


Figure 4.1.1 Shares of subsectors within Industrial sector (Gg, CO₂-eq)

Several subsectors within Industrial Processes sector consist of emission originating from industrial facilities that are also falling under the scope of European Union Emission Trading System (EU ETS) - Directive 2003/87/EC. 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. 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.4 *Other mineral (Glass and Bricks and ceramics)* and partly in 2.B and 2.C.1 sectors. Consistency is ensured by the fact that before including extrapolation, the implied emission factor is always analyzed and depending on the trend either the IEF of the last year, or the average implied emission factor of the years is applied.

In the case of indirect greenhouse gases, consistency with CLRTAP/NEC reporting has been reached since 2014 submission. The calculation method of the indirect GHG and SO₂ 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/2015_submissions/

QC of completeness and allocation of CO₂ from Non-Energy Uses and other fuels used in IPPU sector

Please find below *Figure 4.1.2* based on Table 1.3 in Volume 3 of the 2006 IPCC Guidelines recommended for check of completeness of non-energy use (NEU) of fuels filled in for year 2014.

Verification of Completeness of Reported CO₂ from Non-Energy Use of Fossil Fuels

This spreadsheet contains the full table presented as Table 1.3 in Volume 3.																		
For guidance on how to use this table, consult Volume 3, Chapter 1, Section 1.4.3.1.																		
In the tabular part, bolded boxes mark the main fuels as feedstock or reductant for the processes at the left hand side. Regular boxes mark other known feedstock/reductant for the processes at the left hand side.																		
NOTES					Solids			Liquids							Gas			
	Year: 2014			Unit	Coke	(CO gas) b)	Total solids	Naphtha	Gas oil	LPG b)	Other	Lubricants	Waxes	Bitumen	Total liquids	Nat Gas	Total gas	
1	A: Declared NEU (from commodity balance)			TJ	14407.2	598.723		36666	252	11374	5671.85	2228.8	751.8	6561.5		23257.65		
2	B: Carbon Content			kg C/GJ	29.2	12.1		20	20.2	17.2	20	20.00	20.00	22.00		15.3		
3	C: Total supplied for feedstock/non-energy			[C = A * B / 1000]	Gg C	420.691	7.2445483	427.935285	733.32	5.0904	195.63	113.437	44.58	15.04	144.35	1251.44607	355.8421	355.8421
4	D: Total supplied for feedstock/non-energy			[D = C * 44/12]	Gg CO ₂ -eq.	1542.53	26.5633438	1569.09605	2688.84	18.665	717.32	415.936	163.44533	55.132	529.3	4588.6356	1304.754	1304.754
5	E: Implied carbon fraction oxidised			[E = F / D * 100]	%	1.005	1.00075131	1.00492618				0.2	0.2		0.2652187	0.99997	0.99997	
		Activity a)	CO ₂	IEF														
		Emissions a)																
6	F: Total fossil IPPU CO ₂ reported			Gg CO ₂	1550.24	26.5833012	1576.82569					32.689067	11.026		1216.99197	1304.715	1304.715	
2 INDUSTRIAL PROCESSES																		
7	2A: Mineral Industry			Gg CO ₂														
	(Please specify the subcategory.)			Gg CO ₂														
7	2B: Chemical Industry			Gg CO ₂											1173.2765	1251.072	1251.072	
	2B1: Ammonia Production			Gg CO ₂												1157.694	1157.694	
	2B5: Carbide Production			Gg CO ₂														
	2B6: Titanium Dioxide Production			Gg CO ₂														
	2B8: Petrochemical and Carbon Black Production			Gg CO ₂											1173.2765	93.37768	93.37768	
	2B8a: Methanol			Gg CO ₂														
	2B8b: Ethylene			Gg CO ₂														
	2B8f: Carbon Black			Gg CO ₂														
	2B10: Other			Gg CO ₂														
7	2C: Metal Industry			Gg CO ₂	1550.24	26.5833012	1576.82569									53.64309	53.64309	
	2C1: Iron and Steel Production			Gg CO ₂	1550.24	26.5833012	1576.82569									53.64309	53.64309	
	2C2: Ferroalloys Production			Gg CO ₂														
	2C3: Aluminium Production			Gg CO ₂														
	2C5: Lead Production			Gg CO ₂														
	2C6: Zinc Production			Gg CO ₂														
	2C7: Other			Gg CO ₂														
7	2D: Non-Energy Products from Fuels and Solvent Use			Gg CO ₂								32.689067	11.026		43.7154667			
	2D1: Lubricant Use			Gg CO ₂								32.689067			32.6890667			
	2D2: Paraffin Wax Use			Gg CO ₂									11.026		11.0264			
	2D3: Solvent Use			Gg CO ₂														
	2D4: Other			Gg CO ₂														
7	2H: Other			Gg CO ₂														
	2H1: Pulp and Paper Industry			Gg CO ₂														
	2H2: Food and Beverages Industry			Gg CO ₂														
	2F3: Other			Gg CO ₂														
EXCEPTIONS REPORTED ELSEWHERE																		
7	1A FUEL COMBUSTION ACTIVITIES			Gg CO ₂														
	1A1a: Main Activity Electricity and Heat Production			Gg CO ₂														
	1A1b: Petroleum Refining			Gg CO ₂														
	1A1c: Manufacture of Solid Fuels and Other Energy Industries			Gg CO ₂														
	1A2: Manufacturing Industries and Construction			Gg CO ₂														

Figure 4.1.2 Non-energy use of fuels in 2014

Notes to Figure 4.1.2:

Solids: Coke is not considered as NEU but the amount reported in IPPU sector is included here.

The "Implied carbon fraction oxidised" of 1.005 for coke might be explained by the differences between default factors (used by calculation of rows A to D) and the plant specific data reported in the inventory (and included in row F within the table).

Liquids: The "Implied carbon fraction oxidised" of total liquids (0.265) seems to be satisfactory, as in this case significant amount of carbon is stored in petrochemical products.

The weighed (by production volume) average of default carbon contents (carbon stored) of petrochemical products occurring in Hungary is 0.73 for year 2014. (Calculated from default carbon content of products included in Table 3.10 of Vol 3: ethylene: 0.856; VCM: 0.384; carbon black: 0.970).

So, the fraction of carbon stored (0.73) and the "Implied carbon fraction oxidised" (0.3) results near 1. The difference might be explained by the differences between default factors (used by calculation of rows A to D) and the plant specific data reported in the inventory (and included in row F within the table). In addition lubricants and paraffin wax use are not taken into consideration by this comparison.

"Implied carbon fraction oxidised" of 0.2 by lubricants and paraffin wax use is the default value.

4.2 Emission Trends

Total emissions estimated from industrial processes were 6129 kt CO₂-eq in 2014, or 11% of the total national emissions compared to 14% in the base year. Total sectoral emissions decreased by -60 % between the base year and 2014, and increased by 7% between 2013 and 2014.

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 34% between 2005 and 2014. There was a slight growth in year 2010 and 2011, but GHG emissions from industrial processes sector were again lower both in 2012 than in 2013. In 2014 emissions increased again by 7% due to higher production volumes in several subsectors.

Figure 4.2.1 shows the trend of GHG emissions from industrial processes by subcategories from the base year to 2014. The application of 2006 IPCC Guidelines has changed the ranking and proportion of the subsectors within industrial processes compared to the submissions of years before.

Chemical industry was the most important emitter in the beginning of inventory period, especially N₂O emission from nitric acid production (for details see chapter 4.4). Between 1990 and 2005 *Chemical industry*, *Mineral industry* and *Metal production* were fluctuating around the same level. After the significant fall of emission in *Chemical Industry* thanks to the N₂O 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 SF₆* has also stopped in 2008.

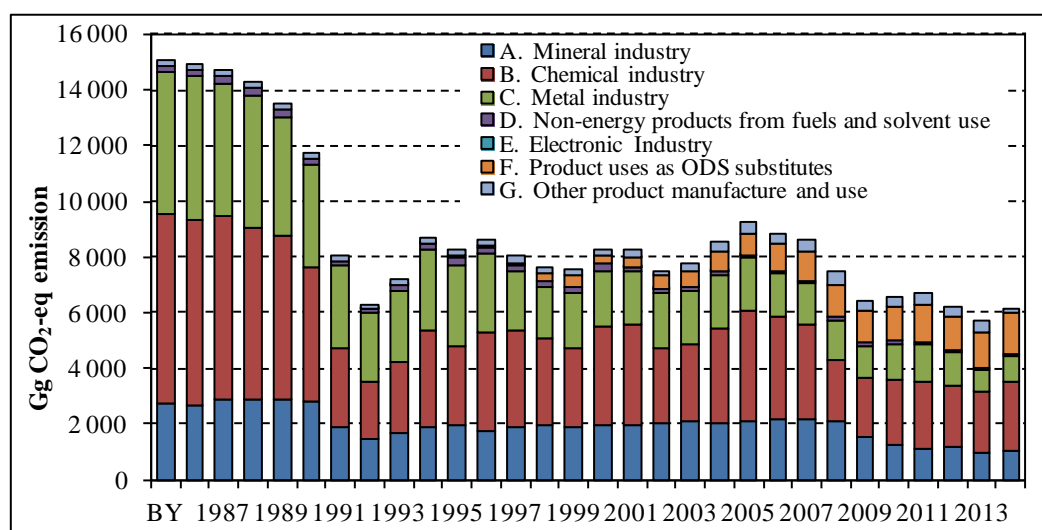


Figure 4.2.1 GHG emissions from Industry sector by subsectors (Gg CO₂-eq)

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

Some examples:

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

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

One of the reasons of temporary production decrease was the modernization process of the remaining factories which was carried out that time and which by the way lead to favourable changes of specific emission factors as well. This was the situation e.g. in the cement and limestone industry. In some cases, however, also plants having more advantageous emission factors were closed, causing unfavourable 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 behaviour 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 72% to total GHG emissions in this sector in 2014, followed by hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆) contributing 24% to GHG emissions CH₄ and N₂O contributed 0.8% and 2%, respectively (*Figure 4.2.2*). Total sectoral emissions decreased by 60% between base year and 2014.

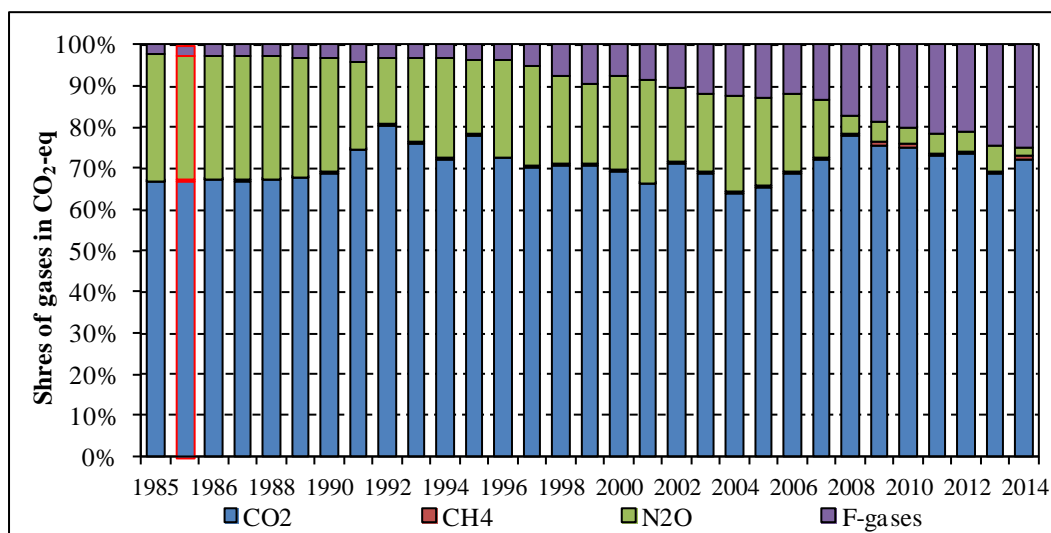


Figure 4.2.2 Shares of gases in Industry sector (Gg CO₂-eq)

(BY: average of 1985-87 but 1995 for F-gases - data in red frame)

The figure below (*Figure 4.2.3*) shows the emissions of this sector by gases. It can be seen that in 2008, N₂O 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.

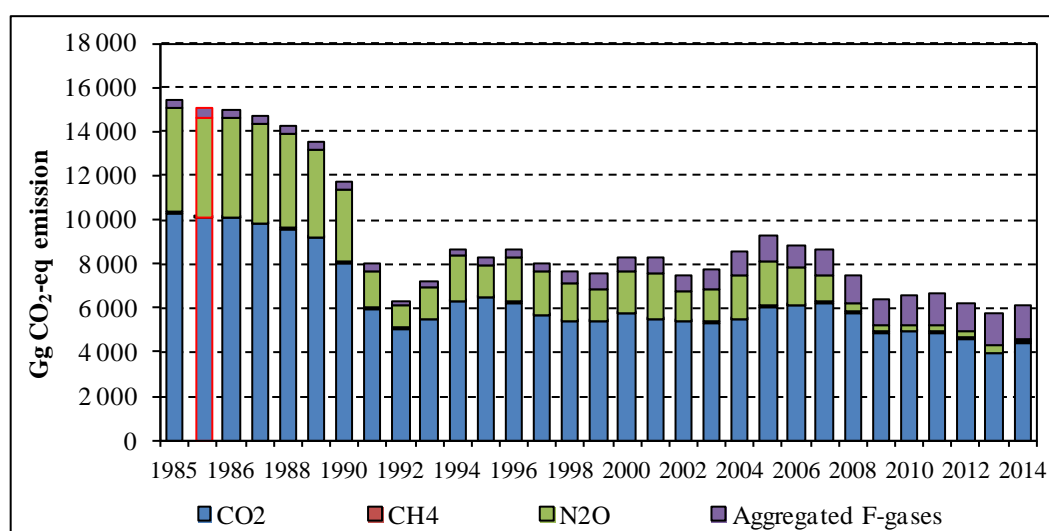


Figure 4.2.3 Trend by greenhouse gases in Industry sector
(BY=average of 1985-87 but 1995 for F-gases- data in red frame)

4.2.2 Emission Trends by sources

In the base year, the chemical subsector accounted for 45% of total industrial GHG emissions, followed by metal subsector 34%, mineral subsector 18%. In 2014, 41% of the emissions came from chemical industry, followed by 23% from consumption of F-gases and 16% from mineral products. The contribution of iron and steel industry and other (SF₆ and N₂O containing) product uses is 15% and 3% respectively. (See Figure 4.1.1 above.) Emissions by sources and by gases appear in Table 4.2.1 for 2014.

Table 4.2.1 Emissions of Industrial processes sector in 2014 (CO₂-eq)

	CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	Total
2. Industrial processes	4425	45	124	1428	2	104	6129
A. Mineral industry	1013	NO	NO	NO	NO	NO	1013
B. Chemical industry	2388	42	64	NO	NO	NO	2494
C. Metal industry	904	4	NO	NO	NO	NO	908
D. Non-energy products from fuels and solvent use	120	NO	NO	NO	NO	NO	120
E. Electronic industry	NO	NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes	NO	NO	NO	1428	2	NO	1430
G. Other product manufacture and use	NO	NO	60	NO	NO	104	164
H. Other	NO	NO	NO	NO	NO	NO	NO

4.3 Mineral Products (CRF sector 2.A)

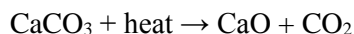
4.3.1 Cement Production (CRF sector 2.A.1)

4.3.1.1 Source category description

Emitted gas: CO₂

CO₂ 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 (CaCO₃) fed into the furnace, which occurs at around 1,300°C and results in CaO (Calcium Oxide) and CO₂ (calcinations).



The raw materials may contain other carbonate minerals (e.g., MgCO₃). 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:

$$g \text{ CO}_2 / g \text{ CaCO}_3 = 44/100 = 0.44$$

$$g \text{ CO}_2 / g \text{ MgCO}_3 = 44/84 = 0.52$$

$$g \text{ CO}_2 / g \text{ CaO} = 44/56 = 0.785 \text{ (default IPCC1996 and EU ETS Clinker output based method)}$$

$$g \text{ CO}_2 / g \text{ MgO} = 44/40 = 1.019$$

(molar weight - C:12 g; O:16 g; Ca:40 g; Mg:24 g)

Significant decrease of emissions has occurred in this sector between 2008 and 2013, but in 2014 the trend has changed (see *Figure 4.3.1*). The decrease of emissions correlates with the decrease of activity data. Activity data is reported directly by the cement producer companies via EU ETS Annual Emission Reports since the last years and verified with the data of HCSO if the latter is available. 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 also turned up and 2014 is the first year that brought some recovery since 2010. The producing facilities were 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%; 2010: 75%; 2011: 86%; 2012: 96%; 2013: 77%; 2014: 117%). Although solely 3 cement producers have been operating in 2014 (compared to 5 in 2010), the production volumes increased in 2014.

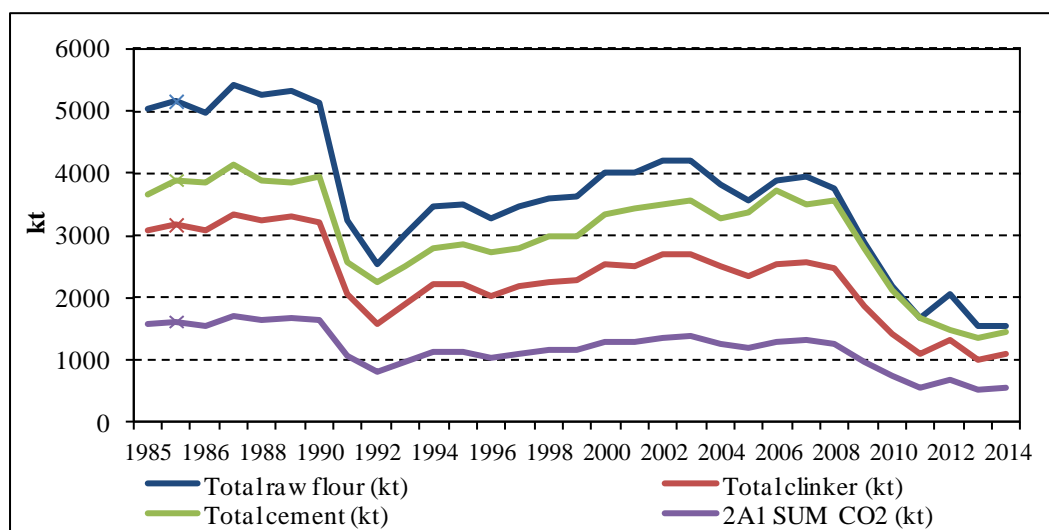


Figure 4.3.1 Trend of activity data and CO₂ emission in Cement production
(BY: marked with X)

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 subsector 1.A.2*.

Emissions were estimated using a country specific method that consists of plant-specific data and full accounting of carbonates (Tier 3 in 2006 IPCC Guidelines) for the years 2005-2013 and extrapolation for the years before 2005 based on country specific emission factor.

In 2012 five factories were operating in Hungary, while in 2013 only three. Production data for the whole time-series were obtained directly from the factories and from the EU Emission Trading System (*Table 4.3.1*).

According to the EU ETS directive (2003/87/EC) introduced by the European Union, the factories report their CO₂ emission from 2005 on. The factories calculate their CO₂ emissions on the basis of their production data, and the analysis of raw flour, and cement kiln dust (CKD), which contains CO₂ generated from all carbonates, including MgCO₃ and other. Wet and dry technologies and CKD are also taken into account, which is in line with methodology of the 2006 IPCC Guidelines. The analysis must fulfill the strict requirements of 601/2012/EU regulation which prescribes the use of ISO17025 accredited laboratories and the minimum annual frequency of analysis. In addition the annual emission reports of the factories are verified by independent EU ETS verifiers and checked by the authority responsible for EU ETS in Hungary.

Table 4.3.1 shows the time-series of production data, the emission estimated in 2A1 sector and the implied emission factor.

As it was suggested by the UN review (ARR) of 2014, and based on the investigation of the trend of the time series (also described in NIRs of previous years), time-series before 2005 have been recalculated for the 2015 submission using country-specific implied emission factor based on the IEFs of the years between 2005-2013 in order to improve consistency. As the trend of the IEF is decreasing, IEF of year the 2005 was used for extrapolation for the years before 2005 (instead of the average of years 2005-2013). Please find below *Figure 4.3.2* showing the trend of IEFs.

Table 4.3.1 Amount of raw flour used in process, clinker and cement production (kt) in Hungary and the CO₂ emission and implied emission factor in 2.A.1 sector

	Total raw flour (kt)	Total clinker (kt)	Total cement (kt)	2A1 SUM CO ₂ (kt)	2A1 CO ₂ (kt)perclinker (kt)
1985	5044	3098	3671	1579	0.5096
1985-87	5152	3173	3889	1617	0.5096
1986	4982	3070	3845	1564	0.5096
1987	5430	3352	4151	1708	0.5096
1988	5264	3250	3871	1657	0.5096
1989	5338	3321	3857	1692	0.5096
1990	5148	3210	3933	1636	0.5096
1991	3247	2067	2563	1054	0.5096
1992	2533	1591	2246	811	0.5096
1993	3010	1907	2521	972	0.5096
1994	3477	2211	2795	1127	0.5096
1995	3493	2214	2875	1128	0.5096
1996	3275	2034	2745	1037	0.5096
1997	3463	2185	2806	1113	0.5096
1998	3603	2262	2995	1153	0.5096
1999	3617	2271	2979	1157	0.5096
2000	3998	2532	3348	1290	0.5096
2001	4009	2522	3452	1285	0.5096
2002	4218	2687	3504	1369	0.5096
2003	4209	2696	3565	1374	0.5096
2004	3828	2495	3267	1271	0.5096
2005	3579	2353	3364	1199	0.5096
2006	3884	2533	3723	1296	0.5116
2007	3939	2577	3485	1328	0.5153
2008	3747	2468	3570	1261	0.5107
2009	2889	1883	2808	973	0.5166
2010	2181	1433	2134	735	0.5131
2011	1672	1109	1692	564	0.5081
2012	2047	1333	1478	678	0.5091
2013	1552	1018	1364	516	0.5067
2014	1537	1095	1467	566	0.5167

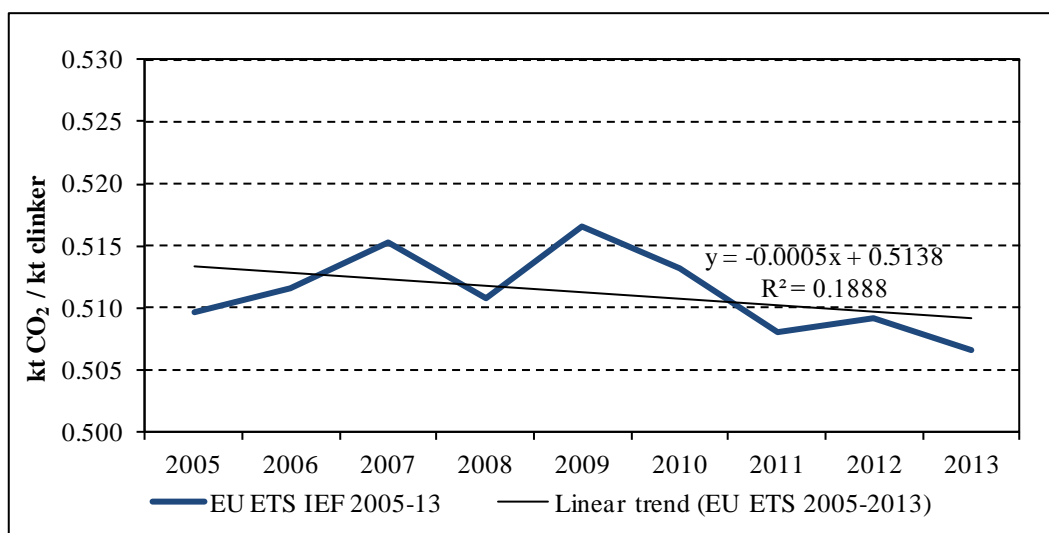


Figure 4.3.2 Trend of IEF between years 2005-2013

The difference of the country-specific emission factor compared to the default is below 2% (see Table 4.3.2).

Table 4.3.2 Comparison of country-specific and default emission factors in case of cement production

Source of IEF	Value (kt CO ₂ /kt clinker)	Diff. to CS IEF
Country-specific(CS)	0.5096	
default – Revised 1996 IPCC Guidelines	0.5071	-0.5%
default – 2006 IPCC Guidelines	0.52	2%

As emissions are calculated taking into account all types of carbonates and CKD recovery between years 2005-2013, used IEF contains these corrections, too.

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 in Table 4.3.1. So, for example not all the factories produce cement from (all their) clinker or cement is produced from clinker produced in earlier years based on the declarations of the companies. Considering this fact, unfortunately 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

Uncertainties are estimated based on the minimum requirements of EU ETS Monitoring and Reporting Regulation (601/2012/EU) for determination of AD and EF in the case of cement production:

Uncertainty	AD	EF	Combined
2A1 Cement Production CO ₂	2.5	2.5	3.54

As the use of ETS data means the use of verified data, where 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).

4.3.1.4 Source-specific QA/QC information and verification

General QA/QC procedures apply.

4.3.1.5 Source-specific recalculations

Time-series have been recalculated for the years before 2005 in order to improve consistency.

4.3.1.6 Source-specific planned improvements

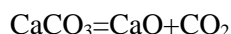
Further verification is continuously planned.

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

4.3.2.1 Source category description

Emitted gas: CO₂

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



Here, only CO₂ is generated according to this formula. CO₂ generated by combustion 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 the 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 CO₂ emissions arise from Hungarian sugar producers since all of them use Ca(OH)₂ + CO₂ precipitation technology to remove impurities. This technology is described in the sector specific IPPC BAT BREF document as well (European Commission, 2006).

“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 (CO₂) into a liquid to form calcium carbonate and to precipitate and remove impurities. The effect of lime and CO₂ 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 CO₂ 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 and Water (KVVM, 2005 - available only in Hungarian) states that CO₂ emission from lime kilns in sugar production facilities are attributable solely to fuel combustion of the lime kilns since “CO₂ originating from dissociation of limestone is rebound again into CaCO₃.” (Section 4.1.2.2.2) Fuel consumption of lime kilns are reported in *Energy* sector. Precipitated CaCO₃ is used for liming of soils in general (reported in *Agriculture* sector).

4.3.2.2 Methodological issues

The amount of CO₂ generated by this subsector is reported by using plant-specific (EU ETS) emission data of companies in years 2005-2014 and using a country specific IEF for extrapolation for the years before 2005.

The country specific IEF has been created taking into account that IEFs of years between 2005 and 2012 do not show a clear trend as it is presented in the following *Figure 4.3.3*, 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 CO₂/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 the 2013 Synthesis and Assessment Report of UNFCCC.

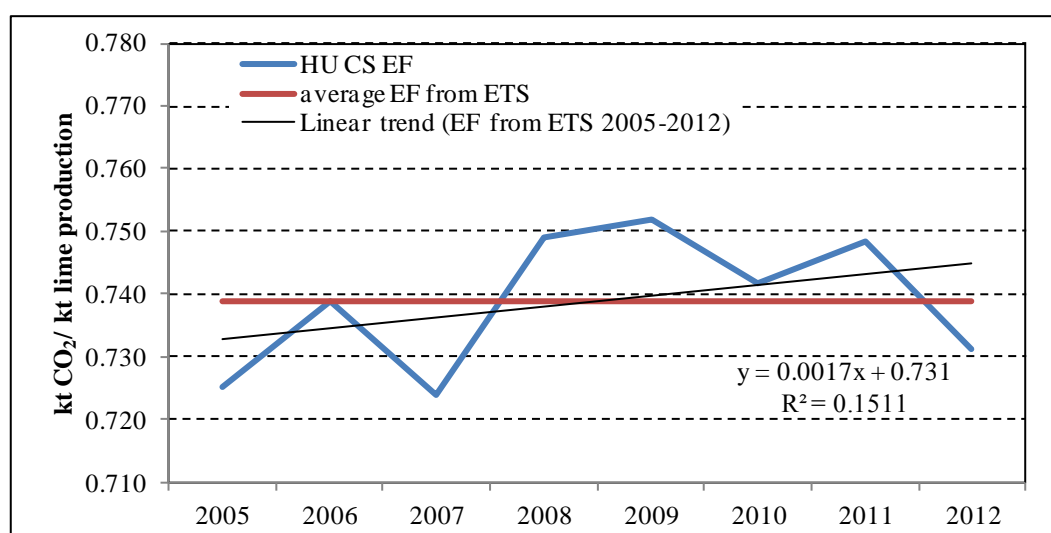


Figure 4.3.3 Trend of kt CO₂/kt lime produced IEF between years 2005 and 2012

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 MgCO₃), impurities and the eventual presence of hydraulic lime (which has the same stoichiometric ratio as lime but has a lower CaO content and the eventual recycling of lime kiln dust are also taken into account as it is required by the 2006 IPCC Guidelines. As EU ETS data for the years 2005-2012 contains the above mentioned corrections, also the IEF used for extrapolation contains them.

The difference between the country-specific EF and the default EF is below 1 % (see Table 4.3.3).

Table 4.3.3 Comparison of country-specific and default emission factors in case of lime production

Source of EF	Value (kt CO ₂ /kt limestone)	difference to default
Default Tier 1 EF of 2006 IPCC Guidelines		
(Vol3 2.3.1.2 - Table 2.4) = (CO ₂ /CaO) * CaO content = 0.785* 0.95 =)	0.7458	
HU CS EF	0.7388	-0.93%

Time-series of lime production and related emissions can be seen in Figure 4.3.4.

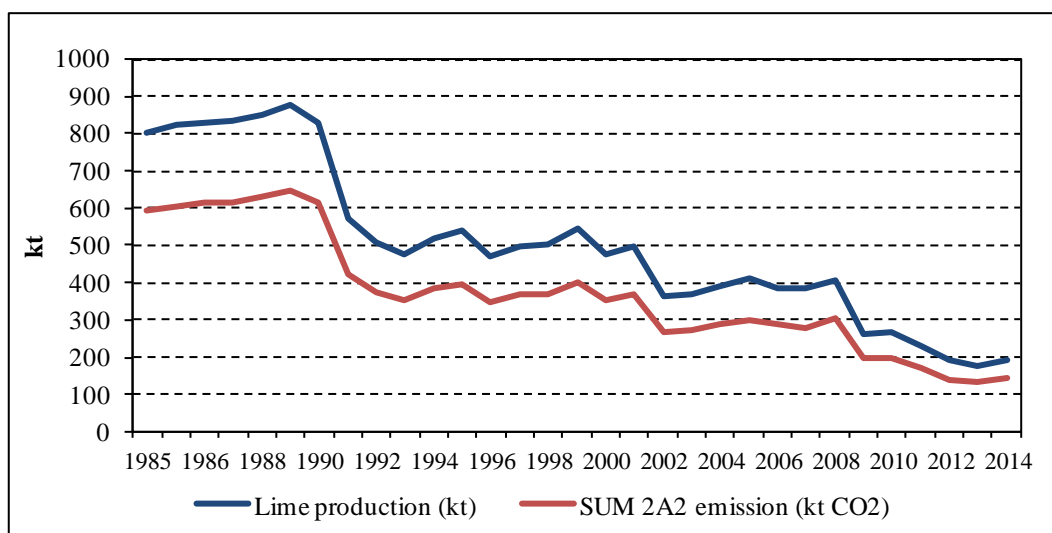


Figure 4.3.4 *Trend of production and emissions in sector 2.A.2.Lime*

4.3.2.3 Uncertainties and time-series consistency

Uncertainties are estimated based on the minimum requirements of EU ETS Monitoring and Reporting Regulation (601/2012/EU) for the determination of AD and EF in the case of Lime production:

Uncertainty		AD	EF	Combined
2A2 Lime Production	CO ₂	2.5	2.5	3.54

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.

During informal review organized by EEA in November 2015, a question was raised if it was verified that all emissions from lime production was reported and all lime was produced only in lime plants which are included in the EU ETS (except sugar production as described above). Regarding this issue industrial associations in the field of mineral industry have been looked over and no other plants have been found. In addition lime production data in EU ETS annual emission reports and data from the Hungarian Statistical Office was also compared and strange result has been found that usually statistics are the lower. The average difference between years 2004 and 2012 is that HCSO data on lime production is 8% lower than EU ETS data. However EU ETS data seems to be more accurate as EU ETS annual emission reports are verified every year. So, it seems that emissions are not underestimated due to incompleteness of the sector.

Please also note that emissions from lime and dolomite used in iron and steel industry are reported in sector 2.C.1 Iron and steel.

4.3.2.5 Source-specific recalculations

None.

4.3.2.6 Source-specific planned improvements

Further verification is continuously planned.

4.3.3 Glass Production (CRF sector 2.A. 3)

4.3.3.1 Source category description

Emitted gas: CO₂

In the case of *Glass production*, CO₂ emission is generated by adding the carbonates (mainly soda ashes) of alkali metals (Ba, Li, Na, etc.) to the melt in the course of glass melting. Glass production is also within the scope of EU Emissions Trading System. Please note that solely process emissions are reported in this sector, as combustion emissions are included in 1.A.2.

4.3.3.2 Methodological issues

Considering the fact that most of the glass factories are covered by EU Emission Trading System, the quantity of CO₂ emitted from carbonates reported by them is used as emissions between 2005 and 2014, and country-specific IEFs have been created for extrapolation for the years before 2005. In addition, +10% (of the EU ETS emissions) is added in order to cover the emission of plants not falling under the scope of EU ETS Directive.

In inventory submissions before 2015, one single IEF was used for all glass types. As it was suggested by the ARR of 2014, new IEFs by glass types are now applied (details in *Table 4.3.4*). The difference between the default and country-specific IEFs might be further investigated, however they are within the range of Tier 2 default emission factors of the 2006 IPCC Guidelines.

Table 4.3.4 Comparison of country-specific and default IEFs in the case of glass production

source/ type of emission factor	Value (t CO ₂ / t glass)
Default T1 IEF (Eq.2.13)	0.200
Default T2 IEFs (Table 2.6)	0.03 -0.25
CS IEF - Float glass	0.156
CS IEF - Container glass	0.181
CS IEF - Speciality glass	0.154
Default IEF - Fiberglass (glass wool)	0.250
OLD HU submission IEF	0.164

Quite detailed activity data is available from HCSO, so time-series by different glass-types could have been separated for the extrapolation.

The *Figure 4.3.5* below shows the complete CO₂ emission from this category.

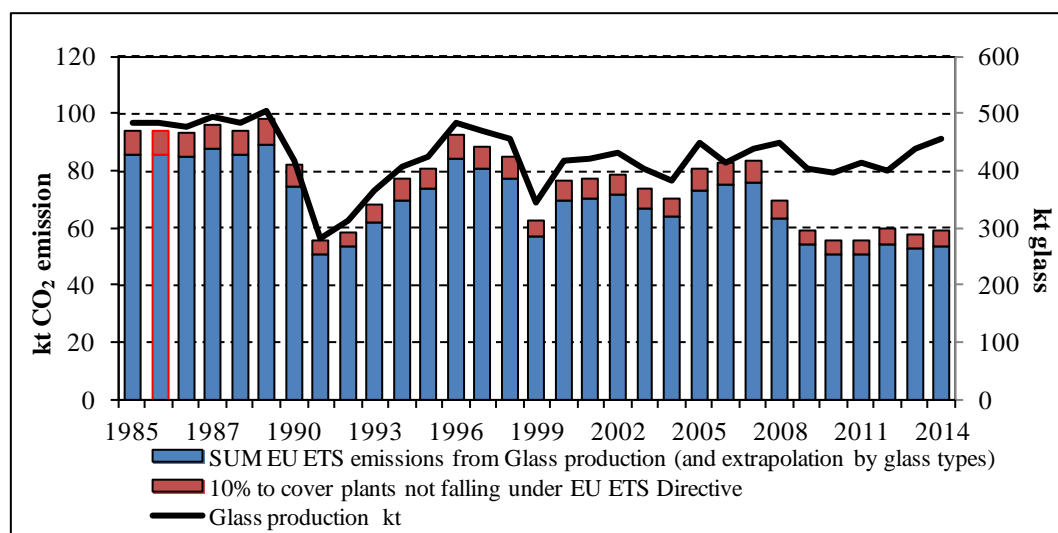


Figure 4.3.5 Trend of CO₂ emission and Glass Production (kt)

4.3.3.3 Source-specific QA/QC information and time-series consistency and uncertainty

Uncertainties are estimated based on the minimum requirements of EU ETS Monitoring and Reporting Regulation (601/2012/EU) for the determination of AD and EF in the case of glass production:

Uncertainty		AD	EF	Combined
2A3 Glass production	CO ₂	2.5	2.5	3.54

4.3.3.4 Source-specific recalculations and verification

During informal review organized by EEA in November 2015, a question was raised if it was verified that all emissions from glass production was reported and all glass was produced only in plants which are included in the EU ETS. Unfortunately in sector *Glass* it is not possible to perform comparison of activity data from Hungarian Central Statistical Office with EU ETS data, as in this case in EU ETS Annual emission reports there is no information on production, but solely on the amount of input materials (and emissions of course). So, also in this case industrial associations in the field of mineral industry has been looked over and no plants with technological emissions (emissions from carbonates) have been found in addition to those covered by EU ETS. However in the National Air Emissions Database (LAIR) at least one glass producer had been found that is not covered by EU ETS. Therefore in the case of Glass subsector +10% was added in order to cover the emission of plants not covered by EU ETS and time-series have been recalculated as it is described above.

4.3.3.5 Source-specific planned improvements

Further analysis of the consistency and verification of activity data and emission factors is needed.

4.3.4 Bricks and ceramics (CRF sector 2.A.4. a.Other)

4.3.4.1 Source category description

Emitted gas: CO₂

During manufacturing of bricks, tiles and ceramic products, CO₂ emission is generated from the degradation of carbonates in raw materials (mainly from clay) on the one hand, and from burning of materials added to bricks on the other. Please note that in present submission all the fuels (also as additives) are reallocated into 1.A.2 together with all other combustion emissions from *Bricks and Ceramics production*.

4.3.4.2 Methodological issues

The same country-specific method is used to determine emission as in case of other EU ETS sectors. Plant-specific data is reported for the years 2005-2013 and a country-specific IEF is generated based on IEFs from these years for the extrapolation of emissions before 2005. Also in this case, the trend of IEFs is taken into consideration, in order to decide if average or the IEF of year 2005 represents better. In the case of bricks and ceramics, the latter is applied as the trend is decreasing.

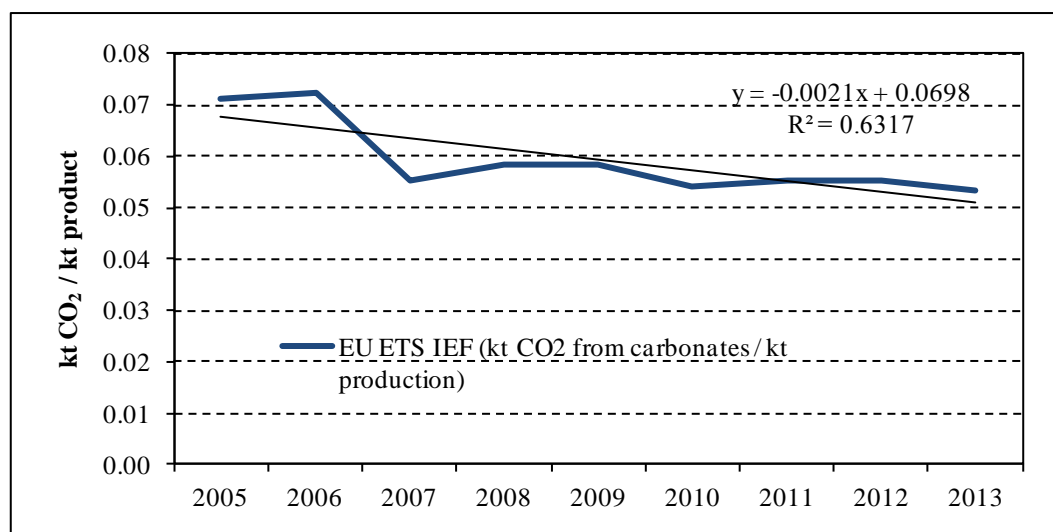


Figure 4.3.6 Trend of plant specific IEF between 2005 and 2013 in Bricks and ceramics

In previous inventory submissions, +10% of the EU ETS emissions have been added supposing that not all the factories fall within the scope of EU ETS. This supposition could not be demonstrated until now, so, it is not applied anymore. In addition, all fuels used as additives have now been reallocated into 1.A.2, so in this case also the years after 2005 have been recalculated.

4.3.4.3 Uncertainties and time-series consistency

Uncertainties are estimated based on the minimum requirements of EU ETS Monitoring and Reporting Regulation (601/2012/EU) for the determination of AD and EF of process uses of carbonates:

Uncertainty	AD	EF	Combined
2A4 Other Process Uses of Carbonates CO ₂	2.5	2.5	3.54

4.3.4.4 Source-specific QA/QC information and verification

General QA/QC procedures apply.

During the informal review organized by EEA in November 2015, a question was raised if it was verified that all emissions was reported and all bricks, tiles and ceramics are produced only in plants which are included in the EU ETS.

Unfortunately also in sector *Ceramics* it is not possible to perform comparison of activity data from Hungarian Central Statistical Office with EU ETS, as in this case in EU ETS annual emission reports there are no information on production, but solely on the amount of input materials (and emissions of course) the same as in the case of *glass sector*. So, also in this case industrial associations in the field of mineral industry have been looked over and no plants with technological emissions (emissions from carbonates) have been found in addition to those covered by EU ETS.

In addition, unlike *Glass sector*, *Bricks, tiles and ceramics industry* underwent significant recession in the recent years. In 2005, 52 bricks, tiles or ceramics factory had been operating in Hungary, while in 2013 only 21. It seems that only the biggest plants are able to survive that are covered by EU ETS. However this issue have to be regularly verified and the search for potentially arising emitters have to be repeated also in the future.

4.3.4.5 Source-specific recalculations

Time-series of emission has been recalculated, as it is described above.

4.3.4.6 Source-specific planned improvements

Further verification and analysis of the time-series of activity data is needed.

4.3.5 Soda Ash Use (CRF sector 2.A.4.b)

Emitted gas: CO₂

4.3.5.1 Methodological issues

Carbon dioxide is released when soda ash (Na₂CO₃) is heated.

During the 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 CO₂ emission arising from soda ash not used in glass industry is needed in 2.A.4.b. In the 2006 IPCC Guidelines this category has been moved under 2.A.4 – *Other Process uses of carbonates*, (while *Production of Soda Ash* has been moved under 2.B. – *Chemical Industry*).

Activity Data

Total import/export of soda ash

Time-series of activity data is presented in *Figure 4.3.8* and *Table 4.3.7*. 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 UNComtrade (<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) Na₂CO₃).

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 4.3.5* as sector-specific volume indices are available only from 1999 within the databases mentioned above.

Table 4.3.5 *Volume indices of total trade of soda ash*

		1985	1986	1987	1988	1989	1990	1991	1992
Volume indices of trade (compared to previous year)	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

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 4.3.7. The data on Na_2CO_3 used in EU ETS glass production have been extracted from the EU ETS Annual Emission Reports of the glass producing companies.

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 that 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 1820.31 t/year, which results 0.75543 Gg CO_2 /year. The average of soda ash NOT used in glass production (=1820.31 t) compared to the average of total import – export (=65869.05 t) results 2.76353%.

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 2.76353% as it is presented in *Table 4.3.6*.

Table 4.3.6 SUM of total domestic soda ash consumption and soda ash used in glass industry

SUM of 2005-2012	
Total import-export (t) Na_2CO_3	526,952.44
(t) Na_2CO_3 in EU ETS glass	512,389.96
(t) Na_2CO_3 difference	14,562.48
(t) Na_2CO_3 difference /(t) Total	2.76353%

So, for our calculations, 2.76353% of the total import-export data of the given year is considered to be the amount of soda ash NOT used in glass production.

This ratio seems 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 the figure below (*Figure 4.3.7*).

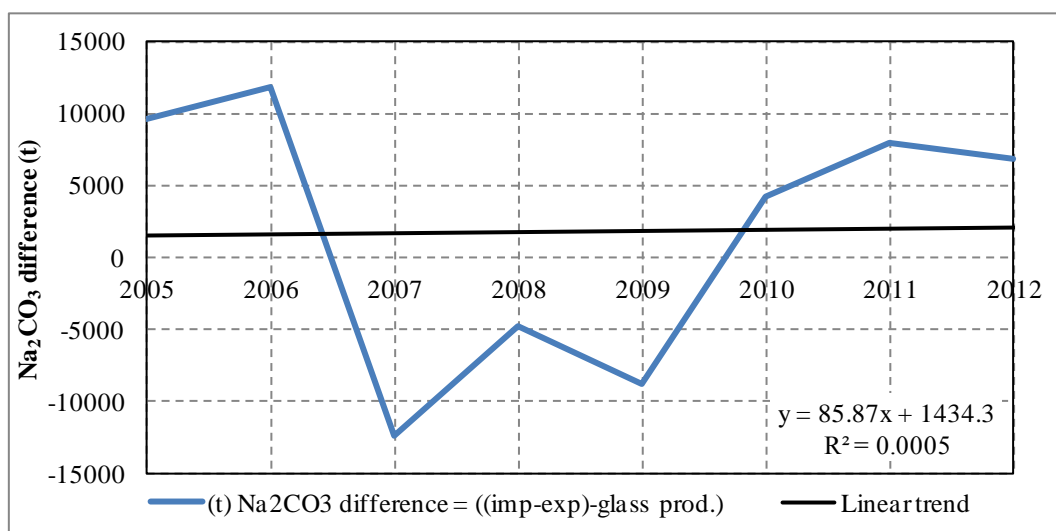


Figure 4.3.7 Trend of soda ash not used in glass production between 2005 and 2012

So, the following equation is applied for the entire time series and the results are presented in the 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)) *2.76353%

Emission factor and CO₂ emission of sector 2.A.4.

Stoichiometric ratio of 0.415 t CO₂/ t Na₂CO₃ is used.

(44 g/mole CO₂ /106 g/moleNa₂CO₃ = 415 kg CO₂/tonne Na₂CO₃)

The following *Table 4.3.7* and *Figure 4.3.8* summarizes the time-series of activity data and CO₂ emissions in sector 2.A.4 Soda Ash use.

Table 4.3.7 Activity data and CO₂ emission in 2.A.4.of several years

	source of data	Total import-export (t) Na ₂ CO ₃	Soda ash NOT used in glass industry (t)	kt CO ₂ emission
1985	extrapolated using annual volume index of trade	81713.1	2 258.2	0.94
BY		83765.5	2 314.9	0.96
1992		80743.3	2 231.4	0.93
1993	UNComtrade	97969.9	2 707.4	1.12
1994	interpolated	103232.4	2 852.9	1.18
1995	UNComtrade	108992.4	3 012.0	1.25
2005		94739.6	2 618.2	1.09
2006	interpolated	83936.0	2 319.6	0.963
2007	UNComtrade	60067.5	1 660.0	0.689
2010		56856.5	1 571.2	0.652
2011		61102.0	1 688.6	0.701
2012		64327.3	1 777.7	0.738
2013		64080.6	1770.9	0.735
2014		49417.6	1 365.7	0.567

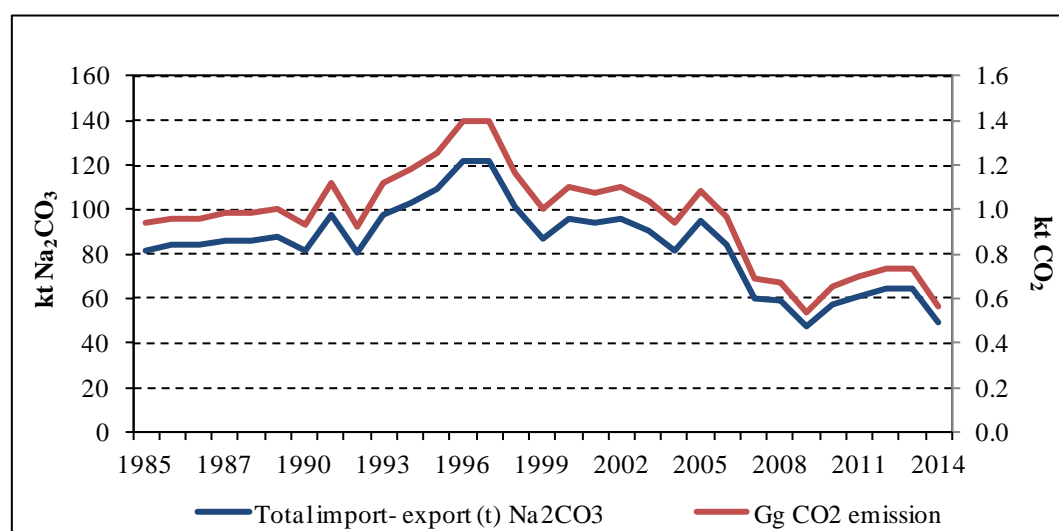


Figure 4.3.8 Trend of total domestic consumption of soda ash and CO₂ emissions in sector 2.A.4.b.

4.3.5.2 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 data of the Hungarian Central Statistical Office. 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) Na₂CO₃).

The same uncertainty values have been applied as in the case of all subcategories of 2.A.4 *Other Mineral Industry*.

4.3.6 Other Process Uses of Carbonates (CRF sector 2.A.4.d)

4.3.6.1 Source category description

Emitted gas: CO₂

This subsector includes processes in which calcinations (CO₂ loss) occur as a result of heating carbonates. CO₂ emissions generated by the degradation reaction are calculated while gases from fuel combustion are included in subsector 1.A.2. In this sector limestone and dolomite use for flue gas scrubbing and process emissions from mineral wool production 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.C.1;
- emissions from carbonates during production of clay-based products are included in 2.A.4.a *Bricks and ceramics*;
- emissions from carbonates during production of glass are included in 2.A.3. *Glass*, which includes also glass wool production.

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

4.3.6.2 Methodological issues

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 SO₂ 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 also CO₂ emission from the use of carbonate for scrubbing separately in their annual emission report since 2008. So, direct, plant-specific emission data is used in 2.A.d.i. subcategory from year 2008 and emissions are calculated using stoichiometric ratios (included in Table 2.1 of Vol3. of the 2006 IPCC Guidelines: 440 kg CO₂ / ton limestone) for the years before 2008. In 2014 two new operators reported CO₂ emissions from flue gas scrubbing in EU ETS, both are included in the inventory as well.

In the case of EU ETS plant specific data, emissions are also calculated by the operators using the stoichiometric ratio and fraction of purity of 1 (440 kg CO₂ / ton limestone), except in the case of one operator in the year 2013. They started to analyze the exact carbonate content of the limestone used in laboratory (fulfilling the requirements of 601/2013/EU Regulation), so, this plant does not use a purity fraction of 1 anymore.

Process emissions from mineral wool production are small, but it is included in order to improve completeness of the inventory. Mineral wool producers report their CO₂ emissions since 2008 under the EU ETS. So, plant-specific emissions and activity data is available for these years. However, mineral wool production has been present in Hungary since 2001 due to EuroStat Prodcom database. Therefore extrapolation was applied for the years 2001-2008 for the estimation of emissions. Activity data was taken from EuroStat Prodcom database and from HCSO database, and IEF of process emissions of year 2013 is applied for the extrapolation due to lack of other detailed data.

Please note that in CRF waste gas scrubbing and mineral wool are reported together under 2.A.4.d, as it is not possible to add child node in this category.

Unfortunately AD are also different in the two subsectors. Carbonates used for waste gas scrubbing was chosen as AD in the CRF as it is much more significant than mineral wool.

Please find the detailed time-series of activity data and emission in *Table 4.3.8* below.

Table 4.3.8 Emissions from different sources and activity data within 2.A.4 Other Carbonate Uses

	Carbonates used for waste gas scrubbing (AD in CRF) (kt)	Emission from waste gas scrubbing (Gg CO ₂)	Mineral wool production (kt)	Emission from mineral wool production (Gg CO ₂)	Sum emission 2.A.4.d (EM in CRF) (Gg CO ₂)
1985-2000	NO	NO	NO	NO	NO
2001	NO	NO	45.0	2.1	2.1
2002	262.6	115.5	51.0	2.3	117.9
2003	315.2	138.7	57.1	2.6	141.3
2004	388.2	170.8	58.0	2.7	173.5
2005	504.8	223.9	61.0	2.8	224.9
2006	487.2	217.1	84.2	3.8	218.2
2007	493.2	220.0	99.9	4.6	221.6
2008	467.5	208.4	61.1	2.8	208.5
2009	437.8	194.7	36.7	1.7	194.3
2010	429.9	191.1	40.6	1.9	191.0
2011	478.2	212.6	51.4	2.4	212.8
2012	466.7	207.8	46.7	2.1	207.5
2013	473.7	205.1	45.4	2.1	206.0
2014	438.4	186.8	43.3	2.7	189.5

4.3.6.3 Uncertainties and time-series consistency

Uncertainties are estimated based on the minimum requirements of EU ETS Monitoring and Reporting Regulation (601/2012/EU) for the determination of AD and EF of process uses of carbonates:

Uncertainty	AD	EF	Combined
2A4 Other Process Uses of Carbonates CO ₂	2.5	2.5	3.54

4.3.6.4 Source-specific QA/QC information and verification

General QA/QC procedures apply.

4.3.6.5 Source-specific recalculations

During the informal review organized by the EEA in November 2015, for category 2.A.4.d.i the TERT identified overestimate (approximately 2 Gg CO₂ for the period 2005-2013) due to incorrect inclusion of amount of CaO used for waste gas scrubbing in the case of one operator. As indeed, no CO₂ emissions arise in the case of flue gas treatment technology using CaO, correction has been performed and time series have been recalculated.

4.3.6.6 Source-specific planned improvements

Further verification of activity data for mineral wool and improvement of country-specific implied emission factor 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 organic chemicals: carbon black, ethylene and dichloroethylene.

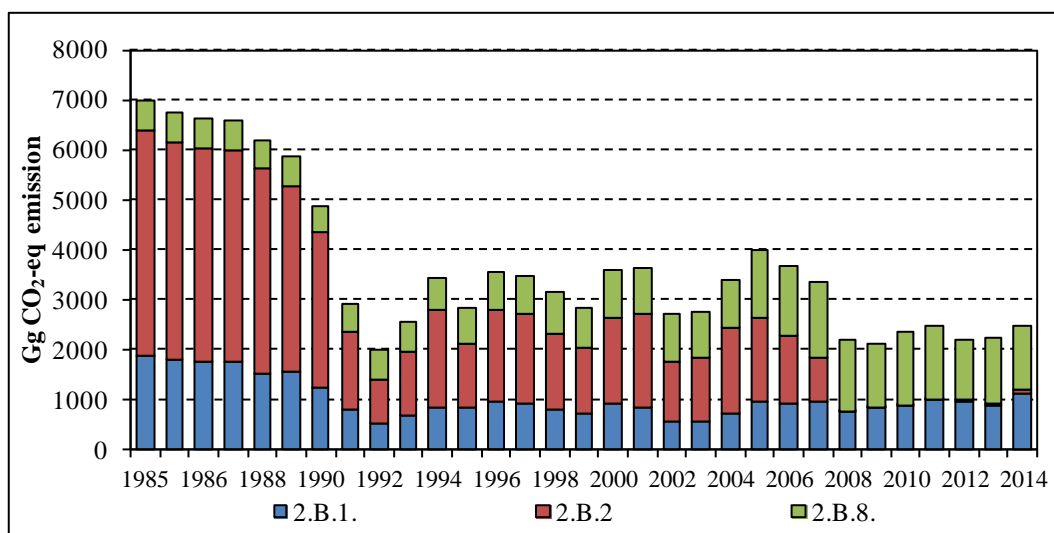


Figure 4.4.1 Shares of subsectors within chemical industry

Also in the case of chemical industry, the decrease of emissions after 1990 was due to the regime change (see *Figure 4.4.1*). Several factories were closed down and the production decreased drastically. Another significant drop of emissions occurred in 2007 when a state-of-the-art N₂O abatement technology has been introduced in a nitric acid plant (Nitrogénművek Zrt., 2008).

Production of the chemical industry is fluctuating 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: 99.7; 2013: 105.6; 2014: 108.6). It is worth to mention that production of ammonia was 41% higher in 2014 than the year before. The difference between the trend of production of chemical industry and the trend of emissions in 2.B sector might be explained by the increasing environmental performance of the chemical plants. This was the case between 2012 and 2013 when emissions were almost the same, while volume index increased by ca. 5%.

It is also worth to take into consideration that a significant part of the CO₂ emissions from petrochemical industry is now allocated here anymore, while it was reported in old sector 2.G in submissions before 2015.

In addition the 2006 IPCC Guidelines Vol. 3 Chapter 1 suggests that:

“Combustion emissions from fuels obtained directly or indirectly from the feedstock for an IPPU process will normally be allocated to the part of the source category in which the process occurs. These source categories are normally 2B and 2C.”

Therefore all natural gas used in chemical industry for process purposes are accounted now here. Please find below the table (*Table 4.4.1*) showing the allocation of natural gas use in IEA Energy Statistics and in the HU GHG inventory.

Table 4.4.1 The allocation of natural gas use in IEA Energy Statistics and in the HU GHG inventory

Natural gas use in <i>Chemical Industry in IEA</i> Energy Statistics (TJ NCV)				Natural gas allocation in <i>Chemical Industry</i> in HU GHG Inventory (TJ NCV)						
	Energy used in Chemical Ind.	non- energy use	SUM	2.B.1 Ammonia	2.B.1. Hydrogen	2.B.1 Tail gas treatment Nitric Acid	2.B.8 Petrochemical	SUM 2B	Reported in 1.A sector	SUM
1985	19919	34294	54212	35317	0	1373	1709	38399	15813	54212
BY	21461	33968	55430	34371	0	1483	1707	37562	17868	55430
1986	22205	33897	56102	33820	0	1432	1706	36957	19144	56102
1987	22260	33715	55975	33976	0	1646	1707	37329	18646	55975
1988	21373	30393	51766	30583	0	1529	1694	33805	17961	51766
1989	22578	31115	53693	31182	0	1127	1689	33998	19695	53693
1990	22831	23113	45944	24342	0	993	1629	26963	18981	45944
1991	18754	14869	33623	14687	0	702	1574	16962	16661	33623
1992	17847	10099	27946	10111	0	445	1568	12123	15822	27946
1993	16622	12871	29493	12358	0	574	1662	14595	14898	29493
1994	13573	15560	29133	14683	0	1116	1854	17653	11480	29133
1995	17537	15950	33486	14536	0	981	2049	17565	15921	33486
1996	18580	17169	35749	16223	0	1669	2079	19972	15777	35749
1997	21939	12574	34513	15555	0	1678	2260	19492	15021	34513
1998	14162	12575	26736	13779	0	1476	2387	17642	9094	26736
1999	10892	11215	22107	12299	0	1357	2310	15966	6140	22107
2000	10266	13668	23935	15865	63	1567	2600	20095	3839	23935
2001	10256	13867	24123	14288	188	1599	2634	18709	5413	24123
2002	9383	8712	18095	10167	189	1024	2519	13900	4195	18095
2003	8097	9169	17267	10114	170	1141	2491	13916	3351	17267
2004	6368	13454	19822	13035	183	1235	2386	16839	2982	19822
2005	8257	15055	23312	14729	2368	1392	2754	21243	2069	23312
2006	7938	14192	22130	13856	2707	1328	2918	20809	1321	22130
2007	9031	16409	25439	15115	2937	911	3275	22238	3202	25439
2008	7937	14719	22656	11486	2930	6	2857	17279	5377	22656
2009	5391	13534	18925	12730	2433	8	2546	17717	1208	18925
2010	6538	15149	21686	13699	2393	9	3118	19218	2468	21686
2011	6579	17134	23713	15788	3019	17	2680	21504	2209	23713
2012	4467	19000	23467	14022	4468	16	1653	20161	3306	23467
2013	10060	16472	26532	11377	4917	9	1869	18172	8360	26532
2014	9184	20712	29897	15392	5232	12	1664	22301	7596	29897

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

4.4.1.1 Source category description

Emitted gas: CO₂

Ammonia (NH₃) production in Hungary uses natural gas. In the case of ammonia manufacture, natural gas provides both feedstock and fuel, whose carbon content is released in the form of carbon dioxide. The same process occurs in the case of hydrogen production and the treatment of tail gas with natural gas in nitric acid plants.

In Hungary the significant part of hydrogen synthesized is used also for ammonia production, but the hydrogen plant is operated by another company. The share of hydrogen/nitrogen based ammonia production within all ammonia production has been about only 5%. 95% of ammonia production is “traditional” natural gas based, but the share is increasing recently.

As in the new CRF Reporter Software there is no possibility to report CO₂ in sector 2.B.2, the emission from tail gas treatment with natural gas is reported here. The process (emission factor) is anyway the same as in the case of ammonia and hydrogen production.

The 2006 IPCC Guidelines requires also subtraction of amount of CO₂ emitted from ammonia production but used for urea production (and the reporting of urea used in agriculture and as catalyst in vehicles). So, urea recovery is also reported in sector 2.B.1. Please find below (Table 4.4.2) the time-series of the different emission sources and the recovery.

Table 4.4.2 CO₂ emission from the different sources in 2.B.1 sector

	Ammonia production with urea recovery	CO ₂ recovery in urea production	Hydrogen production	Tail gas treatment by nitric acid production
	kt CO ₂ emission			
1985	1786.80	194.46	NO	77.02
1985- 1987	1705.85	222.35	NO	83.22
1986	1673.35	223.95	NO	80.31
1987	1657.40	248.63	NO	92.34
1988	1445.88	269.81	NO	85.76
1989	1483.62	265.72	NO	63.20
1990	1199.41	166.15	NO	55.68
1991	746.34	77.58	NO	39.36
1992	511.55	55.68	NO	24.95
1993	639.89	53.42	NO	32.22
1994	774.71	49.00	NO	62.62
1995	766.11	49.34	NO	55.02
1996	862.52	47.60	NO	93.65
1997	823.34	49.28	NO	94.12
1998	718.75	54.28	NO	82.78
1999	631.58	58.40	NO	76.15
2000	827.27	62.75	3.55	87.93
2001	734.66	66.88	10.56	89.69

	Ammonia production with urea recovery	CO ₂ recovery in urea production	Hydrogen production	Tail gas treatment by nitric acid production
kt CO ₂ emission				
2002	496.68	73.69	10.59	57.47
2003	489.71	77.66	9.55	64.00
2004	643.19	88.07	10.27	69.27
2005	741.42	84.89	132.83	78.09
2006	688.94	88.39	151.88	74.51
2007	757.05	90.92	164.76	51.09
2008	601.41	42.93	164.40	0.32
2009	689.70	24.48	136.46	0.47
2010	748.25	20.25	134.24	0.48
2011	820.22	65.48	169.39	0.94
2012	722.16	64.50	250.68	0.92
2013	598.45	39.78	275.85	0.49
2014	826.78	36.71	293.50	0.70

4.4.1.2 Methodological issues

CO₂ emission from ammonia production is reported using Tier 3 methodology from the 2006 IPCC Guidelines. The Tier 3 method requires total fuel requirement (SUM TFR_i), which has been available from the reporting of the plants. Default carbon content factor ($\text{CCF} = 56.1$) and default carbon oxidation factor ($\text{COF} = 1$) is applied.

CO₂ recovery for urea production occurs only in one plant, which provided data on the quantity recovered in 2013 and 2014. In addition they provided data on the exported quantity and the share of the different sectors in which urea is used domestically. For the years before 2013 extrapolation was applied using domestic urea use as surrogate data. Time-series of ammonia production and emitted CO₂ are presented in *Figure 4.4.2*.

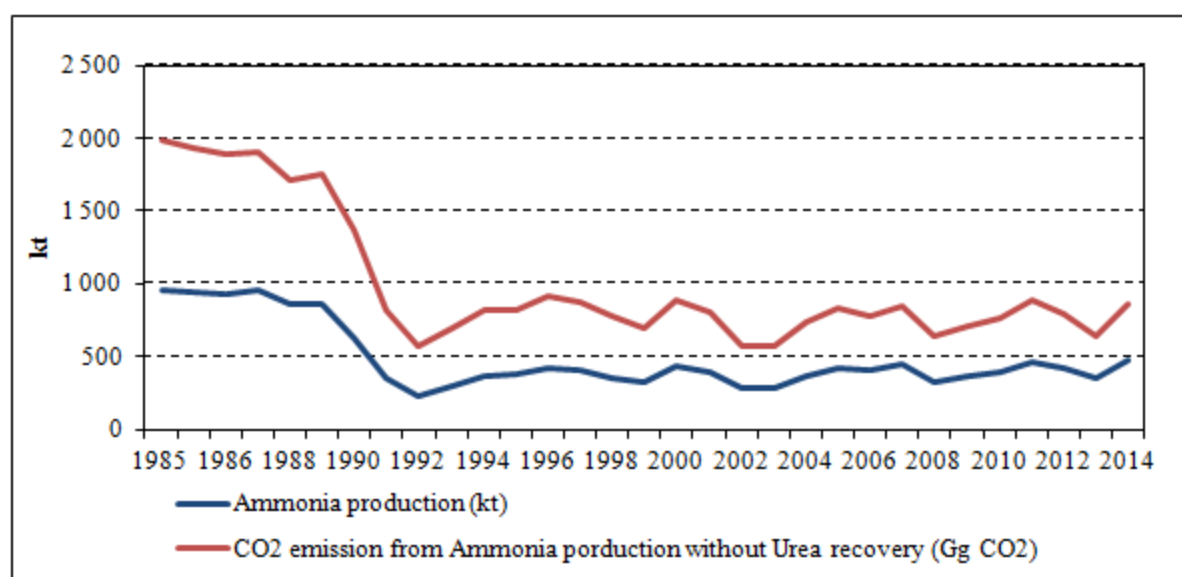


Figure 4.4.2 Trend of Production of Ammonia and CO₂ emissions

Please note that in HU CRF submissions the activity data is the sum of natural gas used for ammonia and hydrogen production and for nitric acid waste gas scrubbing (TJ NCV). HU IEF calculated based on ammonia production is: 1.806 t CO₂ / t ammonia in 2014. The continuous decrease of implied emission factor in *Ammonia production* 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 in decrease of emissions per 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)

From 2013, the extension of the scope of EU ETS also to ammonia production has been an incentive for further energy rationalization.

CO₂ emissions from *Hydrogen production* and *Tail Gas treatment with Natural Gas* are reported using direct, plant specific data. The companies provided data on the quantity of natural gas used for the whole time-series, and the same emission factors (56.1 t CO₂ / TJ natural gas) has been used like in the case of *Ammonia production*.

The main producer of hydrogen in Hungary uses state-of-the-art technology for hydrogen production, when CO₂ emitted by hydrogen production is recovered for the industrial production of CO gas. However the amount of CO₂ recovered is not reported (not subtracted) in HU GHG Inventory at the moment, as the CO produced might be regarded as short term storage. So, all CO₂ is accounted for in the case of GHG inventory which causes a difference in the consistency check with EU ETS emissions (as the operator is also falling within the scope of EU ETS). The other reason of the difference in this subsector is that not all the hydrogen producers are required to report within the framework of EU ETS.

Please find the time-series of emissions from hydrogen production and tail gas treatment with natural gas in nitric acid production in the *Table 4.4.2* above.

The quantities of natural gas used for the different processes have been compared with IEA Energy Statistics, as it is presented in *Table 4.4.2*.

4.4.1.3 Uncertainties and time-series consistency

Uncertainties are estimated based on the minimum requirements of EU ETS Monitoring and Reporting Regulation (601/2012/EU) for the determination of AD and EF in the case of *Ammonia Production*:

Uncertainty	AD	EF	Combined
2B1 Ammonia Production CO ₂	5	5	7.07

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 has been affirmed. The decreasing IEF of CO₂ is also verified and the result is described in the methodological issues subchapter above (4.4.1.2).

Consistency with IEA Energy Statistics was checked and it is presented in *Table 4.4.1*.

Please note that in the case of Hungary, the used activity data in CRF software is natural gas expressed in TJ NCV. So, the implied emission factor of 0.06 in CRF is in fact 0.0561 kt CO₂ / TJ natural gas, which is the default value.

4.4.1.5 Source-specific recalculations

There was no recalculation in this year.

4.4.1.6 Source-specific planned improvements

Further verification and improvement of the extrapolation used by urea recovery is needed.

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

4.4.2.1 Source category description

Emitted gas: N₂O, (CO₂)

Nitric acid (HNO₃) is produced by oxidizing ammonia. The process tail gas contains N₂O and NO_x. In order to control the emissions, the latter is reduced to nitrogen using natural gas and the carbon content of the natural gas is released in the form of carbon dioxide.

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). The Figure (Figure 4.4.3) below shows the operating nitric acid plants since 1985.

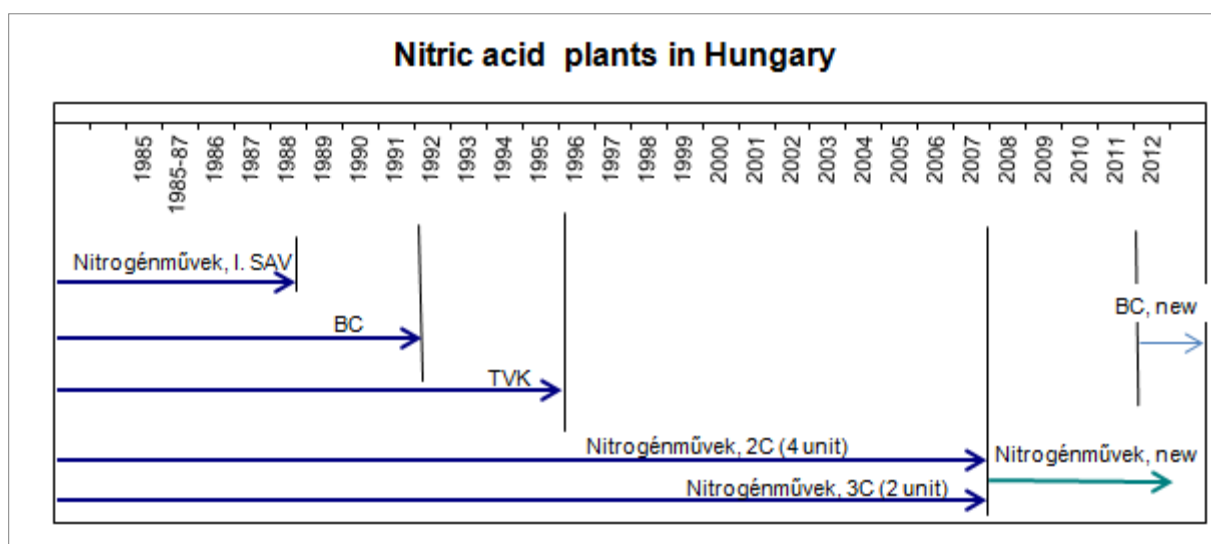


Figure 4.4.3 Nitric acid plants in Hungary, 1985-2014

Implementation of a new and more advanced production technology in Nitrogénművek plant 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 Figure 4.7).

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/GSZRV07J6MCQORD8BAZ3MN839PHNZE5/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)

At the end of year 2011 one of the former nitric acid plants has been restarted after renovation.

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 the IPCC (6 kg N₂O/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. N₂O 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 2000 Good Practice Guidance was used (19 kg N₂O/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. The new factory of Nitrogénművek applies the EnviNO_x technology (please see further details below) consequently a drastic reduction of emission has been reached. N₂O emission from nitric acid production was decreased by 99% between base year and 2009.

Since 2013 nitric acid plants fall within the scope of EU ETS as well, so, measurement of N₂O is also required and regulated by the EU ETS directive and 601/2013/EC Regulation that prescribes strict standards for the measurements and reporting.

Thus, the weighted average IEF 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, 0.087 kg/t in 2011, and 0.113 in 2012. In 2013 the IEF is higher again (0.25 kg/ t) that might be explained by the increasing production volume of the other reopened factory with a less efficient tail-gas treatment.

The amount of carbon dioxide generated during the reduction reaction by the tail gas treatment is so low that it has no detectable effect on the inventory as a whole. Since 2004 process tail gas has been

treated with ammonia, so CO₂ emissions are no longer an issue in this case. 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. As in new CRF Reporter Software there is no possibility to report CO₂ in 2.B.2 sector (no possibility to add child node), this CO₂ is reported under 2.B.1 together with other non-energy uses of natural gas in *Chemical Industry*.

Production data were obtained from the factories (*Figure 4.4.4*).

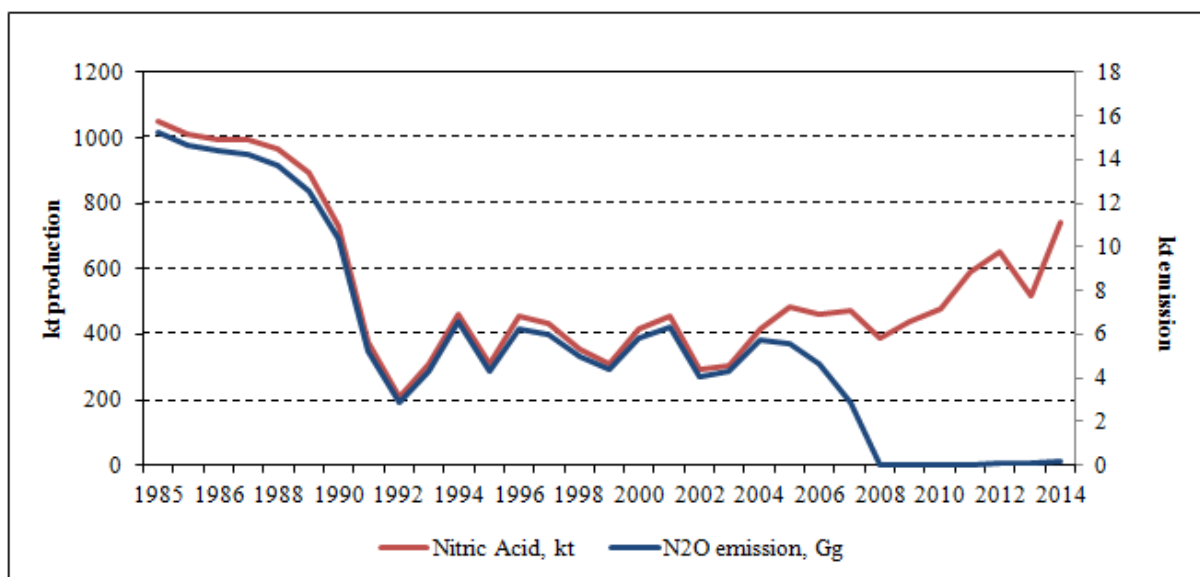


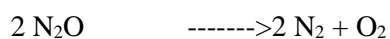
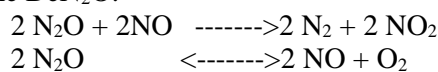
Figure 4.4.4 Nitric Acid production (kt) and N₂O emission in Nitric Acid subsector

EnviNO_x technology

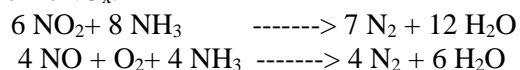
The EnviNO_x process is usually located between the final tail gas heater and the tail gas turbine and contains two catalyst beds filled with iron zeolite catalysts operating at the same pressure and temperature and a device for addition NH₃ between the beds. In the first DeN₂O stage, the N₂O abatement is effected simply by the catalytic decomposition of N₂O into N₂ and O₂. Since NO_x content of the tail gas promotes the decomposition of N₂O, the required DeNO_x stage is arranged downstream of the DeN₂O stage.

In the second stage, NO_x reduction is carried out using NH₃ as a reducing agent similar to natural gas.

Reactions in the DeN₂O:



Reactions in the DeNO_x:



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 ₂ O-REDUCTION IN TAIL GAS	%	min. 94 (initially)	99.63	99.64	99.63	99.63	
NO _x CONCENTRATION IN TAIL GAS DOWNSTREAM ENVI NOx® SYSTEM	ppm vol.	max. 25	5.7	5.6	5.7	5.7	
NH ₃ CONCENTRATION IN TAIL GAS DOWNSTREAM ENVI NOx® SYSTEM	ppm vol.	max. 5	Laboratory 0.19 AI0808 3.4	Laboratory 0.47 AI0808 3.3	Laboratory 0.57 AI0808 3.3	0.41 3.3	
NH ₃ CONSUMPTION IN ENVI NOx® SYSTEM	mol NH ₃ / mol NO _x	max. 2.2	1.36	1.36	1.36	1.36	
NATURAL GAS HYDRO- CARBON CONSUMPTION IN ENVI NOx® SYSTEM	mol H.C. / mol N ₂ O	max. 0.2	0.077	0.078	0.077	0.077	

Figure 4.4.5 Presentation of performance of EnviNO_x technology

For a short description of the used technology can be found in a brochure prepared by ThyssenKrupp Industrial Solutions (see 4.10 References, ThyssenKrupp). Performance of EnviNO_x technology at Nitrogénművek Zrt. is presented on Figure 4.4.5 above.

4.4.2.3 Uncertainties and time-series consistency

Uncertainties are estimated based on the minimum requirements of EU ETS Monitoring and Reporting Regulation (601/2012/EU) for the determination of AD and EF in the case of nitric acid production:

Uncertainty		AD	EF	Combined
2B2 Nitric Acid Production	N ₂ O	7.5	7.5	10.61

4.4.2.4 Source-specific QA/QC information and verification

General QA/QC procedures apply. The data received directly from factories and the requirements of EU ETS since 2013 greatly improved the quality of data.

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

There was no recalculation in last year.

4.4.2.6 Source-specific planned improvements

Further verification of the calculation method of previous years is planned.

4.4.3 Petrochemical and Carbon Black Production (CRF sector 2.B.8)

4.4.3.1 Source category description

Emitted gas: CO₂, CH₄

During petrochemical production processes, mainly oil products are used as feedstock or other non-energy purposes. Most of the carbons contained in these raw materials are stored in the products too, however during the conversion processes some carbon is emitted in the form of CO₂ or CH₄.

Usually it is very hard to distinguish the energy and non-energy uses of fuels during the complex processes in petrochemical production. Therefore the suggestion of the 2006 IPCC Guidelines is to be followed:

„Combustion emissions from fuels obtained directly or indirectly from the feedstock for an IPPU process will normally be allocated to the part of the source category in which the process occurs.”

„If surplus methane or hydrogen from the steam cracking of naphtha is combusted within the petrochemical site for another process then the emissions are reported as emissions in IPPU, 2B8. On the other hand, if the gases are passed to a nearby refinery for fuel use then the associated emissions would be reported under 1A1b, Petroleum Refining.”

In the case of Hungary, no gases are passed for fuel use out of the petrochemical companies, but all are used inside. Therefore all emissions are reported here in 2.B.8 including the natural gas reported by the petrochemical and carbon black production companies. In addition of course, all oil products considered as non-energy use (NEU) in IEA Energy Statistics are considered here in sector 2.B.8, except for lubricants and paraffin waxes (reported in 2.D.1-2).

In Hungary production of ethylene, dichloroethylene (DCE for the purpose of production of further petrochemical products like TDI/MDI) and carbon black are present. Ethylene is made from naphtha. Very few and well-known companies are operating in this sector in Hungary.

Production of bulk organic chemicals fall within the scope of EU ETS since 2013, so the availability of detailed, plant-specific data is even more improved. However EU ETS data has been available already since 2008 for most of the sources of these companies.

4.4.3.2 Methodological issues

CO₂ emissions are reported using plant-specific data from the year 2008 using the very detailed and good quality data from reporting of companies within the EU ETS framework. The good quality of data reported under EU ETS is ensured by the strict monitoring and reporting requirements of Regulation 601/2012/EC including the obligation of the control by independent, accredited verifiers. EU ETS Annual emission reports are available for HMS for GHG Inventory preparation purposes.

For the years before 2008 extrapolation is applied using the appropriate petrochemical production data from HCSO as surrogate data.

Please note that extrapolation of emissions is made based on quantities of petrochemical products (ethylene + DCE + carbon black), and the activity data in CRF in 2.B.8 is also kilotons of products.

But, of course the time-series of non-energy use of oil products (as raw material in petrochemical production) in IEA EnStat have been taken into account, as all emissions from these sources are excluded from *Energy* sector and reported here. So, in order to be consistent with both EU ETS reports of petrochemical companies and IEA Energy Statistics (EnStat), the emissions are reported in 2.B.8 based on EU ETS reporting, and it is supposed that all non-energy use of oil from IEA EnStat and some amount of natural gas (reported by the companies) were used for the production.

In this way, IEF compared to petrochemical products is stable (see red line on *Figure 4.4.6* below), while IEF compared to NEU Oil products in IEA EnStat is changing as it is possible to see at the same figure (blue line). But this problem seems to originate from the original time-series of the NEU Oils in the IEA EnStat, as the trend of petrochemical products (t) per NEU Oils (TJ) is changing, too (see green line on the figure).

Unfortunately it seems that the allocation of NEU Oils within the IEA EnStat is not consistent across the years, so this question is to be clarified with the authority responsible for the preparation of the energy statistics.

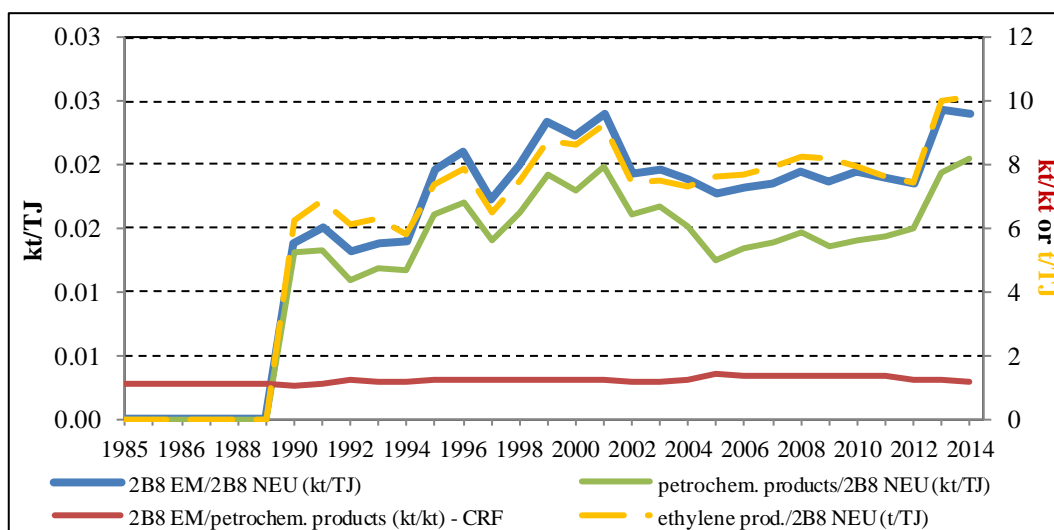


Figure 4.4.6 Trend of implied emission factors in 2.B.8 compared to petrochemical production and the amount of non-energy use of fuels

As EU ETS annual emission reports contain only all CO₂ emission sources, CH₄ is reported based on default Tier 1 emission factors from the 2006 IPCC Guidelines for the whole time-series.

Table 4.4.3 below shows the emissions by type of raw material used, while emissions by type of petrochemical products are included in CRF.

Table 4.4.3 Trend of emissions in 2.B.8

	SUM CO ₂ from NatGas (kt CO ₂)	SUM CO ₂ from NEU Oils (kt CO ₂)	SUM CH ₄ (kt CO ₂ -eq)	SUM 2.B.8 (kt CO ₂ -eq)
1985	95.90	477.07	20.47	593.43
BY	95.79	475.47	20.40	591.66
1986	95.70	474.14	20.34	590.18
1987	95.77	475.20	20.39	591.36
1988	95.01	464.23	19.92	579.15
1989	94.76	460.65	19.77	575.18
1990	91.41	412.78	17.73	521.91
1991	88.31	447.25	19.18	554.75
1992	87.94	494.62	21.19	603.76
1993	93.24	486.87	20.88	600.99
1994	104.00	536.20	20.78	660.98
1995	114.92	583.99	20.51	719.42
1996	116.63	602.21	20.95	739.78
1997	126.79	641.74	22.69	791.22
1998	133.90	680.40	23.89	838.19
1999	129.59	648.77	22.77	801.13
2000	145.85	763.44	27.66	936.94
2001	147.79	753.46	27.22	928.47

	SUM CO ₂ from NatGas (kt CO ₂)	SUM CO ₂ from NEU Oils (kt CO ₂)	SUM CH ₄ (kt CO ₂ -eq)	SUM 2.B.8 (kt CO ₂ -eq)
2002	141.33	776.84	27.63	945.79
2003	139.77	756.67	26.72	923.15
2004	133.87	802.72	28.31	964.90
2005	154.52	1186.71	44.79	1386.01
2006	163.67	1167.36	43.62	1374.65
2007	183.71	1289.10	48.94	1521.75
2008	160.30	1218.37	45.74	1424.42
2009	142.82	1104.95	42.64	1290.41
2010	174.90	1233.56	44.96	1453.42
2011	150.34	1271.41	44.44	1466.19
2012	92.76	1087.74	37.03	1217.53
2013	104.88	1165.68	40.66	1311.22
2014	93.38	1173.28	41.70	1308.36

4.4.3.3 Source-specific QA/QC information and verification

General QA/QC procedures apply. Time-series in IEA EnStat, production data from HCSO and the EU ETS emission reporting data have been thoroughly compared as it is described above.

4.4.3.4 Source-specific recalculations

There was no recalculation in the last year.

4.4.3.5 Source-specific planned improvements

Further investigation of consistency of the trend of non-energy use of oils in IEA EnStat is needed.

4.5 Fluorocarbon Production (CRF sector 2.B.9)

Fluorocarbons are not produced in Hungary.

4.6 Metal Production (CRF sector 2.C)

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

4.6.1.1 Source category description

Emitted gas: CO₂, CH₄

In this subsector, 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 CO₂. Therefore, CO₂ 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 cca. 1%. (1% in the 2006 IPCC Guidelines). Also this is released in form of CO₂. 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 CO₂ 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 as an integrated iron and steel plant.

Processes within iron and steel production are very complex, using several fuels either for energy or for non-energy purposes. It is very hard to distinguish energy and non-energy use also in this case, so the recommendation of the 2006 IPCC Guidelines Vol. 3 Bo1.1 is followed that states:

“During these activities emissions may occur from both the fuel combustion and industrial process stages. However, it is often impractical or impossible to report separately the two types of emissions. Accordingly the following rule has been formulated to simplify reporting:

Combustion emissions from fuels obtained directly or indirectly from the feedstock for an IPPU process will normally be allocated to the part of the source category in which the process occurs. These source categories are normally 2B and 2C. However, if the derived fuels are transferred for combustion in another source category, the emissions should be reported in the appropriate part of Energy Sector source categories (normally 1A1 or 1A2).

Two examples may help illustrate the definition.

1. If blast furnace gas is combusted entirely within the Iron and Steel industry (whether for heating blast air, site power needs or for metal finishing operations) the associated emissions are reported in the IPPU source subcategory 2C1. If part of the gas is delivered to a nearby brick works for heat production or a main electricity producer then the emissions are reported in source subcategories (1A2 for 1A1a).”

The example mentioned above is presented in Hungary, one part of the blast furnace gas is used in own processes, while the other part is delivered to an electricity producer. This amount is reported here as “Recovery” and reported in 1.A sector. Please find the trend of emissions and the trend of production in Iron and Steel sector in Figure 4.6.1 below.

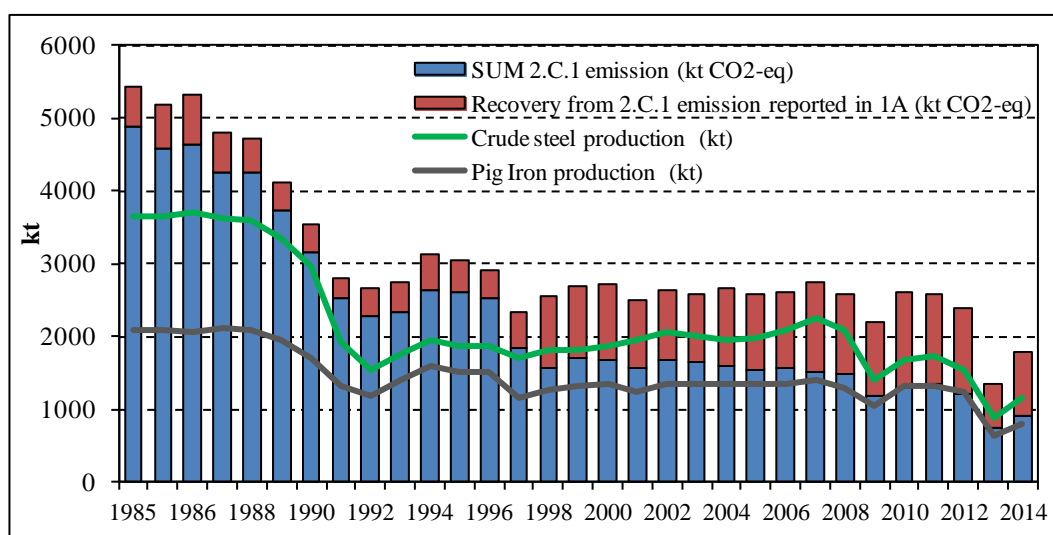


Figure 4.6.1 Trend of production and emissions in Iron and steel sector

As it is possible to observe, drastic reduction of the production occurred around 1990 and between 2012 and 2013, too, but in 2014 it seems that recession has stopped.

4.6.1.2 Methodological issues

Earlier only the emissions from carbon content reduction of the input materials during steel production and emission from consumption of graphite electrodes (2.C.1.1 subsector) were reported within this sector and all the other emissions were included elsewhere. The actual allocation of emissions is summarized in *Table 4.6.1*. All cell comments of IE cells in CRF tables have also been updated accordingly.

Table 4.6.1 Allocation of emissions connected to Iron and steel production

IPCC sector code	Activity	Emission source	From the 2015 submission - Emission reported in
1.A.1.a	Combustion of blast furnace gas recovered from Pig Iron production	combustion	1.A.1.a
1.A.1.c	Production of coke	combustion	1.A.1.c (including coke oven gas)
1.A.2.a	Combustion needed for iron and steel production	combustion	1.A.2.a (including coke oven gas)
2.C.1.d-e	Sinter	Coke consumption during sintering Limestone and dolomite use	2.C.1.d-e Sinter-Pellet
2.C.1.b	Pig Iron	Combustion Consumption of Natural gas for non-energy purposes Limestone and dolomite use Consumption of coke in the blast furnace (after deduction of the amount of recovered blast furnace gas delivered outside for energy production purposes)	2.C.1.b Pig Iron
2.C.1.a	Steel	Reduction of carbon content (from 4% to 1 %) Emission from graphite electrode during EAF steel production	2.C.1.a Steel

Emission factors

In the case of CO₂ emissions, default emission factors from the 2006 IPCC Guidelines or plant-specific emission and activity data were used which is available from both direct reporting to the inventory compiler (HMS) and from EU ETS reports. In the case of CH₄, default emission factors from the 2006 IPCC Guidelines are applied.

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, natural gas, coke oven gas in the blast furnace is extracted from IEA Energy Statistics of Hungary as well as the amount of blast furnace gas (BFG) recovered and used. Amounts of limestone and dolomite, other additives including graphite electrode in EAF steel production are available either from direct reporting of the companies to HMS or from EU ETS reports since 2005. Detailed plant-specific data is available from the EU ETS annual emission reports of the companies.

However, the precise allocation among the subsectors (e.g. the amount of coke used in blast furnace or by sintering) is sometimes not available in IEA Enstat. In these cases extrapolation based on the shares of subsectors in plant specific data is applied, but the sum of the subsectors is always the same as the IEA time-series. Please see the example of coke in the following table (*Table 4.6.2*).

4.6.1.3 Steel (CRF sector 2.C.1.a)

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 CO₂ 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. In order to avoid double counting these emissions should be subtracted from subsector *2.C.1.b Pig Iron*.

The default carbon content of pig iron is: 4% (2006 IPCC Guidelines). In the case of carbon content of steel this guidelines specify it as 1%, which is in accordance with plant specific (EU ETS annual emission report) data.

In the case of EAF steel production, data is available in the EU ETS emission reports on carbon content reduction during the process from 2008, therefore plant-specific data is used for the reporting of emissions from EAF steel production and extrapolation of the average of years 2008-2012 is applied using EAF steel production as surrogate data. The factor calculated as average of years 2008-2012 is 0.055 compared to the default 0.05 t CO₂/ t EAF steel.

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.b*.

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

4.6.1.4 Pig Iron (CRF sector 2.C.1.b.)

Emission from the use of coke, natural gas, coke oven gas (COG) and the own use of blast furnace gas is reported in *2.C.1.b*.

In addition use of limestone, dolomite and other ores and additives is also included here, so the whole process of pig iron production is aimed to be reported here.

The blast furnace gas (BFG) recovered and delivered for energy production purposes is reported in *1.A* sector, while the CO₂ emissions during the carbon content reduction in steel production process (originating from the coke) is reported in *2.C.1.a*.

Time-series of coke, BFG, COG and natural gas are available in IEA EnStat, but the precise allocation is not included (or not consistent). But plant specific data on the exact allocation is available from the year 2004, therefore extrapolations are applied where needed (please see the example in above on allocation of coke consumption from IEA EnStat and within subsectors of 2.C.1). In addition plant-specific net calorific values had been prioritized, where available.

CO₂ emissions from coke (and the amount recovered) are reported using plant-specific data from 2008. For the years before 2008 extrapolations are applied using default emission factors. In the case of CH₄ emissions, emissions from natural gas, COG, limestone and dolomite use are calculated using default factors from the 2006 IPCC Guidelines. Emission from other ores and additives is reported using plant-specific data from 2007 (first year where available) and extrapolation is applied using the average of the implied emission factor of the last two years and pig iron production as surrogate data.

Table 4.6.2 Time-series of coke consumption in IEA EnStat and in 2.C.1

IEA EnStat			2.C.1		
Coke consumption in blast furnaces (Transformation)	Coke consumption in Iron and steel	SUM IEA	2.C.1.b Pig Iron coke used in BF	2.C.1.d Sinter coke used in sinter	SUM 2.C.1
kt	kt	kt	kt	kt	kt
1985	1 471	209	1 565	115	1 680
B.Y.	1 447	144	1 483	109	1 591
1986	1 525	112	1 525	112	1 637
1987	1 346	111	1 358	99	1 457
1988	1 292	141	1 335	98	1 433
1989	1 129	102	1 147	84	1 231
1990	1 040	16	984	72	1 056
1991	737	115	794	58	852
1992	656	158	758	56	814
1993	778	43	765	56	821
1994	891	50	877	64	941
1995	870	43	851	62	913
1996	815	63	818	60	878
1997	562	83	601	44	645
1998	597	100	649	48	697
1999	590	157	696	51	747
2000	639	108	696	51	747
2001	566	126	645	47	692
2002	606	112	669	49	718
2003	549	161	662	48	710
2004	570	170	689	51	740
2005	596	123	671	48	719
2006	601	111	665	47	712
2007	620	135	709	46	755
2008	599	123	668	54	722
2009	593	38	599	41	640
2010	686	52	689	49	738
2011	687	53	685	55	740
2012	661	49	661	49	710
2013	356	27	347	36	383
2014	462	30	443	49	492

Plant specific data (average share of SUM IEA Coke = 6.8%)

Please find the activity data used and the resulting emissions in 2.C.1.b Pig Iron subsector in Table 4.6.3 below.

Table 4.6.3 *Trend of activity data and emissions in 2.C.1 b Pig Iron subsector*

	Pig Iron produced	Coke consumption in BF	BFG recovered and used outside for energy	COG used in BF	NatGas Consump- tion in BF	Lime- stone used in BF	Dolomite used in BF	SUM CO ₂ Emission in 2.C.1.b	SUM CH ₄ emission in 2.C.1.b
	kt	TJ	TJ	TJ	TJ	kt	kt	kt	kt
1985	2 095	42 475	2 189	283	3 948	57	2	3898.98	0.43
B.Y.	2 085	40 234	2 364	436	3 930	57	2	3616.83	0.41
1986	2 054	41 388	2 690	411	3 871	56	2	3648.10	0.42
1987	2 107	36 837	2 214	616	3 971	58	2	3303.39	0.37
1988	2 093	36 231	1 868	679	3 945	57	2	3327.66	0.37
1989	1 954	31 123	1 443	694	3 683	53	2	2897.18	0.32
1990	1 697	26 699	1 446	629	3 198	46	2	2426.70	0.27
1991	1 314	21 541	1 090	656	2 476	36	2	2005.57	0.22
1992	1 176	20 580	1 503	618	2 216	32	1	1815.57	0.21
1993	1 407	20 783	1 615	576	2 652	38	2	1812.03	0.21
1994	1 595	23 820	1 936	794	3 006	44	2	2062.99	0.24
1995	1 515	23 111	1 674	876	2 855	41	2	2061.35	0.23
1996	1 496	22 226	1 553	746	2 820	41	2	1985.46	0.23
1997	1 140	17 470	1 972	746	2 149	31	1	1375.76	0.18
1998	1 259	19 204	3 859	716	2 373	34	1	1077.06	0.20
1999	1 310	20 649	3 939	614	2 469	36	2	1203.20	0.21
2000	1 340	20 719	4 141	673	2 526	37	2	1160.52	0.21
2001	1 226	19 194	3 685	273	2 311	33	1	1071.70	0.19
2002	1 335	19 946	3 800	118	2 516	36	2	1137.44	0.20
2003	1 333	19 535	3 711	311	2 512	36	2	1125.97	0.20
2004	1 351	20 237	4 236	358	2 952	14	0	1080.08	0.21
2005	1 338	19 589	4 063	369	2 453	25	0	1034.86	0.20
2006	1 336	19 619	4 065	906	2 186	20	0	1041.58	0.20
2007	1 394	20 881	4 659	1 031	1 869	24	0	955.43	0.21
2008	1 289	19 685	4 382	774	1 477	28	0	936.18	0.20
2009	1 050	17 743	3 999	300	605	36	0	799.40	0.18
2010	1 325	20 618	5 436	927	1 757	66	0	811.98	0.21
2011	1 315	20 354	4 980	831	1 692	61	0	814.11	0.21
2012	1 228	19 501	4 617	744	490	48	4	748.14	0.20
2013	628	10 121	2 504	380	530	14	5	429.21	0.10
2014	801	13067	3 593	599	816	38	0.8	507.98	0.13

4.6.1.5 Sinter and pellet (CRF sector 2.C.1.d-e.)

Amount of sinter or pellet produced is not available. However, the amount of coke and natural gas, limestone and dolomite and other ores and additives used during sintering is available from direct reporting of the company from the year 2004. For the years before 2004 extrapolation is applied using the implied emission factor of the last year or the average of the years available depending on the trend of the IEF.

CO₂ emissions from coke, natural gas, limestone, dolomite and “Other ores and additives” use are reported.

In addition CH₄ is estimated using default EF for coke (10 kg/ TJ coke), due to lack of data on the amount of sinter or pellet produced. CH₄ is reported from coke combustion in sinter plant and from 2016 submission also the CH₄ emission from natural gas use in sinter plant calculated with default EF has been included due to the recommendation received during the informal review organised by the EU in November 2015. However this recalculation causes less than 0.01 Gg increase in emissions.

Please find the activity data used and the resulting emissions in *2.C.1.d-e Sinter* subsector in the table below (*Table 4.6.4*).

4.6.1.6 Uncertainties and time-series consistency

Uncertainty values are estimated based on maximum uncertainties determined in EU ETS 601/2012/EC Regulation for Iron and Steel production. Uncertainties for CH₄ are estimated based on 2006 IPCC Guidelines.

Uncertainty		AD	EF	Combined
2C1 Iron and Steel Production	CH ₄	10	10	14.14
2C1 Iron and Steel Production	CO ₂	7.5	5	9.01

4.6.1.7 Source-specific QA/QC information and verification

General QA/QC procedures apply. Further verification with EU ETS emission reports is possible.

Please note that in Hungary a quite wide range of emission sources are allocated in present *2.C.1* sector, which might cause differences compared to other countries, although we believe that it is in line with reporting of the 2006 IPCC Guidelines as it is described in the introduction of this chapter above.

For example during the trial review performed by EU in November 2015 it was noted that the IEF is high compared to other countries both in *2.C.1.b* and *2.C.1.d-e* subsectors. The high IEF can be explained by the fact that several types of emissions, including emissions from BOF and limestone and dolomite use are also included in this category.

In addition it was also noted that in 1993, 1998 and 2013, the change in CO₂ emissions (total of 1.A.2.a and 2.C.1, compared to the previous year) deviated distinctly from the change in pig iron production (compared to the previous year). The explanation is that in HU Inventory BFG delivered outside from iron and steel factory and used for energy purposes is reported in 1.A.1.a sector. If BFG used for energy purposes (and reported in 1.A.1.a) is also taken into consideration, the trends are much more parallel (see *Figure 4.6.2* below). In this case the deviations from the trend of pig iron production in the years mentioned also disappear, except for the year 1993. In this year there might be some problem with pig iron production data, as the trend of emissions and the trend of fuel used in IEA EnStat are in agreement (see blue columns and green line in *Figure 4.6.2* below). The amount of BFG used within iron and steel production and delivered outside for energy purposes is based on IEA EnStat allocation.

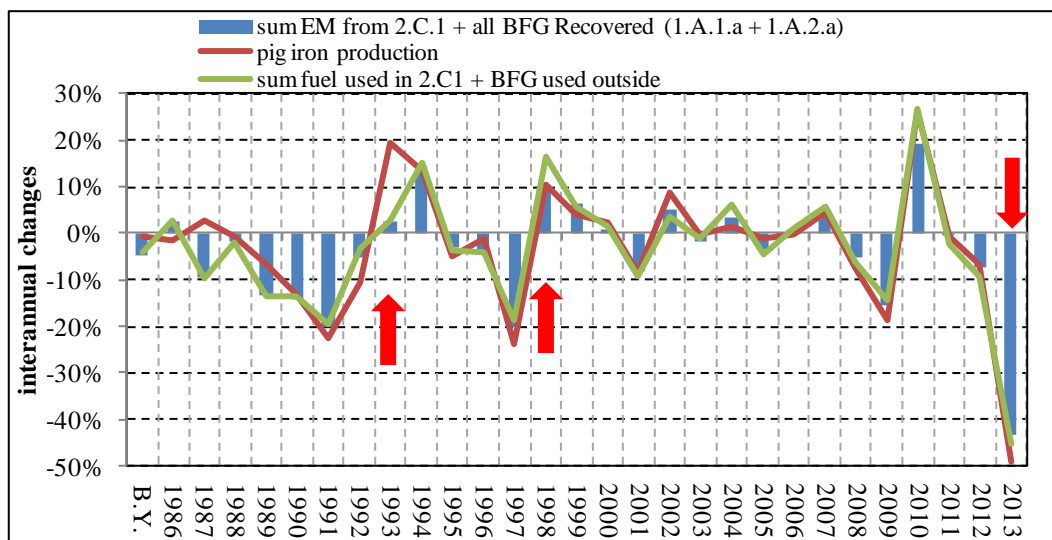


Figure 4.6.2 Comparison of trends of pig iron production, fuel use and the emissions allocated in different sectors in HU GHG inventory

4.6.1.8 Source-specific recalculations

CH₄ emission from natural gas use in *Sinter* subsector has also been included as it was recommended during the informal review organized by the EU in November 2015. However, this recalculation causes less than 0.01 Gg CO₂-eq increase in the time-series.

4.6.1.9 Source-specific planned improvements

Further improvement of the description calculation method in the NIR and further verification and completion of consistency with EU ETS annual emissions reports of iron and steel producer companies are planned.

Table 4.6.4 Trend of activity data and emissions in 2.C.1 d. Sinter subsector

	Coke consumption in sinter plant	NatGas consumption in sinter plant	Limestone used in sinter plant	Dolomite used in sinter plant	SUM emission 2.C.1d-e
	TJ	TJ	kt	kt	kt CO ₂ -eq
1985	3012	207	175	164	552.92
B.Y.	2853	206	174	163	532.59
1986	2935	203	172	161	539.88
1987	2612	208	176	165	504.99
1988	2569	207	175	164	498.49
1989	2207	193	163	153	441.91
1990	1893	168	142	133	380.91
1991	1528	130	110	103	302.49
1992	1460	116	98	92	282.03
1993	1472	139	118	110	303.84
1994	1687	158	133	125	346.70
1995	1637	150	127	119	333.53
1996	1574	148	125	117	324.17
1997	1157	113	95	89	241.74
1998	1250	124	105	99	263.61
1999	1339	129	110	103	279.07
2000	1339	132	112	105	281.70
2001	1241	121	103	96	259.62
2002	1287	132	112	104	274.89
2003	1273	132	111	104	272.96
2004	1333	113	78	137	280.52
2005	1264	157	91	124	273.85
2006	1228	125	104	108	265.50
2007	1147	127	118	103	263.00
2008	1408	137	137	78	293.31
2009	1086	108	91	49	214.35
2010	1338	120	137	65	281.98
2011	1462	128	139	100	310.75
2012	1296	131	110	100	279.04
2013	943	138	35	75	191.04
2014	1340	140	110	76	262.70

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

4.6.2.1 Source category description

Emitted gas: CO₂

Upon smelting alloying additive and iron, together with slag-forming additives, a reduction reaction occurs which results in release of CO₂.

Ferroalloy production was present in Hungary only between 1985 and 1990.

4.6.2.2 Methodological issues

Fuels were included in sector 1.A.2.A and only technological CO₂ emissions were calculated here. The production data were obtained from the HCSO.

Default Tier 1 emission factors from the 2006 IPCC Guidelines have been applied together with the new EF for CH₄ emission.

4.6.2.3 Uncertainties and time-series consistency

Uncertainties are estimated based on 2006 IPCC Guidelines.

Uncertainty		AD	EF	Combined
2C2 Ferroalloys Production	CH ₄	5	37.5	37.83
2C2 Ferroalloys Production	CO ₂	5	37.5	37.83

4.6.2.4 Source-specific QA/QC information and verification

General QA/QC procedure apply.

4.6.2.5 Source-specific recalculations

None.

4.6.2.6 Source-specific planned improvements

None.

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

4.6.3.1 Source category description

Emitted gases: CO₂, PFCs (CF₄, C₂F₆)

During alumina electrolysis, CO₂ 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 in Hungary.

4.6.3.2 Methodological issues

PFC emissions were calculated using Tier 1 methodology for CO₂ and Tier 2 methodology for PFCs recommended by the 2006 IPCC Guidelines.

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 4.6.5).

Very detailed, equipment-level data is also available from the factories on production, anode effect minutes per cell-day that makes possible the use of Tier 2 method for PFCs. Default slope coefficients from Table 4.16 of the 2006 IPCC Guidelines are applied.

The trend of emissions is also included in *Table 4.6.5* below. CO₂-eq emissions of PFC are calculated using new GWP values from IPCC 4th AR as it is required.

Table 4.6.5 Amount of aluminium produced (kt), and trend of CO₂ and PFC emissions

	Production of aluminium (kt)	CO ₂ Emission (kt CO ₂)	CF ₄ emission (kt CO ₂ -eq)	C ₂ F ₆ emission (kt CO ₂ -eq)
1985	73.86	125.57	333.35	34.09
B.Y.	73.75	125.37	336.50	34.58
1986	73.87	125.59	337.46	34.67
1987	73.51	124.96	338.67	34.99
1988	74.64	126.89	329.96	33.67
1989	75.19	127.82	357.52	36.90
1990	75.13	127.72	340.18	35.54
1991	62.88	106.89	293.23	30.37
1992	26.82	45.59	165.55	14.49
1993	27.88	47.39	178.93	15.66
1994	29.65	50.40	195.12	17.07
1995	31.91	54.25	204.80	17.92
1996	33.47	56.89	195.68	17.12
1997	33.67	57.25	195.06	17.07
1998	33.71	57.31	209.94	18.37
1999	33.64	57.19	214.99	18.81
2000	33.85	57.55	258.68	22.63
2001	34.59	58.80	243.64	21.32
2002	35.29	60.00	247.63	21.67
2003	35.04	59.56	231.16	20.23
2004	34.35	58.39	245.58	21.49
2005	31.78	54.03	255.15	22.32
2006-	NO	NO	NO	NO

4.6.3.3 Uncertainties and time-series consistency

Uncertainties are estimated based on 2006 IPCC Guidelines.

Uncertainty		AD	EF	Combined
2C3 Aluminium Production	CO ₂	2	10	10.20
2C3 Aluminium Production	PFC	2	99	99.02

4.6.3.4 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.

4.6.3.5 Source-specific recalculations

None.

4.6.3.6 Source-specific planned improvements

None.

4.7 Other Products Use (CRF sector 2.D)**4.7.1.1 Source category description**

Emitted gas: CO₂

In this sector CO₂ emitted during the use of lubricants and paraffin waxes are included. In these products carbon is mostly stored, however some carbon is oxidized and emitted in the form of CO₂ during their use. In addition CO₂ emitted during urea based catalyst in vehicles is reported in 2.D.3 subsector as it was suggested by EU experts; however these emissions are very low.

Indirect GHGs reported in an aggregated way under 2.D sector are taken from 2016 submission of CLRTAP Air Pollutants Emission Inventory of Hungary. In this way consistency is ensured with the other reporting obligation.

In this submission indirect CO₂ emissions from the oxidation of NMVOC has also been included, but solely from those sectors that had been reported before the 2015 submission too. This is in line with the recommendation of EU WG1 of February 2016 that states:

“According to paragraph 29 of the UNFCCC reporting guidelines for GHG inventories (Annex I to decision 24/CP.19) “Annex I Parties may report indirect CO₂ from the atmospheric oxidation of CH₄, CO and NMVOCs. For Parties that decide to report indirect CO₂ the national totals shall be presented with and without indirect CO₂”.

Para 37(b) the UNFCCC reporting guidelines states: “Once emissions from a specific category have been reported in a previous submission, emissions from this specific category shall be reported in subsequent GHG inventory submissions.”

Reporting of indirect CO₂ emissions is not mandatory (“may” in paragraph 29), however in combination with paragraph 37(b) those countries that included indirect CO₂ emissions in the past in their GHG inventories, shall continue to report indirect CO₂ emissions in their inventory.

In the case of Hungary, indirect CO₂ from the oxidation of NMVOC from old NFR sector 3 (NFR09 codes) had been reported before 2015 submission. This corresponds to NFR sector 2.D.3.a Domestic solvent use, 2.D.3.d Coating applications, 2.D.3.e Degreasing, 2.D.3.f Dry cleaning, 2.D.3.g Chemical Products Use, 2.D.3.h Printing, 2.D.3.i Other products use subsectors at the moment.

4.7.1.2 Methodological issues

CO₂ emission from lubricants and paraffin wax use are reported using Tier 1 method and default emission factors from the 2006 IPCC Guidelines (see Table 4.7.1).

Activity data is taken from IEA Energy Statistics.

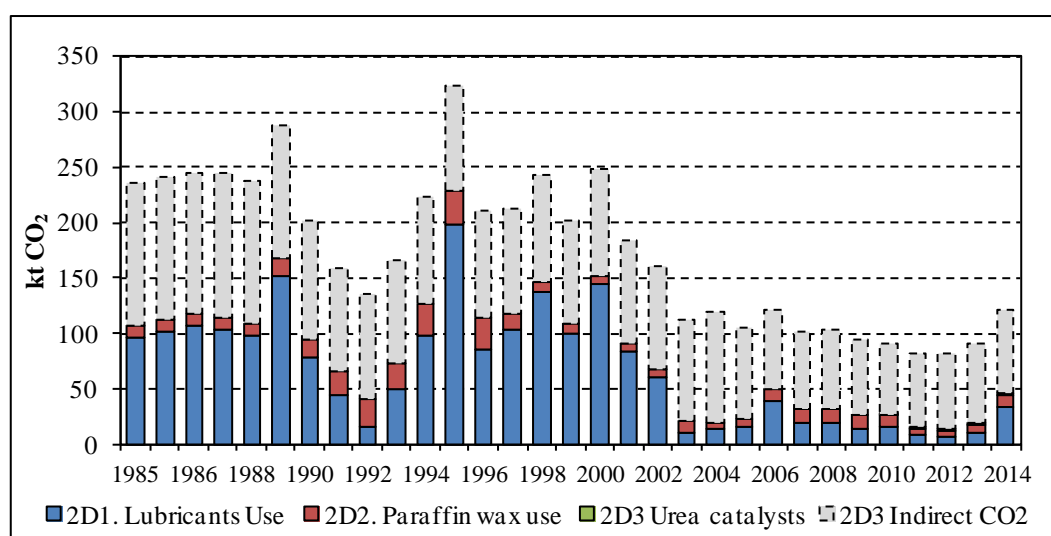
In the case of urea based catalyst in vehicles (2.D.3), emissions are reported using Tier 1 method and Eq.3.2.2 from Vol. 1 of 2006 IPCC Guidelines. Activity data is taken from COPERT model except form 2010 where extrapolation using diesel use as surrogate data is applied.

Table 4.7.1 Default emission factors applied in 2.D.1 and 2.D.2 sectors

	Lubricant Use
	Paraffin wax use
CC Lubricant = carbon content (default) kg C / GJ NCV (=t/TJ)	20
ODU - oxidised during use factor (default)	0.2

Indirect CO₂ emissions from the oxidation of NMVOC from subsectors mentioned above have been included using default 0.6 t C/ t NMVOC value from 2006 IPCC Guidelines (Volume 1, Chapter 7, p. 7.6).

Please note that the same values have been used in case of submissions before 2015 of Hungary. Please find the trend of emission at the *Figure 4.7.1* below:

**Figure 4.7.1** Trend of CO₂ emissions in sector 2.D

Please note that the trend of emissions from lubricant and paraffin wax use is consistent with the trend of lubricant and paraffin wax use in IEA EnStat.

4.7.1.3 Source-specific QA/QC information and verification

General QA/QC procedures apply.

4.7.1.4 Source-specific recalculations

In subsector 2.D.1 *Lubricant Use*, data of year 2013 has been recalculated due to the fact that IEA EnStat does not contain data on non-energy use of lubricants. IEA/Eurostat joint questionnaires on oil products for Hungary contain nothing for lubricant use for non-energy purposes both in year 2013 and 2014, too. In this case the amount allocated in energy use has been used in 2.D.1 sector, as recommended during the informal review organized by the EU in November 2015.

4.7.1.5 Source-specific planned improvements

Further verification is needed in 2.D.3 *Urea based catalyst* subsector, in the case data becomes available.

4.8 Use of fluorinated greenhouse gases (CRF sector 2.E - 2.F – 2.G.1 – 2.G.2)

4.8.1 . General

4.8.1.1 Source category description

HFCs are chemicals containing only hydrogen, carbon, and fluorine, while PFCs contain only carbon and fluorine. HFCs and PFCs, SF₆ and NF₃ are included under the UNFCCC as they have high global warming potentials (GWPs). New GWPs from the IPCC 4th Assessment Report are applied as it is required by 24/CP.19 UNFCCC Guidelines (see *Table 4.8.1*).

HFCs (partially fluorinated hydrocarbons) and PFCs (perfluorocarbons) are used as substitutes for ozone depleting substances (CFCs, HCFCs, etc.) that are being phased out under the Montreal Protocol (therefore often are called as ODS Substitutes). HFCs and PFCs might be used alone or mixed in blends.

HFCs or their blends are used in household and commercial and transport refrigeration and air conditioning equipments; fire suppression and explosion protection equipments; in aerosol products; by solvent cleaning; as foam blowing agents and other applications.

PFCs were started to be used as an ingredient of cooling blends in 1997. In 1998 and 1999, some quantities were also used for adhesive tape production. Please note that PFCs are also emitted during aluminium production to be reported in sector 2.C.3 that used to be the main source of PFCs in the beginning of the time-series, but stopped in 2005.

SF₆ is mainly used as an insulation gas in electrical equipments, such as switchboards, switchgears. It was further used in the past as intermediate gas in double-glass heat insulation windows and production of optical bodies, etc. and in electronics industry for several years. In Hungary SF₆ is not used as a cover gas in coloured metal foundries.

NF₃ is mainly used in electronics industry, but no NF₃ use has occurred in the country as far as our present knowledge.

No HFCs or PFCs, SF₆ or NF₃ are produced in Hungary.

Trend of emissions of fluorinated greenhouse gases is presented in *Figure 4.8.1*.

Table 4.8.1 The list of F-gases and the GWP values to be used are defined in Annex III of Decision 24/CP.19

<i>Greenhouse gas</i>	<i>Global warming potentials (GWP)</i>
HFC-23	14800
HFC-32	675
HFC-41	92
HFC-43-10mee	1640
HFC-125	3500
HFC-134	1100
HFC-134a	1430
HFC-143	353
HFC-143a	4470
HFC-152	53
HFC-152a	124
HFC-161	12

<i>Greenhouse gas</i>	<i>Global warming potentials (GWP)</i>
HFC-227ea	3220
HFC-236cb	1340
HFC-236ea	1370
HFC-236fa	9810
HFC-245ca	693
HFC-245fa	1030
HFC-365mfc	794
PFC-14	7390
PFC-116	12200
PFC-218	8830
PFC-3-1-10	8860
PFC-318	10300
PFC-4-1-12	9160
PFC-5-1-14	9300
PFC-9-1-18b	>7500
c-C₃F₆	>17340
SF₆	22800
NF₃	17200

The applicable GWPs are determined based on the effects of greenhouse gases over a 100-year time horizon as provided by the IPCC in its Fourth Assessment Report.

Emissions are to be reported by gas in the inventory (*Figure 4.8.1*), so the blends/preparations containing different F-gases need to be proportionated.

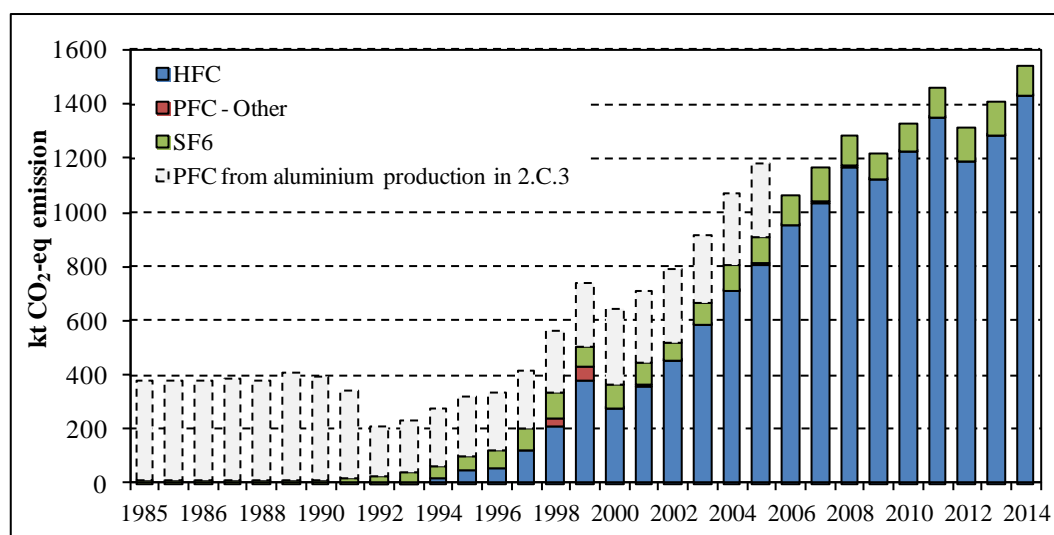


Figure 4.8.1 Trend of emissions of HFCs, PFCs and SF₆ in Hungary (kt CO₂-eq)

This category includes the following subcategories: *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), *2.E – SF₆ use in Electronics industry* (solely for the years (2000-2005), *2.G.1 – SF₆ use in Electrical Equipment Manufacture*, *2.G.2 – Other SF₆ use*. Figure 4.8.2 shows the trend of emissions by subcategories.

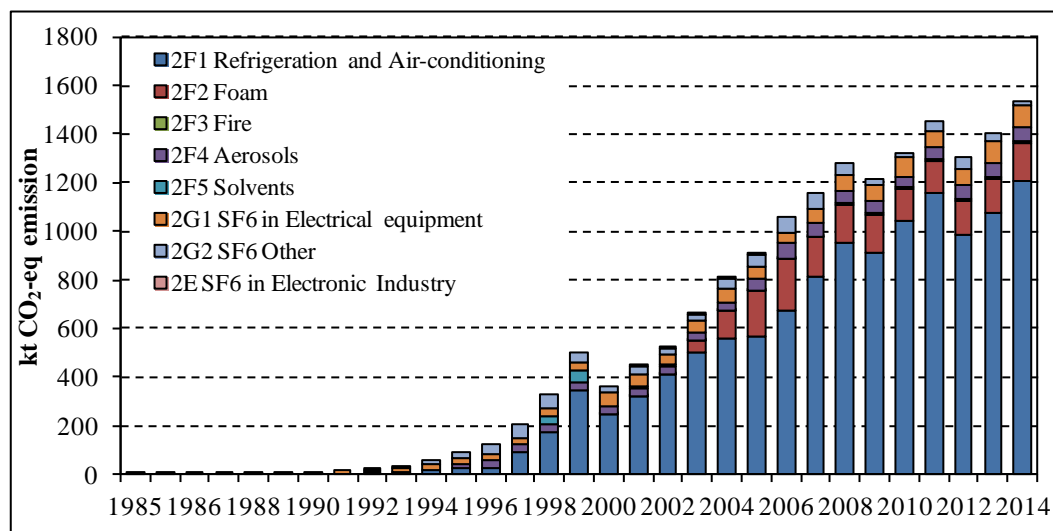


Figure 4.8.2 Trend of F-gases emissions by subcategories (kt CO₂-eq)

4.8.2 Electronics Industry (CRF 2.E)

Emitted gases: SF₆

During the search for potential emission sources of fluorinated gases from electronics industry, no NF₃ use has been identified in Hungary, but it came out that some SF₆ has been used between 2001 and 2005 by a semiconductor manufacturer company. So, SF₆ is reported in 2.E sector solely between years 2001 and 2005 based on the data provision of a semiconductor manufacturer company. They also declared that the SF₆ has been acquired domestically, so the amount was allocated from the time-series of annual sales of SF₆ for other use in order to avoid double-counting. This fact is in line with Table 6.7 of Volume 3 of the 2006 IPCC Guidelines, where some amount of “Si design capacities” from Hungary is listed for the years 2003-2005.

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

Emitted gases: HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-236fa, HFC-245fa, PFC116 (C₂F₆), PFC218 (C₃F₈), PFC-5-1-14 (C₆F₁₄)

The use of HFCs started in 1992, first in household refrigerators. Then the use of HFCs as a refrigerant in household refrigerators has strongly declined (for example the only Hungarian producer of household refrigerators uses exclusively R600 (isobutane) for years), and commercial, industrial refrigeration and air-conditioning became more and more important.

Coverage of all gases and all 2.F.1 subsectors are ensured by the fact that both a Hungarian and an EU-level Regulation are in force that require quite detailed data provision. The scope (list of gases to be reported) of Govt.Decree 310/2008 on fluorinated gases is the same as the scope of 842/2006/EC Regulation of the EU on F-gases, which is the same as the UNFCCC.

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

Please note that in Hungary, Govt.Decree 310/2008. (XII. 20.) is not in force since February 2015, because it has been replaced by Govt.Decree 14/2015. (II.10) and also 842/2006/EC Regulation of the EU on F-gases has been replaced by Regulation (EU) No 517/2014 in year 2014.

4.8.3.1 Methodological issues

Hungary uses Tier 2 mass-balance approach for the estimation of emissions. So, Equation 7.9 from Vol.3 of the 2006 IPCC Guidelines is applied, where data on annual sales of new refrigerant; total charge of new equipment, original total charge of retiring equipment and amount of intentional destruction is needed.

Annual sales of New Refrigerant

Annual sales data is calculated as import-export of bulk chemicals. Documented, consistent time-series of import-export exists since 1992, thanks 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 the 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 (HMBC) 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 Agriculture). Consistency of the time series is ensured by the fact that it was checked that the wholesale companies reporting to the Ministry of that time are the same companies that report to the HMBC database too (except for the natural changes of the market, like cessations and entries of course).

The Hungarian Monitoring and Certification Body was also appointed for certification of persons required by 842/2006/EC ("EU F-gas Regulation"). HMBC and the database were maintained by the Association of Cooling and Air Conditioning Businesses. 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 Hungarian 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

Govt.Decree 310/2008. (XII.20.) is now replaced by Govt.Decree 14/2015 (II.20) that moves the responsibilities of HMBC to the newly established National Climate Protection Authority. The Authority takes over all responsibilities required by 517/2014/EC Regulation and the handling of the HMBC database that it is now renamed as "F-gas database".

In the Hungarian calculation method, the imported products and equipment containing F-gases (e.g. air conditioners) are considered, because also in this case bulk chemical is used for filling of new or refill after leakage. In other words, annual sales of bulk chemical might be used either for refill of equipment (including leakage from imported equipment) or for filling of new equipment (including imported equipment that was not filled originally). The former is the basis of reporting of annual operational emissions, while the latter is the basis for reporting of disposal emissions as it is described in NIR chapter 4.8.3.1. So, it is assumed that also emissions from import in products and equipment are reported.

In the case of annual sales and the amount destructed in year 2014 unfortunately data is not yet available due to major restructuring of the institutes handling the database. Therefore for this year temporarily, extrapolation was used. Extrapolation is performed solely for the year 2014 by using the trend of annual sales data available by HCSO as surrogate data (see *Figure 4.8.3*). Annual sales of items including fluorinated substances (Combined nomenclature codes of EuroStat: 382471; 382474; 382478; 382479) shows 8% increase by the HCSO.

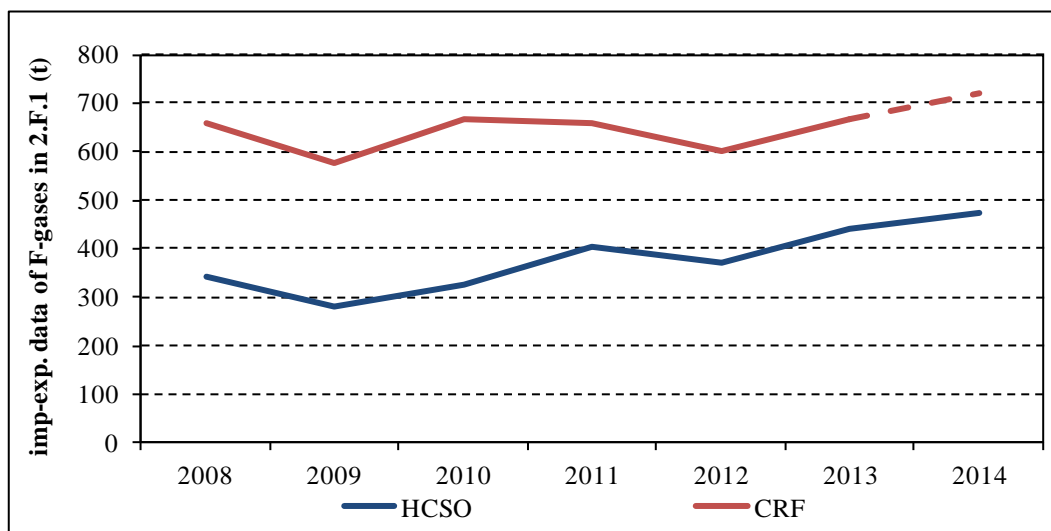


Figure 4.8.3 Trend of annual sales data of F-gases by HCSO and the F-gas database

Total Charge of New Equipment

Data on intended use (proportion of quantities used for new or for recharge) from the F-gas database became available from year 2010. The average of 2010 and 2011 new / recharge % by gas has been used for the calculation of total charge of new equipment since 2014 submission.

The average of 2010 and 2011 data on intended use resulted in the following values by gas (*Table 4.8.2*).

Table 4.8.2 Average of 2010 and 2011 data of intended use by gas

	new %
HFC 23	53.60%
HFC 32	45.67%
HFC 125	38.84%
HFC 134a	35.41%
HFC 143a	43.76%
HFC 152a	100.00%
HFC-236fa	100.00%
PFC116 - CF4	34.49%
PFC218 - C3F8	19.15%

Due to the design of the CRF Table (where emissions from manufacturing, from stocks, from disposal is to be distinguished) 1% of the amount calculated as total charge of new equipment is included in the row “emissions from manufacturing” and regarded as prompt emission.

Original Total Charge of Retiring Equipment

Determination of original total charge of retiring equipment is the total charge of new equipment lifetime years ago. An average lifetime of 12 years has been applied based on Table 7.9 and chapter 7.5.2.2 on Choice of Emission Factors from Vol. 3 of 2006 IPCC Guidelines.

Amount of Intentional Destruction

Solely final thermal treatment by hazardous waste incineration facilities is estimated and subtracted as "Amount of Intentional Destruction". Estimation is based on data reported by incineration facilities and data extracted from F-gas database as it is detailed below.

Hungarian Govt.Decree 440/2012 (XII. 29.) requires the reporting of 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 the Unit of National Emissions Inventories of HMS has also full access. Several aggregated time-series (including aggregated amount of wastes by EWC code) are also publicly available at: <http://web.okir.hu/en/> (in English).

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 are presented in the following *Table 4.8.3* 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 4.8.3 *Data on destruction of F-gases*

	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
2004	1.82	0		0
2005	1.20	0		0
2006	8.42	0		0
2007	15.25	0		0
2008	13.22	0		0
2009	21.12	0		0
2010	14.95	61.44%	Average of the share of HFC/PFC within sold quantities by certified companies reported into HMCB database.	9.18
2011	12.02	61.44%		7.38
2012	17.03	92.53%	Data reported by HU destruction facilities required by Art.27 of 1005/2009/EC on ODS	15.75
2013	18.78	83.69%		15.72

Reporting by subcategories

It was a planned improvement to report the emissions from 2.F.1 *Refrigeration and Air-conditioning* divided into subcategories. So, after the emissions are calculated by HFC type as it is described above, the results are divided between subcategories.

A study published by the DG Climate Action of the EU (available at:

http://ec.europa.eu/clima/policies/f-gas/legislation/docs/refrigeration_air_conditioning_en.pdf)

prepared SKM Enviros on Possible Bans for New RAC Equipment (Version 1, February 15th 2013) (later: SKM Study) has been used for the division.

Table 3.1 of the SKM study determines the HFC demand of the six subcategories (Stationary AC and HPs and Chillers and hydronic HPs are regarded here together as Stationary A/C) as it can be seen in Figure 4.8.4.

Table 3.1: HFC Demand in 2010

Sector	kt CO2	% of HFCs	Key Subsectors
Domestic refrigeration	400	0.2%	
Commercial refrigeration	68,400	36.4%	Multipacks 32%
Transport refrigeration	2,700	1.4%	
Industrial refrigeration	23,000	12.2%	DX Systems 11%
Stationary AC and HPs	43,800	23.3%	Split systems 18%
Chillers and hydronic HPs	18,800	10.0%	
Mobile air-conditioning	30,800	16.4%	Cars / vans 11%
Total RAC Applications	187,700	100%	

Source: SKM Refrigerants Model

Figure 4.8.4 Copy of Table 3.1 of SKM Study on HFC demand of different subcategories

As it is possible to observe, this table is not detailed by HFC type. But the chapters describing the subcategories contain information on which type of HFCs (or blends) are used in which subcategory. HFC-134a is used in all subcategories, so the original contribution of the subcategories might be used.

In the case of other HFC types the contribution is divided only between the subcategories where the given HFC type is used. Please see the estimated contribution of the subcategories by HFC type in the following Table 4.8.4. So, the emissions are divided between the subcategories using these percentage contributions.

Table 4.8.4 Contribution of subcategories within 2.F.1 by HFC type

	HFC-134a	HFC-125	HFC-143a	HFC-32	All other
Domestic refrigeration	0.2%				
Commercial refrigeration	36.4%	36.4%	72.8%	36.9%	100%
Transport refrigeration	1.4%	1.4%	2.8%		
Industrial refrigeration	12.2%	12.2%	24.4%	12.4%	
Stationary A/C	33.3%	33.6%		34.1%	
MAC	16.4%	16.4%		16.6%	
SUM	100%	100%	100%	100%	100%

Reporting in CRF

Unfortunately CRF is designed for reporting using emission factor approach, so we had to apply specific allocation. Please find the explanations of the values inserted into the appropriate cells of the CRF in Table 4.8.5 below, following the structure of the CRF:

Table 4.8.5 Explanation of reporting in CRF of 2.F.1 sector of Hungary

ACTIVITY DATA Amount of fluid		
Filled into new manufactured products	In operating systems (average annual stocks)	Remaining in products at decommissioning
<i>new% * annual sales</i>	FOR INFORMATION ONLY! (Not used in the calculations, since it is not needed for mass-balance approach);	amount of fluid filled in new 12 years before
<i>new% is the proportion of the use intended to charge new equipment</i>	accumulation of "amount of fluid filled in new" of the year n years before n= lifetime = 12	
EMISSIONS		
From manufacturing	From stocks	From disposal
k % of amount of fluid filled in new <i>k= manufacturing/initial emission factor= 1 %</i>	annual sales - amount of fluid filled in new manufactured products (total charge of new equipment)	remaining in products at decommissioning – intentional destruction (NO recovery is distinguished)

4.8.3.2 Uncertainties and time-series consistency

Uncertainties are estimated taking into account the uncertainty of a legally binding data provision of the companies.

Uncertainty	AD	EF	Combined
2.F.1 Refrigeration and Air Conditioning Equipment - HFC+PFC	10	10	14.14

4.8.3.3 Source-specific QA/QC and verification

General QA/QC procedures apply.

In addition, several consultations have been organized with external experts and experts from the HMCB since 2012.

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). No findings or recommendations have been received during these occasions.

In 2013, Hungary 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) has 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 Refrigeration and Air Conditioning

Equipment 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, which is now included.

4.8.3.4 Source-specific recalculations

In this submission the sum of emissions did not change in the time-series, but the division of emissions within the 6 subsectors have slightly been changed as it was recommended by the informal review organized by the EU in November 2015. In *Mobile Air-conditioning (MAC)* subsector solely HFC-134a is now reported and other HFCs are allocated into other subsectors within 2.F.1.

4.8.3.5 Source-specific planned improvements

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 in Hungary and the effect for the emissions is also planned in the future.

As recommended also by the informal review organized by the EU in November 2015, there are two more planned improvements. The first is that the parameter on the intended use (charge of new equipment/ refill quantities) established on the basis the average of the data reported by companies in the years 2010 and 2011 is planned to be updated. In addition the split into subcategories that is based on the shares of HFC demand in 2010 could also be updated in the future.

4.8.4 Foam Blowing (CRF sector 2.F.2)

Emitted gases: HFC 134a, HFC-152a, HFC-227ea, HFC-365mfc

4.8.4.1 Methodological issues

Country specific method is applied using activity data derived from PRODCOM statistics and emission factors from the 2006 IPCC Guidelines. This method has been developed due to the requirement of ERT during 2012 review and has been checked during the EU MS Support Project (described in chapter 4.8.3.3.)

The new method of 2006 IPCC Guidelines is basically different because it encourages the inclusion of emissions from decommissioning and recovery. Please note that no decommissioning losses and destroyed quantity are reported currently but at the moment no product have yet reached the estimated (default) end of lifetime and no specific information is available on any destructed quantity or recycling technology.

Emissions of different gases from 2.F.2 Foam blowing sector are summarized in *Figure 4.8.5*.

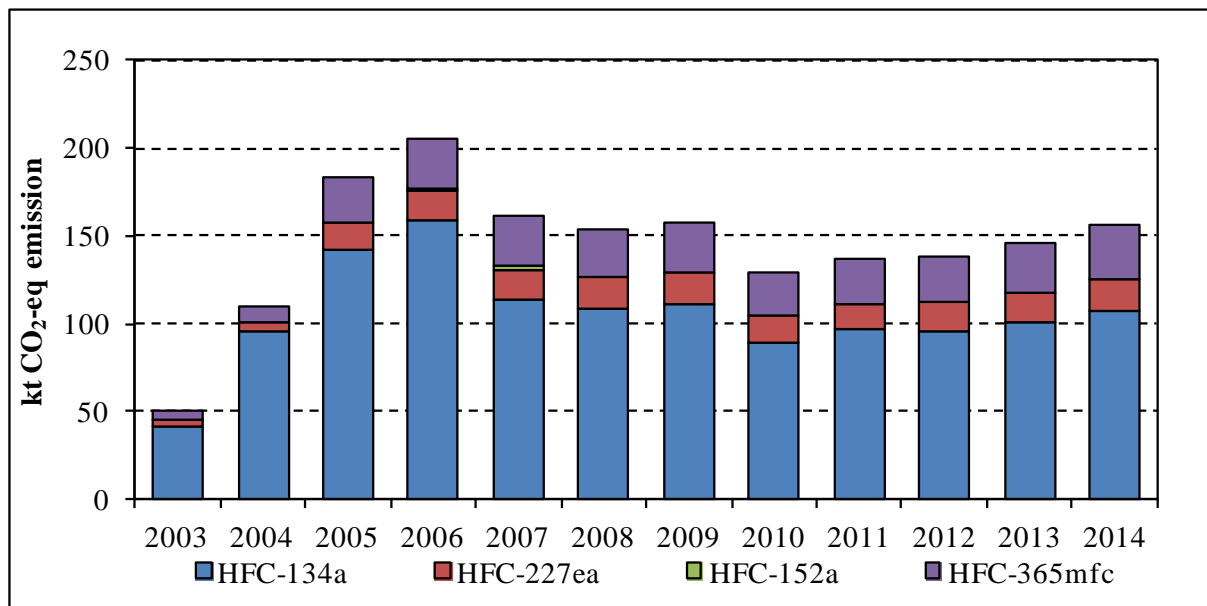


Figure 4.8.5 Emission of different gases from 2.F.2 Foam blowing (kt CO₂-eq)

At the moment we have no information on the use of HFC-245fa as foam blowing agent in Hungary. Until 2013 there was no reporting on any import or export of this gas into Hungary and the emission estimation method in 2.F.2 subsector does not include this gas either.

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. 7.7 of the 2006 IPCC Guidelines has been expressed, so default EF-s from Table 7.5 and 7.6 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 4.8.6* summarizes the values and their references used in the calculation.

Table 4.8.6 *Summary of factors used by the calculation in 2.F.2*

	XPS	PUR	Reference
domestic production of year t of foam product (t)	Prodcom Statistics		http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database
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 until 20%	20% and decreasing until 10%	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 the 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 and 2005 were averaged in order to avoid negative production+import-export values in the years 2006 to 2008 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 (CO₂, Hydrocarbons, HFO, etc.) The background study of F-gases Regulation Review of DG Climate states the ratio of HFCs among the blowing agents is 40% for XPS and 20% for PUR between 2003 and 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 (IPCC/TEAP, 2005), 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 have been recalculated based on this suggestion in sector 2.F.2.Foam.

Table 4.8.7 Proportions of HFC foam blowing agents applied by calculation in 2.F.2

		2007	2008	2009	2010	2011	2012	2013	2014	2015
% 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

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.

HFC-365mfc is reported the same as HFC-227ea because the company reported the use of a blend containing precise proportion of HFC -227ea and HFC-365mfc. So, HFC-365mfc is reported by multiplying the amount for HFC-227ea by this appropriate proportion. This method is the same as HFC-365mfc had been reported as cross cutting info in previous inventory submissions.

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. 7.8 of the 2006 IPCC Guidelines) and all hard foam is accounted as closed cell foam (using eq.7.7 of the 2006 IPCC Guidelines).

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 7.6 of the 2006 IPCC Guidelines are used for XPS and general default emission factors from 7.5 of the 2006 IPCC Guidelines are used for PUR as the proportion of the different types of PUR foams is not known. Used values are summarized in *Table 4.8.8*.

Table 4.8.8 Default emission factors used from 2006 IPCC Guidelines

	XPS	PUR
lifetime	50 years	20 years
first year loss	40%	10%
annual loss	3%	4.5%

In the case of soft foams (all accounted as open-cell foam) equation 7.8 of 2006 IPCC Guidelines is used, so ALL the filled amount is emitted during manufacture.

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

4.8.4.2 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 4.8.3.3). Several findings of the review have been implemented resulting recalculation in 2014 submission.

Uncertainties are estimated based on Table 7.9 of IPCC/TEAP, 2005 chapter 7- Foam , where it is stated for HFCs: +/- 21% and based on 2006 IPCC Guidelines chapter 7.4.3, where it is stated: “uncertainty of country specific consumption information may be more than 50 percent”.

Uncertainty	AD	EF	Combined
2.F.2 Foam Blowing – HFC	50	21	54.23

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.

4.8.5 Fire Extinguishers (CRF sector 2.F.3)

Emitted gases: HFC 125, HFC-227ea

4.8.5.1 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 as part of the yearly national statistical data collection program. 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. Comparison of the methods can be found in *Figure 4.8.6*.

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 emission factors have been applied:

Annual operational emission % per installed base	4%
Lifetime years	15-20 (not yet reached from 2003)

(source: 2006 IPCC Guidelines chapter 7.6.2.2, Tier 1 methodology)

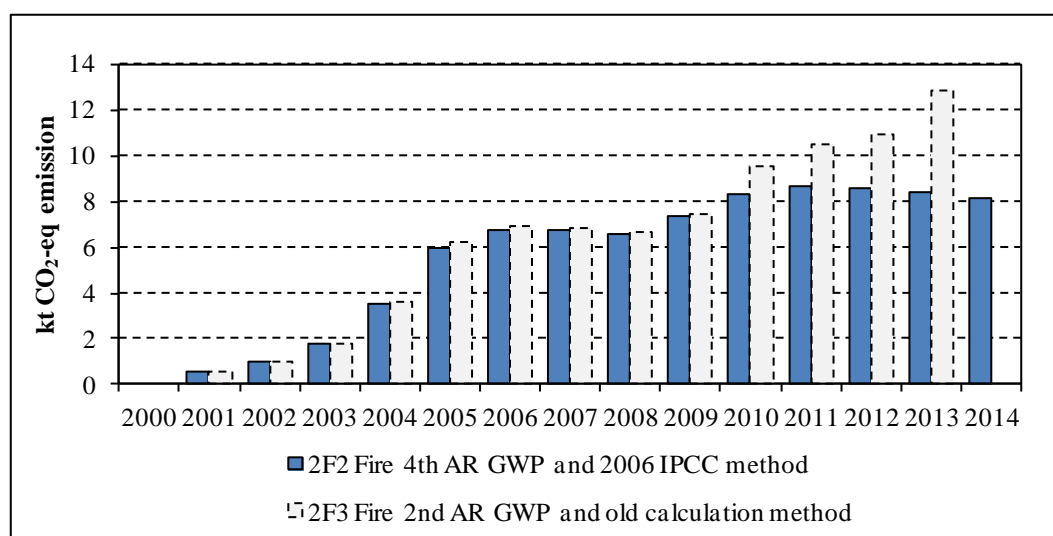


Figure 4.8.6 Trends of emissions using different methods and GWPs in sector 2.F.3 Fire

4.8.5.2 Recalculations, QA/QC activities, uncertainties and planned improvement

Application of the 2006 IPCC Guidelines caused recalculation, as default emission factors have been changed. The main change caused is the longer default life-time of the equipments, that causes the different trends of the new and the old methods that might be observed at *Figure 4.8.6* above. In addition there is no (TIER) name of the method in the 2006 IPCC Guidelines and the new GWPs are also applied of course.

A mistype error has been corrected affecting solely year 2012 and 2013 that caused less than 1 Gg increase of emissions.

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 the 2006 IPCC Guidelines chapter 7.6.4 regarding activity data and chapter 7.6.2.2 regarding the emission factor, where it is stated: “*factor range of 2 to 6 percent (that is 4 % +/-2%)*”

Uncertainty	AD	EF	Combined
2.F.3 Fire extinguishers - HFC	15	2	15.13

4.8.6 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.

Tier 1a method from the 2006 IPCC Guidelines is applied which “means that half of the chemical charge escapes within the first year and the remaining charge escapes during the second year” (chapter 7.3.2.2. of the Guidelines).

In addition a country specific calculation method is applied in MDI subsector suggested by the expert of EU MS Support Project organized by DG Climate Action (described in chapter 4.8.3.3). 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. *Figure 4.8.7* shows time-series of emissions of sector 2.F.4.

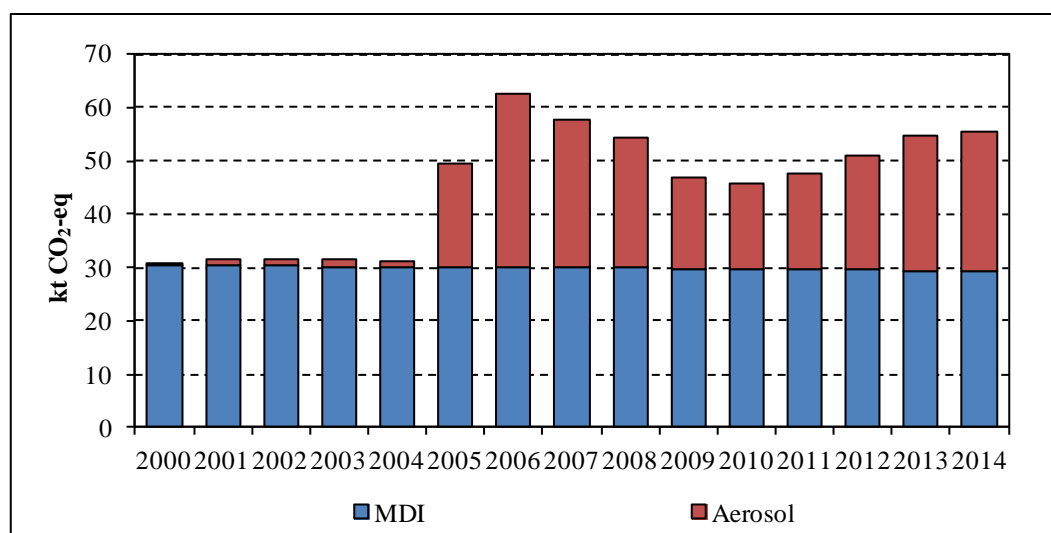


Figure 4.8.7 Trend of emission in sector 2.F.4 Aerosols and MDI

4.8.6.1 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 with following parameters:

Prevalence of asthma (and COPD) in Hungary: 4% (GINA report, 2004)

MDI share for Hungary: 65% - calculated as average of Germany: 50% and Spain: 80%

Relation of treatment methods: German default (t/ million) = 210 t HFC / 2,85 million = 73.68 (to be multiplied with population, prevalence and MDI share)

Share of the two types of HFC: HFC-134a / HFC-227ea = 0.93/ 0.07

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

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

The calculation method of subsector MDI was recommended and reviewed by the external expert during the EU MS support Project in order to include import in products.

Emissions are not changed but rows “filled into new products” within 2.F.4 sector have also been filled in within CRF as it was recommended by the informal review organized by the EU in November 2015.

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.

Uncertainties are estimated based on chapter 7.3.3 of 2006 IPCC Guidelines and taking into account that activity data is provided on one hand by individual companies, on the other hand national statistics are used.

Uncertainty	AD	EF	Combined
2.F.4 Aerosol + MDI(HFCs)	10	50	50.99

4.8.7 Electrical Equipment (CRF sector 2.G.2.)

Emitted gases: SF₆

4.8.7.1 Methodological issues

The application of the 2006 IPCC Guidelines causes a major change within this sector although still the basic Tier 1 method is applied. Old Tier 1 calculation method accounted only for potential emissions, while the new Tier 1 method estimated actual emissions. As it was expected, emissions are lower using the new method (see *Figure 4.8.8*).

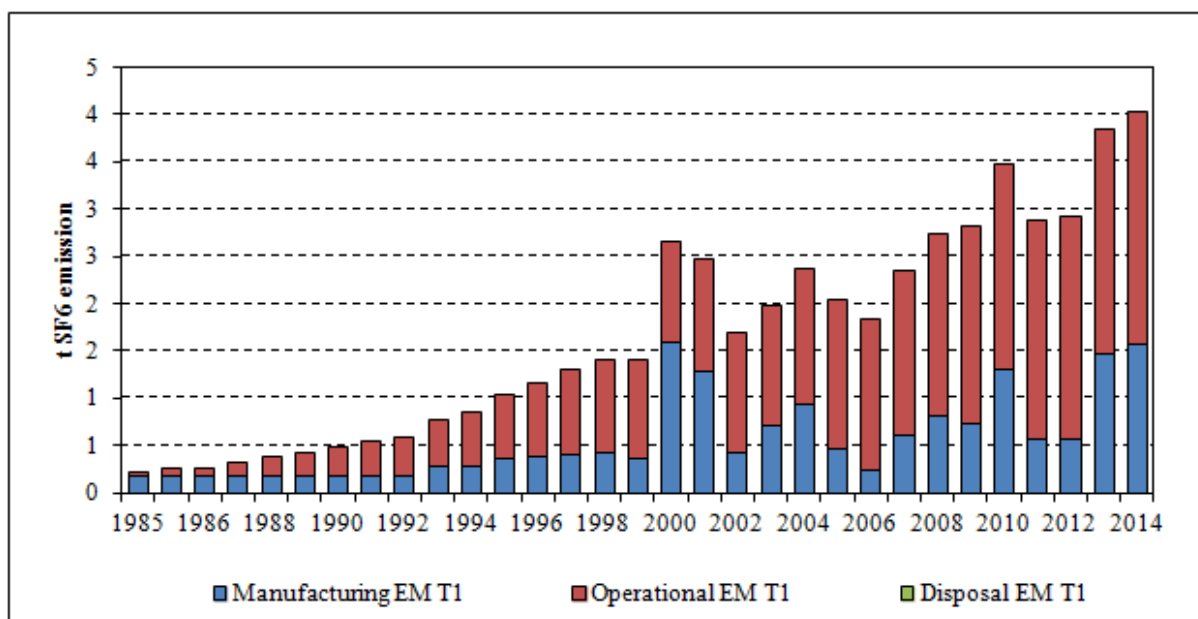


Figure 4.8.8 Trend of SF₆ emissions in 2.G.1 Electrical equipment sector (t)

Activity data

Annual sales data is the basis for the calculation in the new method, as well. Data was collected from both manufacturers and the Hungarian Electrotechnical Association. The latter was appointed to data collection by 310/2008. Govt. Decree for data collection on import-export of SF₆. This is the same time-series of annual sales data that had been used by the old calculation of potential emissions in previous submissions. However during the review of time-series it came out that the largest equipment manufacturer did not report any export before 1998. Therefore export data has been extrapolated using the import/export proportion of the last reported year (1998).

310/2008. Govt. Decree has now been replaced by 14/2015 (II.14) Govt. Decree that moves the responsibilities and the handling of the database to the newly established National Climate Protection Authority.

In the case of annual sales in year 2014 data is not yet available due to major restructuring of the institutes handling the database. Therefore for this year temporarily, volume index of electrical equipment manufacture from HCSO (= 107 percent compared to last year) was used as surrogate data for extrapolation.

Emission factors

Default emission factor from Tables 8.2, 8.3 and 8.4 of the 2006 IPCC Guidelines are applied. As there is no information in the country what percent of electrical equipment are sealed pressure electrical equipment (MV switchgear) or closed pressure electrical equipment (HV switchgear) or gas insulated transformers, always the higher EFs are taken into consideration as conservative estimation.

Table 4.8.9 Emission Factors used in 2.G.1 sector

Manufacturing Emission Factor	0.085
Use Emission Factor	0.026
Fraction of SF ₆ remaining at retirement	0.930
Lifetime (years)	35

4.8.7.2 Recalculations, QA/QC activities, uncertainties and planned improvements

General QA/QC procedures apply. Emission factors (and resulting time-series) have been verified with those included in "Update on global SF₆ emissions trends from electrical equipment – Edition 1.1 Ecofys Emission Scenario Initiative on Sulphur Hexafluoride for Electric Industry (ESI-SF6)". Latter EFs are lower than the EFs in the 2006 IPCC Guidelines but it is planned to potentially include in the calculation method this more up-to-date information after further verification.

Uncertainties are estimated based on Table 8.5 of 2006 IPCC Guidelines, taking the highest value as conservative estimation. Activity data's uncertainties are estimated taking into account that activity data is provided by individual companies based on a legally binding data provision requirement.

Uncertainty	AD	EF	Combined
2.G Other Product Manufacture and Use - SF ₆	3	40	40.11

4.8.8 Other applications (CRF sector 2.G.2.)

Emitted gases: SF₆

4.8.8.1 Methodological issues

SF₆ used for sound-proof window production (only in the past due to the ban introduced by 842/2006/EC), scientific research and other non-defined purposes is included in sector 2.G.2.

Equation 8.23 from the 2006 IPCC Guidelines is applied, so emissions are considered as 'prompt' emissions that is recommended in the case of any other applications. At the moment this method is applied also in the case of sound-proof windows due to lack of complete data, but it is a planned improvement to estimate these emissions separately. This means that emissions are distributed within two years, "because both sales and emissions are assumed to be continuous over the year; that is, chemical sold in the middle of year $t-1$ is not fully emitted until the middle of year t ." (Chapter 8.3.2.2 of the 2006 IPCC Guidelines).

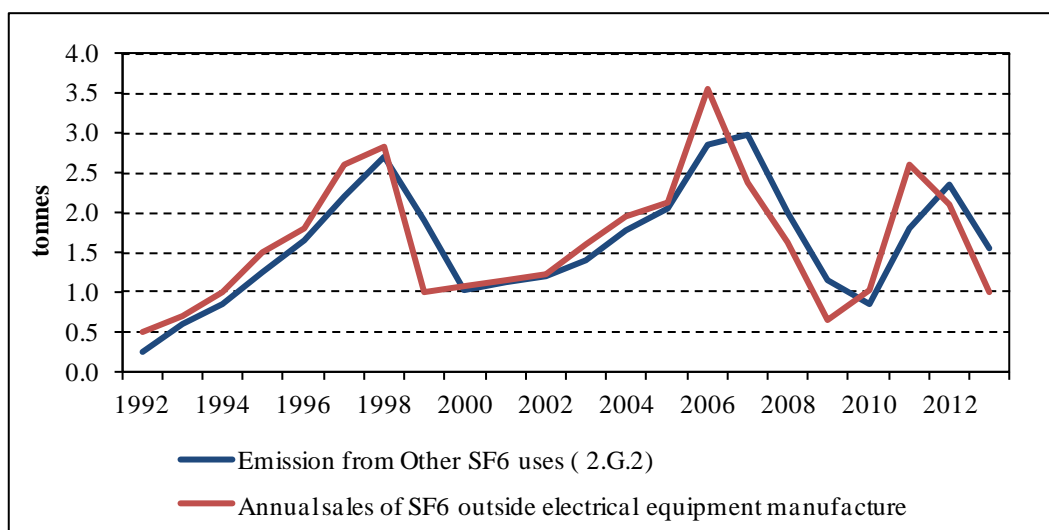


Figure 4.8.9 Annual sales of SF₆ outside electrical equipment manufacture and other SF₆ emissions

Therefore annual sales data is the activity data. The same time-series (see Figure 4.8.9) are used as in the case of previous inventory submissions and from same sources as described in chapter 4.8.7.1.

SF₆ is reported in 2.E sector between years 2001-2005 based on the data provision of a semiconductor manufacturer company. They also declared that the SF₆ has been acquired domestically, so the amount was allocated from the time-series of annual sales of "SF₆ for other use" in order to avoid double-counting. The SF₆ wholesaler company reports the list of their customers, too. So, the intended use of SF₆ might be determined based on the sector of the activity of the customers. The activity data (and consequently the emissions calculated with present methodology, too) show strong interannual variations throughout the whole time series.

4.8.8.2 Recalculations, QA/QC activities, uncertainties and planned improvement

General QA/QC procedures apply.

Uncertainties are estimated together with sector 2.G.2.

It is a planned improvement to collect data on the potential existing stock of sound-proof windows and to estimate the emissions separately.

4.9 Use of N₂O (CRF sector 2.G.3)

Emitted gas: N₂O

4.9.1.1 Source category description

This sub-sector includes emissions of N₂O from different product uses and the manufacturing (and other) losses from the production of these products. One of the two main important purposes is bulk N₂O use as an anaesthetic gas. Another is the use by household whipped cream cartridges. In Hungary, making whipped cream in siphons using N₂O cartridges is highly popular (although decreasing). N₂O from these products is emitted directly into the atmosphere, so all the filling of these products used should be considered as emission.

The largest manufacturer of the region of bulk N₂O is operating in Hungary. The manufacturers of the whipped cream cartridges acquire the bulk N₂O also from this manufacturer.

4.9.1.2 Methodological issues

Emissions are reported using plant-specific data. Production and domestic sales data for both bulk N₂O and N₂O in whipped cream cartridges are available from the manufacturers for the whole time-series (presented in *Figure 4.9.1*). N₂O used for the preparation of whipped cream cartridges (2.G.3.b.i) is subtracted from bulk domestic N₂O use (2.B.b.ii), as the manufacturer declared that they acquire the gas from the manufacturer of bulk N₂O.

Manufacturing losses for the whole time-series is also available in the case of whipped cream cartridges. While in the case of bulk N₂O production data on losses is available only from 2008. In this year, extrapolation was performed in order to include emissions from losses for the years before 2008 too, for the improvement of the consistency of the time-series. Extrapolation was performed using data on losses from 2008 (as trend of the losses is decreasing later in time) and N₂O production as surrogate data. Please find the trend of production and emissions on the following *Figure 4.9.1*.

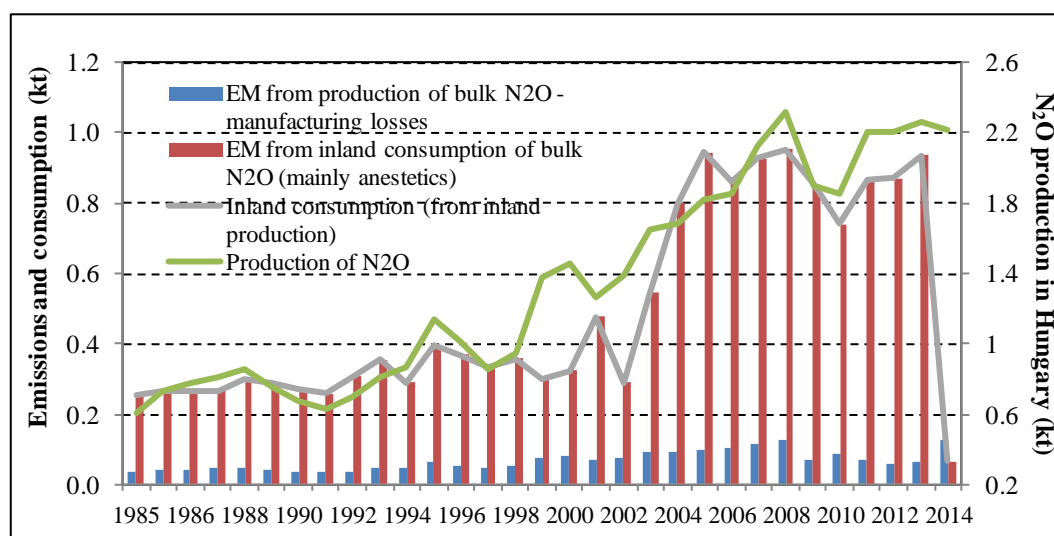


Figure 4.9.1 Trend of N₂O production and N₂O emissions from Product Uses

In 2014, an expert from the manufacturer of whipped cream chargers (cartridges) containing N₂O 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. So, imports are estimated only within the subsector whipped cream, however in the case of other subsector (2.G.3.b.ii bulk use mainly for anaesthetics) imports are even less significant, as there is no notable bulk 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 N₂O domestically (from the Hungarian producer).

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. The significant decrease on inland consumption (and consequently the emissions from inland consumption) was also reported by the companies.

4.9.1.3 Uncertainties and time-series consistency

Production data is quite reliable because they are obtained directly from manufacturers, based on a legally binding data provision requirement, therefore the uncertainties are estimated as follows:

Uncertainty	AD	EF	Combined
2.G Other Product Manufacture and Use - N ₂ O	3	3	4.24

4.9.1.4 Source-specific QA/QC information and verification

General QA/QC procedures apply.

4.9.1.5 Source-specific recalculation

New GWP of N₂O was applied. In addition in the case of bulk N₂O production data on losses has been extrapolated for the years before 2008, too, and time-series of 2.G.3.b.ii has been recalculated in order to improve the consistency of the time-series.

4.9.1.6 Source-specific planned improvements

Further investigation of data regarding imported products (especially whipped cream cans) might be performed. However this source is reported only by few countries at the moment, and the amount are expected to be insignificant compared to emissions reported under 2.G.3.b.ii. (production and domestic use of bulk N₂O) by Hungary.

In the case of 2.G.3.i Aerosols it is planned to collect of data for consistent time-series on the losses related to production for export.

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Personal communication to Mr. Róbert Tóth (*Ministry for Environment, Nature and Water; HMS*), Mr. Attila Zoltán, Mrs. Erika Barna (*HMBC*)

2.F.2. Sector:

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5. AGRICULTURE (CRF sector 3)

5.1 Overview of sector

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

- 3.A Enteric Fermentation by domestic livestock (CH₄);
- 3.B Manure Management (CH₄ and N₂O);
- 3.C Rice Cultivation (CH₄);
- 3.D Agricultural Soils (N₂O);
- 3.F Field Burning of Agricultural Residues (it has not been occurring since 1990 and therefore not reported for the years after 1990);
- 3.G Liming (CO₂);
- 3.H Urea application (CO₂);
- 3.I Other carbon containing fertilizers (CO₂).

Category 3.E Prescribed Burning of Savannas is not relevant to Hungary therefore notation key 'NO' is used relating to all associated emissions in the CRF Tables. In spite of this the NIR contains a chapter on 4.E, following a recommendation from the annual review conducted in 2013.

The main greenhouse gas emissions from Agriculture are CH₄ and N₂O. Although CO₂ emissions from carbonate containing materials are also reported in the Agriculture sector, these emissions are less significant compared with non-CO₂ emissions. Other CO₂ emissions associated with agricultural production as energy consumption of agricultural activities (heat production, agricultural vehicles and machinery) are reported in the Energy sector (1.AA.4C Energy, Agriculture/Forestry/Fishing), while CO₂ emissions from agricultural soils are included in the LULUCF sector.

For this inventory submission some minor changes were implemented in the Agricultural inventory due to the findings of the EU review processes.

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 3.7 per cent in 2014 (HCSO, 2015). The agricultural land area was 57 per cent of the total (HCSO, 2015). According to the data of the Farm Structure Survey, 2013 (HCSO, 2014), 8798 economic enterprises and 482 thousand private farms had been operated in Hungary. The farm structure of agricultural enterprises and private farms is rather different. The agricultural enterprises mostly managed at least 300 ha, whereas three quarters of the private farms managed one ha or less than one ha.

Currently 2179 agricultural enterprises and 373 thousand private farms deal with animal husbandry (HCSO, 2014). Although the number of private farms is more significant, the bulk of the GHG dominant livestock populations are owned by agricultural enterprises. Roughly two thirds of the cattle population and three quarters of the swine population are held by agricultural enterprises. The private farms are only dominant in sheep farming, as 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 current 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 decreased, 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 thirds or less of the level of 1990 (Laczka and Soós, 2003). The volume index of gross agricultural production in 1993 reached a minimum of 69.1 per cent of 1990 level. The

crop production has fluctuated considerably since 1993. It fell 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. 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). In the years 2012 and 2013 swine population stabilized, while cattle population slightly increased as a result of the state incentives to promote the recovery of livestock sector. In 2014 the gross production of agriculture increased by 4% compared with 2013, partially due to the 6.6% increase in the animal husbandry. (HCSO, 2015)

5.1.1 Emission trends

In 2014, the agriculture sector contributed 11.4% to Hungary's total GHG emissions (excluding LULUCF), which is near the level of 11.0 in the base year (the average of the years 1985-1987, hereafter referred to BY). The trend in emissions (**Figure 5.1.1**) shows a decrease of 45.8% over the period 1985-2014 as a result of a drop in activity data (**Figure 5.1.2**). 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 had stagnated around 6.2 Mt CO₂-eq with fluctuations of up to 4%. Agricultural emissions decreased both in 2009 and 2010, hitting the lowest point in 2010. There was a slight increase in emissions in 2011 which reflects the higher fertilizer use and crop production. In 2012 emissions remained almost unchanged compared to the previous year. In 2013 and 2014 further rising fertilizer use, relatively higher crop production and the increasing livestock production resulted in growing emission levels again.

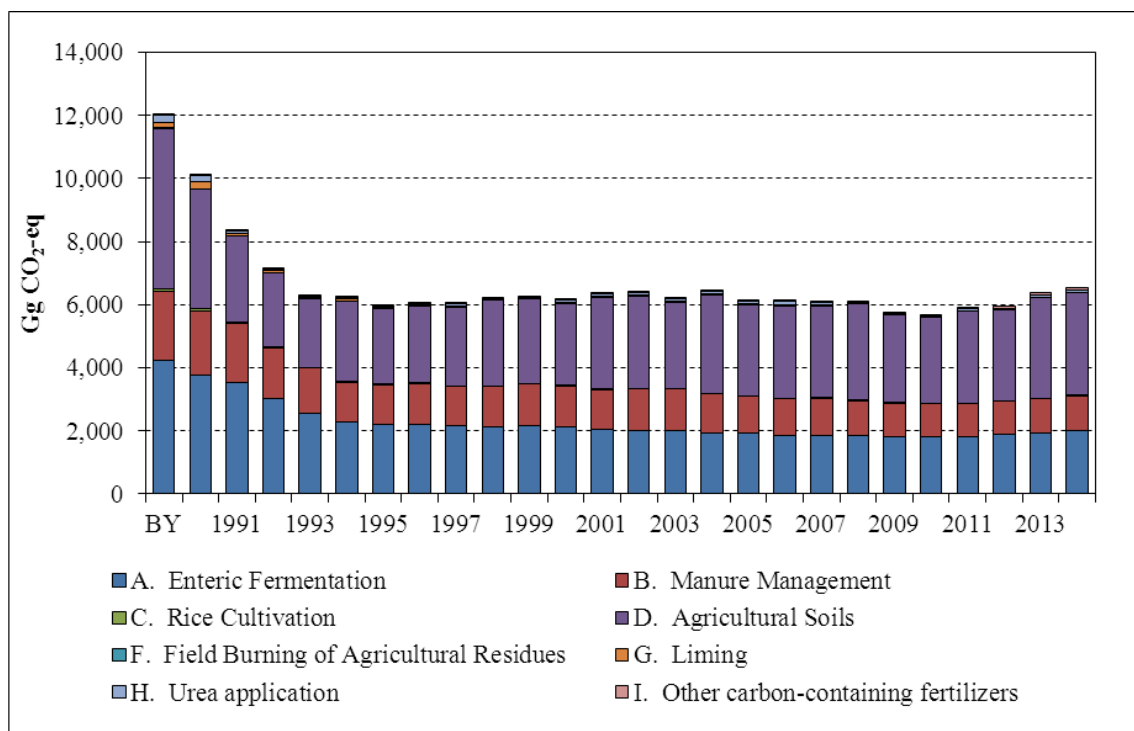


Figure 5.1.1 Trends in emissions from Agriculture BY-2014

Note: emissions from 3.C, 3.G, 3.H and 3.I are small, but not zeros. Emission for 3.F is not zero in the BY, and NO for the other years. BY=average of 1985-1987

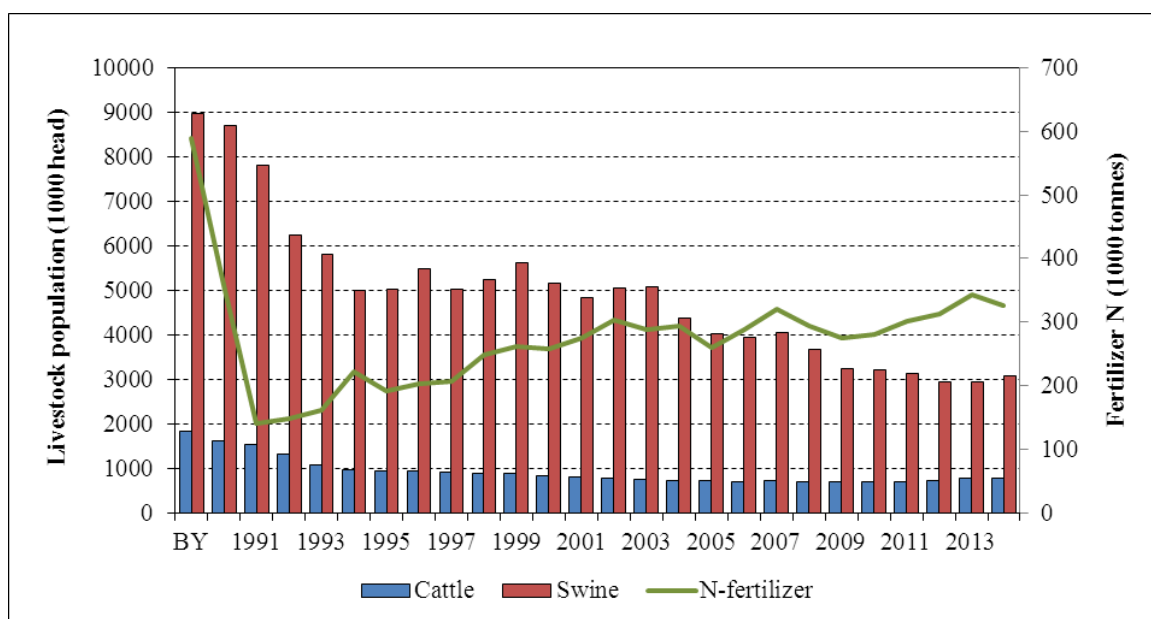


Figure 5.1.2 Main drivers of Agricultural emissions BY-2014

5.1.1.1 Emission trends by gas

From the BY to 2014, CH₄, N₂O and CO₂ emissions from agriculture decreased by 52, 38 and 65 per cent, respectively.

The decrease in CH₄ emissions is even more significant than N₂O, because CH₄ emissions are driven by the type and numbers of livestock. In Hungary's case, the amounts are largely determined by cattle and swine population. In 2014 cattle and swine accounted for 71 and 15% of combined total of emissions of CH₄ from enteric fermentation and manure management, respectively. After the sudden drop of livestock population at the beginning of the '90s it remained at that low level. Thus, CH₄ emissions had dropped by 46% from the base year level of 5,590 Gg CO₂-eq to 3,014 Gg CO₂-eq in 1994, when reached a plateau. In 2004, which is the year of the European Union accession for Hungary, animal livestock started to decrease moderately again, leading to the lowest level of CH₄ emissions at 2,436 Gg CO₂-eq in 2010 represent a reduction of 56% on the level of the BY. Since 2012 cattle populations slightly increased resulted in a moderate increase in the emissions to 2,663 Gg CO₂-eq in 2014.

Emissions of N₂O show similar trends to those of CH₄, because the change of the regime resulted in a significant reduction in emissions. Agricultural N₂O emissions were 6,040 Gg CO₂-eq in the BY and decreased by 54% up to 1993 to reach the lowest level in emissions at 2,784 Gg CO₂-equivalent. But unlike the livestock sector, there was a slight recovery in the crop production and nitrogen fertilizer use beginning in the second half of the 90s, resulting in a moderate increase in the emissions in the period between 1993 and 2004. Subsequently, in spite of the slightly increasing trends in nitrogen fertilizer use, N₂O emissions fluctuated, rather than increased, because the effect of the decreasing animal livestock overbalanced the increasing emissions from synthetic fertilizers. As a result, emissions amounted to 3,723 Gg CO₂-eq in 2014, representing a reduction of 38% cent on the BY level. N fertilizer use produces the bulk of agricultural N₂O emissions (23 per cent of the sector N₂O emissions in 2014).

Reduction of CO₂ emissions is the most significant change among the GHGs in the Agriculture sector. It has dropped by 65% over the inventory period, which is the effect of a sharp fall in urea use and liming. However, Agricultural CO₂ emissions are of low importance in the overall emissions, accounting for 0.3 per cent of the national total (excluding LULUCF).

The trends in emissions by gas are presented in **Table 5.1.1**. Trends by gas and sub-categories are

shown in *Figure 5.1.3*, *Figure 5.1.4* and *Figure 5.1.5*.

Table 5.1.1 Emissions of CH₄, N₂O and CO₂ from Agriculture BY-2014

Year	GHG emissions (Gg)		
	CH ₄	N ₂ O	CO ₂
BY	224	20	421
1990	200	16	436
1991	186	12	189
1992	159	10	157
1993	136	9	92
1994	121	10	106
1995	118	10	92
1996	119	10	103
1997	116	10	96
1998	116	11	66
1999	119	11	70
2000	116	11	117
2001	112	11	127
2002	112	12	129
2003	112	11	143
2004	107	12	145
2005	105	11	140
2006	102	11	148
2007	103	11	140
2008	101	12	83
2009	98	11	94
2010	97	11	103
2011	98	11	135
2012	101	11	138
2013	103	12	169
2014	107	12	146
Share of national total in BY	44%	53%	0.5%
Share of national total in 2014	35%	83%	0.3%
Trend BY-2014	-52%	-38%	-65%

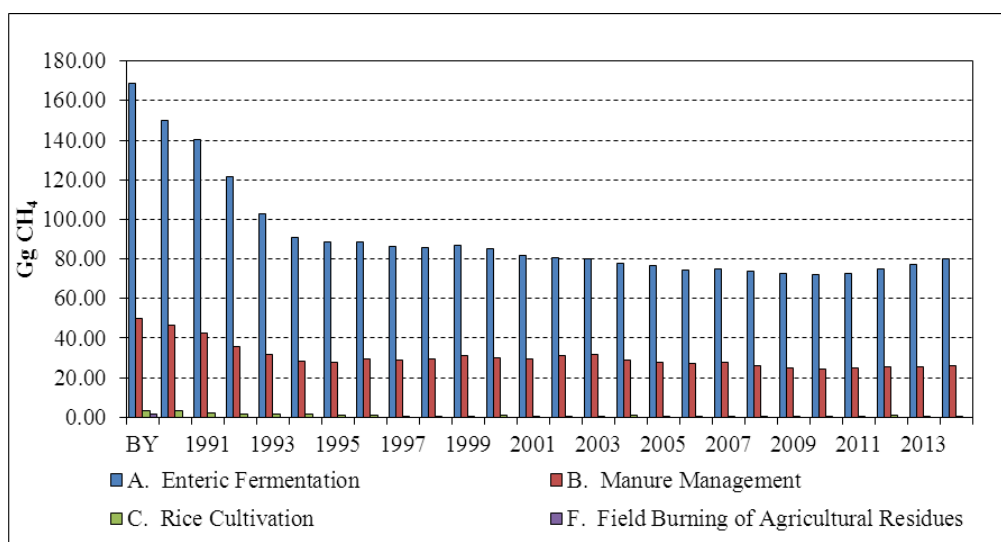


Figure 5.1.3 CH₄ emissions from Agriculture BY-2014

Note: Emission from 3.F is not zero in the BY and zero for the other years

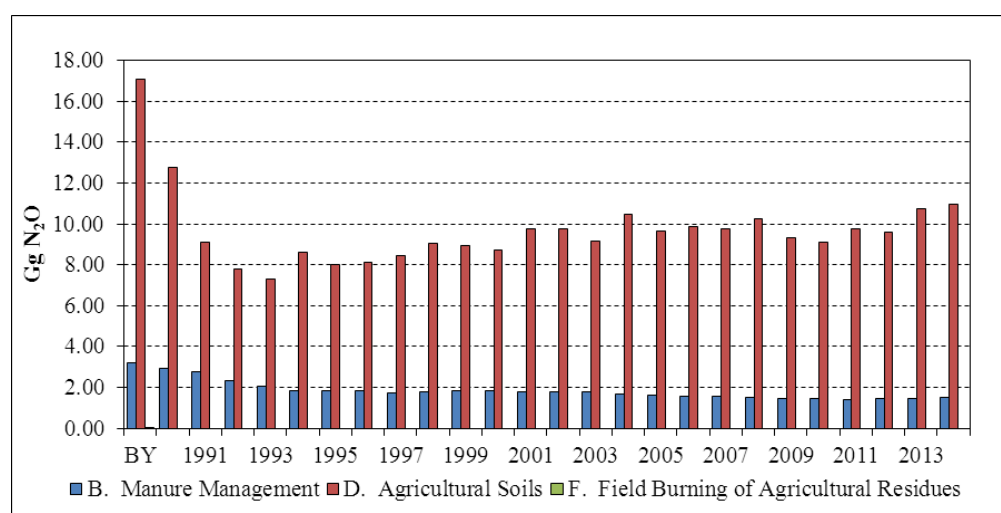


Figure 5.1.4 N₂O emissions from Agriculture BY-2014

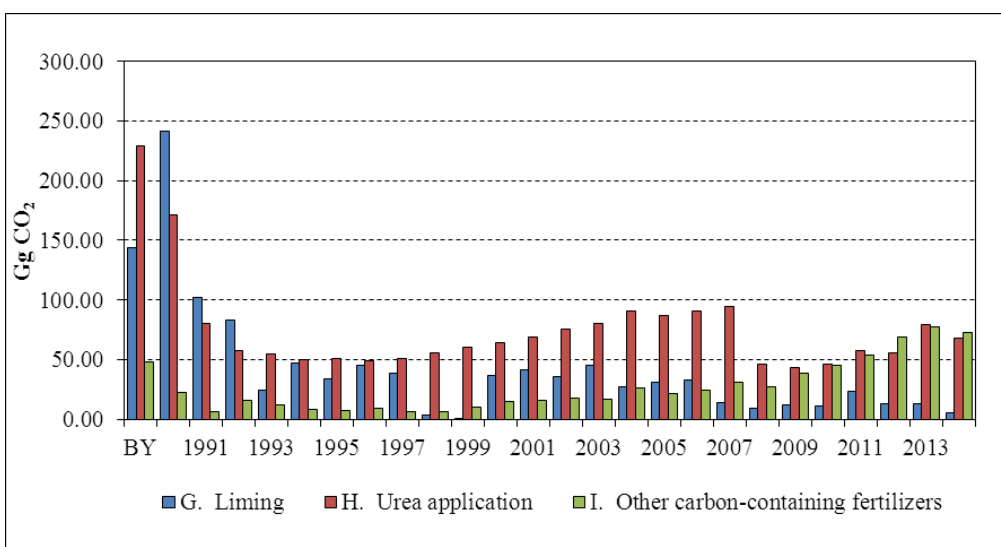


Figure 5.1.5 CO₂ emissions from Agriculture BY-2014

5.1.1.2 Emission trends by sub-category

Agricultural GHG emissions amounted to 12,051 Gg CO₂-eq in the BY and 6,533 Gg CO₂-eq in 2014, which means a reduction of 46%. Total emissions from the Agriculture sector in 2010 at 5,685 Gg CO₂-eq was the lowest level in the whole time-series.

Table 5.1.2 shows the trends in GHG emissions by source categories as well as their contribution to the overall national emissions (excluding LULUCF). The most important category is 3.D Agricultural Soils at 5.7%, followed by 3.A Enteric Fermentation at 3.5% and 3.B Manure Management accounting for 1.9% of national total GHG emissions in 2014. CRF category 3.C Rice Cultivation accounts for less than one-tenth of a per cent of the national total. As it reveals from the **Table 5.1.2** and **Figure 5.1.3-Figure 5.1.5** emissions from all categories are decreasing except 3.I. The reason for the declining trend in the emissions from enteric fermentation and manure management is the decrease in livestock numbers, especially cattle and swine. The total emissions from the Livestock, which is equal to the combined total of emissions from 3.A Enteric fermentation and 3.B Manure management (Indirect emissions excluded) expressed in CO₂ equivalents was 6,063 Gg CO₂-eq in the BY. This decreased by 45 per cent to reach 3,330 Gg CO₂-eq in 1994 and subsequently increased by 6 per cent to 2,947 Gg CO₂ -eq in 2014. Livestock accounted for 45% of GHG emissions in agriculture in 2014. The biggest contributor to Livestock emissions is cattle, with 31% share of agricultural total emissions.

Over the period 1985-1993 emissions from 3.D Agricultural soils had dipped sharply from 5,079 Gg CO₂-eq in the base year to 2,171 Gg CO₂-eq represents a decrease of 57% from the BY level, when the state subsidies on fertilizers were halted and the amount of animal manure decreased due to the decreasing animal livestock. Emissions totaling 3,265 Gg CO₂-eq in 2014 represent a reduction of 36% from the base year level. The slight increase in emissions from agricultural soils over the period 1993-2014 is a result of compensatory processes, the slight and steady increase in emissions from nitrogen fertilizers were partly overbalanced by the decreasing emissions from organic manure. N₂O emissions from 3.D in the BY and 2014 accounted for 42% and 50%, respectively of the total agricultural emissions, reflecting the restructuring of the Hungarian agriculture.

The trends of emissions from liming, urea application and carbon-containing fertilizers slightly differ from of the other sectors. Emissions from all of the CO₂ relevant sectors decreased at the beginning of the time-series, but emissions from urea application and carbon-containing fertilizers started to increase at the end of the '90s due to the increasing fertilizer use, while emissions from liming fluctuated. The reason for the second drop in the emissions from urea use was the economic crisis in 2008, when the price of the urea increased thus the urea application fell sharply. Emissions from urea and carbon-containing fertilizers increased again over the period 2009-2013, while emissions from liming fluctuated. In 2014 emissions from all CO₂ sources decreased.

Table 5.1.2 GHG emissions BY-2014 from agriculture by subcategories

Year	GHG emissions [Gg CO ₂ -eq]								
	3	3.A	3.B	3.C	3.D	3.F	3.G	3.H	3.I
BY	12,051	4,220	2,191	81	5,079	60	144	229	48
1990	10,108	3,754	2,040	81	3,798	NO	242	171	23
1991	8,356	3,513	1,881	61	2,712	NO	103	80	7
1992	7,148	3,043	1,591	34	2,323	NO	84	57	16
1993	6,279	2,573	1,409	34	2,171	NO	25	55	12
1994	6,232	2,271	1,257	34	2,563	NO	47	50	8
1995	5,968	2,214	1,245	27	2,389	NO	34	51	8
1996	6,039	2,211	1,283	21	2,421	NO	45	49	9
1997	6,021	2,159	1,242	15	2,510	NO	39	51	7
1998	6,198	2,141	1,277	15	2,698	NO	4	56	6
1999	6,245	2,166	1,329	15	2,665	NO	0	60	10
2000	6,165	2,131	1,301	22	2,594	NO	37	65	15
2001	6,356	2,046	1,268	16	2,899	NO	42	69	16
2002	6,385	2,022	1,308	14	2,913	NO	35	76	18
2003	6,216	2,000	1,320	17	2,735	NO	46	80	17
2004	6,465	1,943	1,231	19	3,127	NO	28	91	26
2005	6,128	1,917	1,172	18	2,880	NO	31	87	22
2006	6,118	1,863	1,148	16	2,942	NO	33	91	24
2007	6,098	1,868	1,159	18	2,913	NO	14	95	31
2008	6,116	1,845	1,110	17	3,061	NO	10	46	27
2009	5,764	1,822	1,052	18	2,778	NO	12	43	39
2010	5,685	1,807	1,048	14	2,713	NO	11	46	45
2011	5,925	1,814	1,045	18	2,913	NO	23	58	54
2012	5,961	1,876	1,060	20	2,866	NO	13	56	69
2013	6,386	1,934	1,072	18	3,193	NO	13	79	77
2014	6,533	1,995	1,111	16	3,265	NO	5	68	73
Share of national total GHG emissions in BY	11.0%	3.8%	2.0%	0.1%	4.6%	0.1%	0.1%	0.2%	0.0%
Share of national total GHG emissions in 2014	11.4%	3.5%	1.9%	0.03%	5.7%	NA	0.01%	0.1%	0.1%
Trend BY-2014	-46%	-53%	-49%	-80%	-36%	NA	-96%	-70%	52%

5.1.2 Key Categories

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

5.1.3 Methodological issues

Methodologies of the 2006 IPCC Guidelines have been implemented throughout the agricultural inventory.

IPCC Tier 2 methods were used for the following categories:

- 3.A Enteric Fermentation in Cattle;
- CH₄ emissions from 3.B Manure Management associated with all livestock categories, except Rabbits;
- N₂O emissions from 3.B for Cattle, Swine and Indirect emissions.

For the 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 used. See the individual categories for further details.

5.1.4 Uncertainties and time-series consistency

The following chapter gives an overview of uncertainty estimates for CH₄, N₂O and CO₂ 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 Unit of National Emission Inventories. The VBA macro uses iteratively the calculation sheets for the agricultural emission estimates. 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. Recalculation of Tier 2 uncertainties of recalculated emission estimates based on the 2006 IPCC Guidelines is underway.

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 2006 IPCC Guidelines Equation 3.1 and 3.2. The results of the Tier 1 approach are shown in **Table 5.1.4**.

The uncertainty of the activity data was calculated on the basis of the available data of the HCSO, the 2013 EMEP/EEA Guidebook and expert judgement; the uncertainty of the emission factors was calculated following the 2006 IPCC Guidelines recommendations. The uncertainty of the livestock population data for 2014 is presented according to the uncertainty assessment of the HCSO, in **Table 5.1.3**. The overall weighted mean of the uncertainties in the livestock population is ± 2.1 per cent. The uncertainty in the swine population is the lowest at 0.7 per cent, while the uncertainty in the mules and asses populations is the highest at approximately 14.5 per cent. The overall uncertainties of the activity data, emission factors and emissions by subcategories are summarized in **Table 5.1.4** and **Table 5.1.5**. For more details of the uncertainty assessment see the subsectoral chapters.

In the Hungarian agricultural GHG inventory, the uncertainties of N₂O 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 (EF₁, EF₄ and EF₅) 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 2006 IPCC Guidelines.

Table 5.1.3 Uncertainty of animal population data for 2014 (HCSO)

Livestock categories	2013 Dec	2014 Jun	2014 Dec	Annual mean	Uncertainty of the annual mean u(AD _i)	Weighted annual mean
	95% Confidence Interval (+/- 1,000 head)				%	1,000 head
Dairy Cattle	7.90	7.90	8.20	4.87	1.93	253
Non-Dairy Cattle	16.10	17.50	19.10	10.75	2.00	538
Buffalo	0.10	0.30	0.30	0.17	4.55	4
Sheep	89.20	93.90	92.70	56.91	4.60	1237
Goats	5.10	6.20	5.70	3.64	4.55	80
Horses	3.60	3.80	3.70	2.30	3.59	64
Mules and Asses	0.51	0.50	0.61	0.32	14.51	2
Swine	30.20	36.40	37.00	21.77	0.71	3067
Poultry	1,042.89	1,585.24	1,086.65	877.51	2.05	42735
Rabbit	26.50	97.20	95.30	54.53	3.32	1643
Overall (weighted mean)					2.1	

Table 5.1.4 Uncertainties of activity data, emission factors and emissions for key and particularly significant categories by Tier 1 approach

3 Agriculture	GHG	Uncertainty of activity data	Uncertainty of Emission Factor	Combined uncertainty of emissions
			%	
3.A Enteric Fermentation	CH ₄	±0	±12	±12
3.A.1 Enteric Fermentation/ Cattle	CH ₄	±0	±14	±14
3.A.2 Enteric Fermentation/ Sheep	CH ₄	±5	±40	±40
3.B Manure Management	CH ₄	±0	±15	±15
3.B.1 Manure Management/ Cattle	CH ₄	±0	±15	±15
3.B.3 Manure Management/Swine	CH ₄	±1	±30	±30
3.B Manure Management	N ₂ O	±0	-39/+147	-39/+147
3.B.13 Manure Management/ Other	N ₂ O	±26	-50/+100	-56/+103
3.B Manure Management/ Indirect	N ₂ O	±40	-80/+400	-89/+404
3D Agricultural Soil Emissions	N ₂ O	±0	-65/+186	-65/+186
3.D.a.1 Direct Soil Emissions/ Synthetic Fertilizer	N ₂ O	±5	-70/+200	-70/+200

3 Agriculture	GHG	Uncertainty of activity data	Uncertainty of Emission Factor	Combined uncertainty of emissions
		%		
3.D.a.4 Direct Soil Emissions/ Crop residues	N ₂ O	±25	-70/+200	-74/+202
3.D.3 Indirect Emissions	N ₂ O	±0	-72/+284	-72/+284

Note: In accordance with the 2006 IPCC Guidelines particularly significant categories are those which contribute together more than 60% to the key category.

Table 5.1.5 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	
3.A.1 Enteric Fermentation/ Cattle	CH ₄	±20	Normal	±14
3.B.1 Manure Management/ Cattle	CH ₄	±30	Normal	±21
3.B.3 Manure Management/Swine	CH ₄	±30	Normal	±29
3.B Manure Management/ Solid	N ₂ O	-50/+100	Lognormal	-55/+92
3.B Manure Management/ Other	N ₂ O	-50/+100	Lognormal	-51/+86
3.D.a Direct Soil Emissions	N ₂ O	-80 / +380	Lognormal	-84/+279
3.D.a.3 Pasture, Range and Paddock Manure	N ₂ O	-50/+100	Lognormal	-56/+95
3.D.b Indirect Emissions	N ₂ O	-80 / +100	Lognormal	-86/+345

5.1.5 Quality Assurance and Quality Control

The agricultural greenhouse gas inventory is compiled by the HMS. The used activity data is mainly derived from the official database of the HCSO, in cases where HCSO's data are not available the EUROSTAT's, NFCSSO's or the Research Institute for Agricultural Economics' data are applied.

Data and documentation are archived by the Unit of National Emissions Inventories of the Hungarian Meteorological Service. 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 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;

Details of other source-specific quality checks can be found in the respective sub-chapters.

Since 2011 the Unit of National Emissions Inventories 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. In 2015 an EU trial review of the 2015 greenhouse gas inventory of Hungary under the Effort Sharing Decision was executed. The informal list of recommendations of the trial review were also taken into account in the Development Plans, and the recommendations implemented as far as possible. In 2016 February the 'STEP 1, EU review of the 2016 greenhouse gas inventory of Hungary under the Effort Sharing Decision' was conducted. Findings and recommendations both of EU reviews were taken into account to improve the inventory for the 2006 inventory submission.

External co-expert opinion was prepared on the entire inventory, so also on the Agriculture chapter in 2007 (Systemexpert 2007).

5.1.6 Recalculations

Numerous changes have been implemented to the calculation of emissions from 3.Agriculture sector for the 2016 submission. The main reasons for the changes between the two submissions were the recommendations and findings of the 'Trial review of the 2015 greenhouse gas inventory of Hungary under the Effort Sharing Decision' (hereafter Trial ESD review, 2015) and the 'Step 1, EU review of the 2016 greenhouse gas inventory of Hungary under the Effort sharing Decision' (hereafter Step 1, ESD review, 2016). In some cases additional changes have also been made in response to a recommendation, e.g. revision of the nitrogen excretion rate for Rabbit resulted in subsequent changes in the direct and indirect N₂O emissions from 3.B as well as 3.D. Additionally, other modifications were also made due to the result of our standard QC procedures, and to ensure the consistency with the 2016 inventory submission under the UNECE/CLRTAP Convention.

The overall impact of recalculations in the Agriculture sector resulted in a 1.1% (135.8 CO₂-eq) decrease in the emissions in the BY and -1.9% (125.6 kt CO₂-eq) decrease on average in the period 1990-2011 and 0.6% (36.7 kt CO₂-eq) increase on average for the years 2012 and 2013 (**Table 5.1.6**). Changes are more significant discussing CH₄ and N₂O emissions separately (**Table 5.1.7** and **Table 5.1.8**). CH₄ emissions decreased by 7.9% (476.2 kt CO₂-eq) in the BY and 10.2% (334.2 kt CO₂-eq) on average in the period 1990-2013. In contrast, the N₂O emissions increased in similar degree. In the BY and the period 1990-2013 agricultural N₂O emissions increased by 6.0% (340.4 kt CO₂-eq) and 7.2% (222.1 kt CO₂-eq) on average, respectively. CO₂ emissions were recalculated for 2012, resulting in a negligible change in the emissions.

Table 5.1.6 Overall changes in the emissions from 3. Agriculture due to recalculations for the BY and the period 1990-2013

Year	Submission 2015 [Gg CO ₂ -eq]	Submission 2016 [Gg CO ₂ -eq]	Difference [Gg CO ₂ -eq]	Percentage change
BY	12,187	12,051	-135.9	-1.1%
1990	10,254	10,108	-146.6	-1.4%
1991	8,459	8,356	-102.5	-1.2%
1992	7,237	7,148	-88.6	-1.2%
1993	6,362	6,279	-82.8	-1.3%
1994	6,286	6,232	-53.7	-0.9%
1995	6,055	5,968	-87.0	-1.4%
1996	6,182	6,039	-142.7	-2.3%
1997	6,155	6,021	-133.4	-2.2%
1998	6,365	6,198	-167.8	-2.6%
1999	6,473	6,245	-227.4	-3.5%
2000	6,350	6,165	-185.6	-2.9%
2001	6,521	6,356	-165.2	-2.5%
2002	6,588	6,385	-203.1	-3.1%
2003	6,438	6,216	-222.0	-3.4%
2004	6,605	6,465	-140.6	-2.1%
2005	6,262	6,128	-134.9	-2.2%
2006	6,251	6,118	-133.6	-2.1%
2007	6,238	6,098	-140.1	-2.2%
2008	6,196	6,116	-80.8	-1.3%
2009	5,826	5,764	-62.1	-1.1%
2010	5,733	5,685	-48.5	-0.8%
2011	5,939	5,925	-14.5	-0.2%
2012	5,941	5,961	20.4	0.3%
2013	6,333	6,386	53.1	0.8%

Table 5.1.7 Changes in the CH₄ emissions from 3. Agriculture due to recalculations for the BY and the period 1990-2013

Year	Submission 2015 [Gg CO ₂ -eq]	Submission 2016 [Gg CO ₂ -eq]	Difference [Gg CO ₂ -eq]	Percentage change
BY	6,066	5,590	-476.2	-7.9%
1990	5,476	4,995	-480.5	-8.8%
1991	5,075	4,638	-437.0	-8.6%
1992	4,318	3,971	-346.7	-8.0%
1993	3,727	3,404	-323.2	-8.7%
1994	3,291	3,014	-277.0	-8.4%
1995	3,228	2,941	-286.2	-8.9%
1996	3,302	2,972	-330.0	-10.0%
1997	3,203	2,892	-310.6	-9.7%
1998	3,241	2,899	-342.2	-10.6%
1999	3,344	2,964	-380.7	-11.4%
2000	3,274	2,910	-364.2	-11.1%
2001	3,162	2,804	-357.5	-11.3%
2002	3,205	2,811	-394.1	-12.3%
2003	3,220	2,805	-415.4	-12.9%
2004	3,050	2,686	-363.4	-11.9%
2005	2,962	2,625	-337.0	-11.4%
2006	2,893	2,555	-337.9	-11.7%
2007	2,923	2,573	-350.3	-12.0%
2008	2,833	2,519	-313.8	-11.1%
2009	2,735	2,458	-276.3	-10.1%
2010	2,709	2,436	-273.5	-10.1%
2011	2,709	2,456	-252.8	-9.3%
2012	2,758	2,527	-231.8	-8.4%
2013	2,824	2,584	-239.4	-8.5%

Table 5.1.8 Changes in the N₂O emissions from 3. Agriculture due to recalculations for the BY and the period 1990-2013

Year	Submission 2015 [Gg CO ₂ -eq]	Submission 2016 [Gg CO ₂ -eq]	Difference [Gg CO ₂ -eq]	Percentage change
BY	5,700	6,040	340.4	6.0%
1990	4,343	4,677	333.8	7.7%
1991	3,195	3,529	334.5	10.5%
1992	2,762	3,020	258.1	9.3%
1993	2,543	2,784	240.4	9.5%
1994	2,888	3,111	223.3	7.7%
1995	2,735	2,934	199.2	7.3%
1996	2,776	2,964	187.3	6.7%
1997	2,856	3,033	177.1	6.2%
1998	3,058	3,232	174.4	5.7%
1999	3,058	3,211	153.2	5.0%
2000	2,959	3,138	178.6	6.0%
2001	3,233	3,425	192.3	6.0%

Year	Submission 2015 [Gg CO ₂ -eq]	Submission 2016 [Gg CO ₂ -eq]	Difference [Gg CO ₂ -eq]	Percentage change
2002	3,255	3,446	191.0	5.9%
2003	3,075	3,268	193.4	6.3%
2004	3,411	3,634	222.7	6.5%
2005	3,160	3,362	202.1	6.4%
2006	3,211	3,415	204.3	6.4%
2007	3,176	3,386	210.3	6.6%
2008	3,281	3,514	233.0	7.1%
2009	2,998	3,212	214.2	7.1%
2010	2,921	3,146	225.0	7.7%
2011	3,096	3,334	237.9	7.7%
2012	3,044	3,296	251.9	8.3%
2013	3,340	3,633	292.4	8.8%

5.1.7 Planned improvements

Participation in the EU review mechanisms, which is part of the QA/QC processes for compiling EU inventory, provides an opportunity for examination of individual IPCC sectors and particular issues relating to methodologies, country-specific emission factors and coefficients. Issues of planned improvements will be assigned largely in accordance with the outcome of the EU review processes. Additionally, as new data relevant to develop emission estimation for key categories in Agriculture becomes available through national research and development programs the required improvements will be implemented.

5.2 Enteric fermentation (CRF sector 3.A)

Enteric fermentation in animals is considered as significant source of CH₄. The most important process of generation is anaerobic cellulose degradation in the rumen of ruminants. Some CH₄ is generated in the colon of horses and rabbits, and in the caecum of poultry. In Hungary the leading CH₄ 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 CH₄ from enteric fermentation.

In 2014 75% of the total CH₄ emissions from agriculture derived from this source category.

5.2.1 Source Category Description

Emitted gas: CH₄

Methods: T1, T2

Emission factors: D, CS

Key source: Yes

Particularly significant sub-categories: Cattle

Figure 5.2.1 presents the estimates of CH₄ emissions for 3.A Enteric Fermentation by livestock categories. Emissions amounted to 169 Gg in the base year and have reduced by 53 per cent to 80 Gg in 2014 due to the decrease in cattle livestock. The bulk of this decrease occurred between 1985 and 1994, during which Hungary experienced a period of unprecedented drop in the agricultural production resulting in a dramatic decrease in animal populations. Despite the continuous decrease in the livestock populations, emissions stagnated in the years between 1995 and 2000, because the improving productivity of milk production overbalanced the effect of declining cattle population (**Figure 5.2.2**). In the period 2000 to 2010 emissions slightly decreased again reaching their lowest level in 2010. This decrease reflects the further decline in Cattle livestock. Since 2011, emissions started to increase, following the slightly rising cattle population. Emissions from 3.A mostly depend on the cattle population and the milk production. Enteric fermentation in dairy and non-dairy cattle produced 79% of emissions from 3.A in 2014.

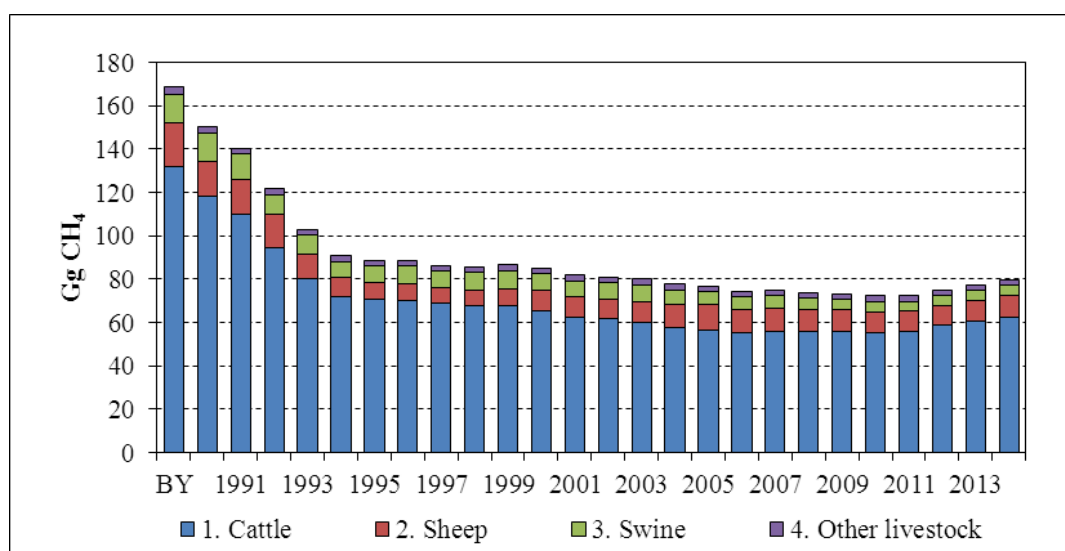


Figure 5.2.1 Trend in emissions from 3.A Enteric Fermentation by livestock categories BY-2014

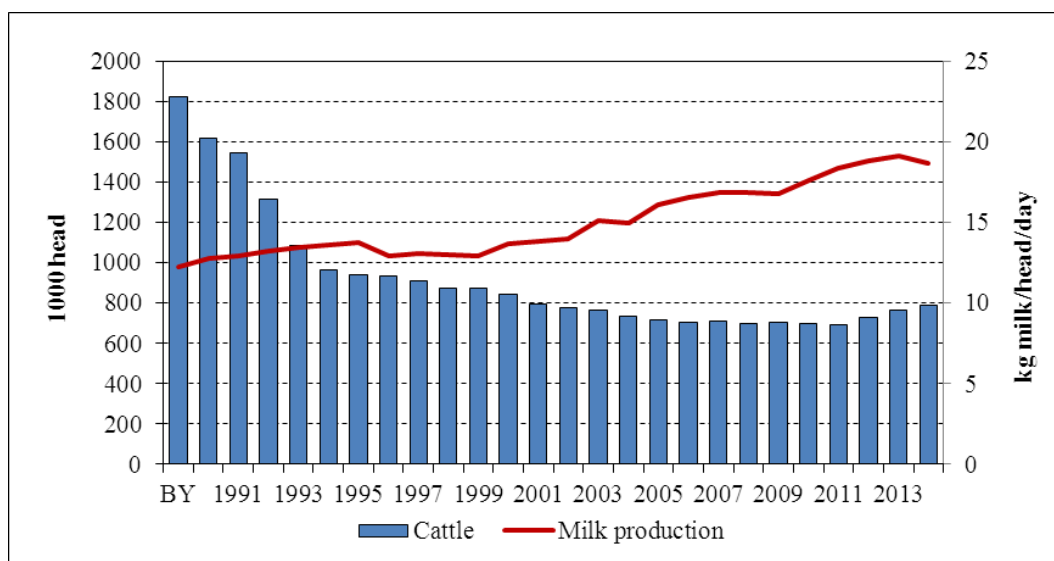


Figure 5.2.2 Cattle population and daily milk production per cow BY-2014

5.2.2 Methodological issues

Emissions from enteric fermentation were calculated using the Tier 1 method of 2006 IPCC Guidelines, 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 2006 IPCC Guidelines.

5.2.2.1 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:

$$\text{NoA}_t = (0.5 \cdot \text{NoA}_{\text{Dec},t-1}) + \text{NoA}_{\text{June},t} + 0.5 \cdot \text{NoA}_{\text{Dec},t} / 2 \quad (\text{Equation 5.1.})$$

Where:

NoA_t = chronological mean of the annual population of a livestock category in a year t [1'000 head]

$\text{NoA}_{\text{Dec},t-1}$ = population of a livestock category in December of the year $t-1$ [1'000 head]

$\text{NoA}_{\text{June},t}$ = population of a livestock category in June of the year t [1'000 head]

$\text{NoA}_{\text{Dec},t}$ = 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 5.2.1**.

In the 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. Background data for Cattle and Poultry are shown in **Table 5.2.2** and **Table 5.2.3**.

Table 5.2.1 Livestock population and trends BY-2014

Source: HCSO

Year	Animal Population (1,000 head)									
	Dairy Cattle	Non-dairy Cattle	Buffalo	Sheep	Goats	Horses	Asses and Mules	Swine	Poultry	Rabbits
BY	590	1,234	0.1	2,584	18	96.2	4.8	8,963	81,739	2,537
1990	564	1,053	0.1	2,064	31	75.5	4.3	8,709	70,326	2,587
1991	527	1,018	0.1	2,018	35	78.0	4.2	7,809	58,827	2,630
1992	480	834	0.1	1,877	43	77.5	4.1	6,237	52,168	2,389
1993	436	649	0.1	1,541	53	73.0	4.1	5,805	43,429	2,149
1994	409	554	0.1	1,140	63	76.0	4.1	5,007	44,477	1,909
1995	395	549	0.2	993	70	76.0	4.1	5,023	44,875	1,669
1996	389	546	0.3	1,004	75	68.1	4.1	5,494	38,538	1,149
1997	388	521	0.4	898	79	71.0	4.1	5,013	40,417	1,071
1998	381	494	0.5	917	84	72.5	4.1	5,247	42,708	1,052
1999	385	489	0.6	956	88	73.5	4.1	5,609	40,260	1,040
2000	363	479	0.7	1,192	97	77.8	3.6	5,146	48,562	943
2001	353	443	0.8	1,163	107	67.5	3.5	4,823	51,074	1,087
2002	345	434	0.9	1,138	97	63.2	3.4	5,050	51,334	1,180
2003	330	433	1.0	1,227	95	62.5	3.3	5,078	52,486	1,089
2004	309	424	1.1	1,380	85	64.5	3.2	4,385	50,492	1,182
2005	300	420	1.2	1,447	78	67.0	3.0	4,022	46,405	1,003
2006	275	428	1.3	1,358	81	64.8	2.3	3,944	44,653	1,084
2007	268	442	1.4	1,301	72	59.0	2.1	4,039	43,160	1,055
2008	264	436	1.4	1,270	73	58.3	2.0	3,665	45,033	904
2009	258	444	1.5	1,261	65	59.8	1.9	3,248	44,789	871
2010	245	454	2.5	1,203	79	65.5	3.1	3,208	46,587	916
2011	250	440	3.7	1,141	84	73.3	3.5	3,120	46,069	950
2012	255	473	3.4	1,141	86	76.1	3.6	2,952	42,908	1,367
2013	249	517	3.7	1,210	88	67.1	2.9	2,938	41,638	1,560
2014	253	538	3.7	1,237	80	63.9	2.2	3,067	42,735	1,643
Trend BY-2014	-57%	-56%	3625%	-52%	352%	-34%	-54%	-66%	-48%	-35%

Table 5.2.2 Livestock population and trends for non-dairy cattle (1'000 head)

Source: HCSO

Year	<1 year		1-2 year		>2 year			Beef Cow
	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	
BY	257	264	226	278	72	20	20	97
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
2013	89	119	41	130	35	8	4	90
2014	90	123	44	131	37	9	3	101
Trend								
BY-2014	-65%	-53%	-80%	-53%	-49%	-58%	-86%	5%

Table 5.2.3 Livestock population and trends for Poultry

Source: HCSO

Year	Poultry Population (1,000 head)					
	Laying hens	Chickens, Hens, Cocks	Geese	Ducks	Turkeys	Guinea-Fowls
BY	24,485	50,939	1,814	2,718	1,420	363
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
2013	11,840	19,959	2,752	4,511	2,432	144
2014	11,292	21,506	2,285	4,820	2,691	141
Trend BY-2014	-52%	-61%	52%	66%	71%	-60%

5.2.2.2 Emission Factors**Cattle**

CH₄ emissions from enteric fermentation in Dairy Cattle and Non-Dairy Cattle categories were calculated using the Tier 2 method (2006 IPCC Guidelines, Equation 10.21):

$$EF = (GE * (Y_m/100) * 365) / 55.65 \quad (\text{Equation 5.2})$$

Where:

EF	CH ₄ emission factor [kg CH ₄ head ⁻¹ yr ⁻¹]
GE	gross energy intake [MJ head ⁻¹ day ⁻¹]
Y _m	methane conversion rate [MJ MJ ⁻¹]
365	days of year [day yr ⁻¹]
55.65	energy content of methane [MJ kg ⁻¹ CH ₄]

Gross Energy Intake in Dairy Cattle

Tier 2 emission estimate requires feed intakes measured in terms of gross energy (MJ/head/day), which is the amount of energy an animal needs for maintenance, activity, lactation and pregnancy. In the calculation of net energy requirements Holstein-Friesian and Hungarian Simmental cattle were distinguished, which are the most widespread dairy cattle breeds in Hungary.

To calculate the daily net energy requirements of cows the Hungarian Nutrition Codex (2004) was generally applied, which contains standards of animal feeding for Hungary. In Hungary the American energy requirement system was adapted in 1986 with some minor changes, thus the Hungarian and the IPCC equations for the calculation of net energy requirements are basically very similar. The main difference between the Hungarian and the IPCC methodology is that, the Hungarian system does not differentiate the net energy for maintenance and activity, thus both energy requirements are taken into account in the net energy for maintenance. To ensure the closest conformity with the IPCC methodology and to avoid underestimate of emissions it was decided to take also into account the net energy for activity based on the IPCC methodology, using the Eq. 10.5 of 2006 IPCC Guidelines.

Calculation of net energy for lactation according to the Hungarian standards also differs from the IPCC methodology. For this reason, it was determined based on both equations. Use of Hungarian standards indicated higher values than the IPCC methodology. Thus, the net energy for lactation was calculated using the Hungarian standards for the inventory purposes, because it was assumed that it is more reliable for the Hungarian species.

The net energy requirement for pregnancy was also determined based on the standards of the Hungarian Nutrition Codex (2004) as well as the IPCC methodology, and it revealed that there is no difference between the outcomes of the two methodologies. As a consequence, Eq. 10.5 of 2006 IPCC Guidelines was applied for the sake of simplicity.

The Equation 10.16 of 2006 IPCC Guidelines was applied to transform net energy requirements into gross energy intake. The value of digestible energy (DE%) was calculated as weighted average of digestibilities of components in the diet to the use of the above mentioned equation. Composition of the diet were taken from the dataset of the Farm Accountancy Data Network (FADN). This dataset 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. This statistical data were combined with expert judgement on the composition of the diet and the seasonal changes in the feeding practices. Digestibility values for the different fodder crops in the diet were taken from the 'feed database' provided in the Hungarian Nutrition Codex (2004). This database contains results of laboratory measurements for feeds used for animal nutrition in Hungary.

Parameters and equations used to estimate the gross energy intake for dairy cattle and their sources are listed in **Table 5.2.4**.

Calculation of net energy requirements requires further statistical data and parameters, which are summarized in **Table 5.2.4**. Net energy for maintenance depends on the average body mass of dairy cattle, which was determined for each year of the time-series based on the change of livestock composition and characteristics of species. 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 proportion of Hungarian Simmental species has been dropped and as a result the annual milk yield increased from 4518 kg to 6429 kg 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 5.2.5**.

Table 5.2.4 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 typical Hungarian species.
C_{pregnancy}		Table 10.7 of 2006 IPCC GLs	0.1
Digestible energy intake (DE)	%	Kovács, 2013	Calculated annually, based on feeding statistics from FADN and laboratory measurements (Hungarian Nutrition Codex, 2004).
C_a		Table 10.5 of 2006 IPCC GLs	0 for stall, 0.17 for pasture
Proportion for grazing		HCSO, agricultural surveys, NFCSO's Nitrate database	See also Chapter 6.3.
$NE_m = 2.96 + FM * 4.25 + W * 0.06$ where, FM = farming method (1 = stalled; 2 = farming on good pasture; 3 = farming on average pasture) W = live-weight of Cow, kg			
	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_a	MJ/day	Eq. 10.5 of 2006 IPCC GLs	calculated
$NE_l = NE_{l,milk} * \text{kg of milk per day}$ $NE_{l,milk} = 1.45 + 38.45 * \text{Milk fat} + 3.02 * \text{Milk protein}$ where, Milk fat = Fat content of milk, % Milk protein = Protein content of milk, %			
	MJ/day	Hungarian Nutrition Codex, 2004	Country-specific methodology according to the Hungarian net energy requirements standards.
N_{cp}	MJ/day	Eq. 10.13 of 2006 IPCC GLs	calculated
REM		Eq.10.14 2006 IPCC GLs	calculated
GE	MJ/day	Eq. 10.16 of 2006 IPCC GLs	calculated
Y_m		Kovács, 2013	calculated

Net energy for lactation depends on the amount of daily milk production and fat content of milk. The daily average milk yield was calculated based on the HCSO's annual milk yield statistics. In 2014 the daily average milk production was 20.34 kg of milk per cattle in Hungary (*Table 5.2.5*). Data on fat content of milk was taken from the Eurostat statistics for the period 1998-2011, while for the period 1985-1997 the average of the values calculated for the period 1998-2011 were assumed due to lack of statistical data. Since 2012 this data has been provided by the HCSO.

Table 5.2.5 Body mass, digestible energy, milk yield, gross energy intake, N-excretion and the resulted emission factors for Dairy Cattle

Year	Body Mass, Average	Digestible Energy	Milk Yield	Gross Energy Intake	N-excretion	Emission Factor for 3.A
	kg/head	%	kg/head/day	MJ/head/day	kg N / head/year	kg CH ₄ / head/year
1985	626	68.29	12.28	251	74	112
BY	628	68.53	12.80	254	76	113
1986	628	68.55	12.91	255	77	113
1987	629	68.75	13.21	255	79	113
1988	631	68.79	13.50	257	79	114
1989	632	69.10	13.62	255	82	112
1990	633	69.26	13.78	255	83	111
1991	636	69.25	12.91	246	81	107
1992	639	69.38	13.10	246	82	107
1993	641	69.41	13.03	244	82	106
1994	641	69.42	12.92	243	82	106
1995	641	69.90	13.67	247	88	107
1996	640	69.93	13.87	249	89	107
1997	640	69.97	14.01	250	90	108
1998	641	70.26	15.10	257	94	110
1999	639	70.18	14.94	257	94	110
2000	641	70.51	16.13	264	97	112
2001	641	70.58	16.58	267	99	114
2002	641	70.62	16.86	270	100	115
2003	642	70.64	16.86	271	100	115
2004	642	70.60	16.80	270	101	115
2005	642	70.74	17.61	273	104	116
2006	642	70.83	18.37	280	106	119
2007	643	70.79	18.83	285	107	121
2008	643	70.57	19.10	288	104	123
2009	642	70.39	18.67	287	104	123
2010	642	70.27	18.84	288	103	124
2011	640	69.45	18.77	292	98	128
2012	639	69.61	19.53	299	101	130
2013	641	69.76	19.53	299	102	130
2014	641	70.05	20.34	302	106	131

Methane Conversion Rate for Dairy Cattle

Following a potential recommendation from the annual review conducted in 2013 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 country-specific values were calculated based on conclusions of the related publication of Soliva (2006). In line with this publication $Y_m=7.25$ was assumed for Dairy Cows fed hay and grass silage only (0% concentrate) and $Y_m=6.2$ for Dairy Cows fed 50% concentrate. The annual country-specific value of Y_m has been based on interpolation between the data points, in line with the annual value of the proportion of concentrate.

The resulted values are shown in **Table 5.2.6**.

Table 5.2.6 Methane Conversion Rates for Dairy Cattle BY-2014

Year	Concentrate Ratio	Y_m
	%	%
BY	22%	6.8
1990	28%	6.7
1991	28%	6.7
1992	29%	6.6
1993	29%	6.6
1994	29%	6.6
1995	32%	6.6
1996	32%	6.6
1997	32%	6.6
1998	34%	6.5
1999	34%	6.5
2000	36%	6.5
2001	36%	6.5
2002	36%	6.5
2003	36%	6.5
2004	36%	6.5
2005	37%	6.5
2006	36%	6.5
2007	36%	6.5
2008	34%	6.5
2009	33%	6.6
2010	33%	6.6
2011	29%	6.7
2012	30%	6.6
2013	30%	6.6
2014	32%	6.6

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 study of 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 judgments were combined to get the most reliable results. Similarly, to the dairy cattle values of net energy requirements and net energy for lactation for other cattle were calculated according to the Hungarian standards. **Table 5.2.7** summarizes the parameters and equations used to estimate the gross energy intake for non-dairy cattle.

Table 5.2.7 Parameters and equations to estimate 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.
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. 10.6 of GI (IPCC, 2006)		2006 IPCC GLs	0.8 for females, 1.2 for bulls, 0 for mature
C_{pregnancy}		Table 10.7 of 2006 IPCC GLs	0.1
Digestible energy intake (DE%)	%	Kovács, 2013	Calculated based on fed diets and laboratory measurements
C_a		Table 10.5 of 2006 IPCC GLs	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 standards of net energy requirements
NE_a	MJ/day	Eq. 10.4 of 2006 IPCC GLs	calculated
NE_l	MJ/day	Hungarian Nutrition Codex, 2004	Country-specific methodology according to the Hungarian standards of net energy requirements
NE_g	MJ/day	Eq. 10.6 of 2006 IPCC GLs	calculated
NE_p	MJ/day	Eq. 10.13 of 2006 IPCC GLs	calculated
REM		Eq. 10.14 of 2006 IPCC GLs	calculated
REG		Eq. 10.15 of 2006 IPCC GLs	calculated
GE	MJ/day	Eq. 10.16 of 2006 IPCC GLs	calculated

Net energy for maintenance depends on the live-weight, which was determined based on the study of Kovács, 2013. 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 2014 are shown in **Table 5.2.8** and **Table 5.2.9**.

Table 5.2.8 Gross energy intakes and emission factors by non-dairy cattle sub-categories for the base 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
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 * year	42	41	40	31	61	56	53	70
Gross Energy Intake	MJ/ head * day	94	92	156	160	200	192	185	157
Concentrat e ratio	%	31%	33%	10%	12%	18%	17%	17%	16%
Y _m	%	5.51	5.47	7.03	7.00	6.87	6.90	6.89	6.90
Emission Factor for 3.A	kg CH ₄ / head * year	24	23	72	73	90	87	84	71

Table 5.2.9 Gross energy intakes and emission factors by non-dairy cattle sub-categories for the year 2014

		<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
2014									
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 * year	44	42	46	41	66	60	57	75
Gross Energy Intake	MJ / head * day	94	94	161	163	192	199	191	162
Concentrate ratio	%	30%	33%	10%	12%	18%	17%	17%	17%
Y _m	%	5.53	5.48	7.03	7.01	6.87	6.90	6.89	6.90
Emission Factor for 3.A	kg CH ₄ / head * year	24	24	74	75	87	90	86	73

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 only milk methane conversion rate zero was assumed in accordance with the 2006 IPCC Guidelines. The time period of consuming only milk for juveniles was assumed to be 60 days, which is in line with the Hungarian standards.

Other livestock categories

Detailed information required to develop the Tier 2 emission factor is not available for other important livestock category in Hungary, such as sheep. Therefore, the Tier 1 methodology for enteric fermentation for all livestock categories other than cattle is applied. The emission factors used are the IPCC default ones provided for developed countries in the Table 10.10 of the 2006 IPCC Guidelines. 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 0.2 percent of the total emissions from enteric fermentations in all livestock, so 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 5.2.10*.

Table 5.2.10 Emission factors used for the calculation of the methane emissions from enteric fermentation

Animal category	CH ₄ -emission factor [kg head ⁻¹ yr ⁻¹]	Comments
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

5.2.3 Uncertainties and time-series consistency

Uncertainty of activity data (animal population) was estimated based on the confidence intervals for each animal category and livestock survey provided by the HCSO. The uncertainty of the mean annual averages was estimated according to the error propagation rules. (See *Table 5.1.3*) For the uncertainty of the country specific EFs $\pm 20\%$ were assumed, while for the default EFs $\pm 40\%$ were applied in accordance with the 2006 IPCC Guidelines. The combined uncertainty in emissions from the 3.A sector is ± 12 per cent.

5.2.4 Source specific QA/QC information

The country specific value of the gross energy intake for Dairy Cattles was verified using values reported by the EU member states. Verification revealed the Hungarian value of 302 MJ head-1 d-1 for the year 2014 was consistent with the reported values by other EU member states. The average gross energy intake for the EU-28 member states was 301 MJ head-1 d-1 according to the EU's NIR 2015 submission. There are no significant difference between the milk production in Hungary and in the EU-28. The milk production for the year 2013 was about 17.6 kg for the EU-28. The feed digestibility was 72% in the EU-15, while 70% in Hungary for the year 2012. (The detailed background data for Cattle was not published in the EU's NIR, 2015 submission, therefore data for the the year 2012 taken from the previous submission was compared.)

5.2.5 Source-specific recalculations

In response to an informal recommendation of the Trial ESD review, 2015 the county-specific methane conversion factor (Y_m) for dairy cattle was recalculated based on a related publication (Soliva, 2006) for the whole time series. As in the previous submissions the same methodology was used to calculate the methane conversion rate for non-dairy cattle, these Y_m values were also revised for the 2016 submission.

Revision of methane conversion factors for dairy cattle and non-dairy cattle resulted in an average of 4.3% increase (91.8 kt CO₂-eq) in the time-series of 1990-2013. The change in the BY was 5.2% which equates to 209.3 kt CO₂-eq. Changes in the emissions due to recalculations in 3.A are shown in *Table 5.2.11*.

Table 5.2.11 Changes in the emissions from 3.A due to recalculations for the BY and the period 1990-2013

Year	Submission 2015 [Gg CO ₂ -eq]	Submission 2016 [Gg CO ₂ -eq]	Difference [Gg CO ₂ -eq]	Percentage change
BY	4,011	4,220	209.3	5.2%
1990	3,579	3,754	174.6	4.9%
1991	3,351	3,513	162.0	4.8%
1992	2,906	3,043	137.0	4.7%
1993	2,459	2,573	114.3	4.6%
1994	2,169	2,271	102.0	4.7%
1995	2,119	2,214	95.1	4.5%
1996	2,116	2,211	94.6	4.5%
1997	2,067	2,159	92.2	4.5%
1998	2,055	2,141	86.2	4.2%
1999	2,079	2,166	87.0	4.2%
2000	2,050	2,131	80.9	3.9%
2001	1,970	2,046	76.5	3.9%
2002	1,947	2,022	74.8	3.8%
2003	1,927	2,000	73.1	3.8%
2004	1,872	1,943	71.2	3.8%
2005	1,848	1,917	69.3	3.8%
2006	1,795	1,863	68.9	3.8%
2007	1,797	1,868	71.4	4.0%
2008	1,772	1,845	72.9	4.1%
2009	1,747	1,822	74.6	4.3%
2010	1,731	1,807	75.5	4.4%

Year	Submission 2015 [Gg CO ₂ -eq]	Submission 2016 [Gg CO ₂ -eq]	Difference [Gg CO ₂ -eq]	Percentage change
2011	1,734	1,814	80.6	4.6%
1012	1,793	1,876	83.0	4.6%
2013	1,848	1,934	86.2	4.7%

5.2.6 Planned improvements

See Section 5.1.7

5.3 Manure management (CRF sector 3.B)

Emitted gases: CH₄, N₂O

Methods: T1, T2

Emission factors: D, CS

Key source: Yes

Particularly significant sub-categories, CH₄: Swine and Cattle

Particularly significant sub-categories, N₂O: Other AWMS and Indirect emissions

Animal manure is an important source of CH₄ and N₂O. The amount of CH₄ and N₂O 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.

5.3.1 Source Category Description

In 2014 25% of agricultural CH₄ and 12% of agricultural N₂O emissions arose from the 3.B Manure management. The bulk of emissions were generated in cattle and swine husbandry (in 2014 they accounted for 472 and 347 Gg CO₂-eq, which equates to 43% and 31% of total GHG emissions from 3.B, respectively), due to the considerable share of liquid manure and deep bedding. The main sources of CH₄ emissions from 3.B are Swine and Cattle manure (**Figure 5.3.1**), and most of N₂O emissions are generated in the solid and 'other' systems containing 'Cattle and Swine deep bedding' and 'Poultry manure with or without litter'. Indirect emissions contributed 35% to the N₂O emissions from this sector. The uncovered manure tanks and the low proportion of grazing cattle are the main sources of the significant amount of N₂O emissions from volatilization of N in form of NH₃ and NO_x.

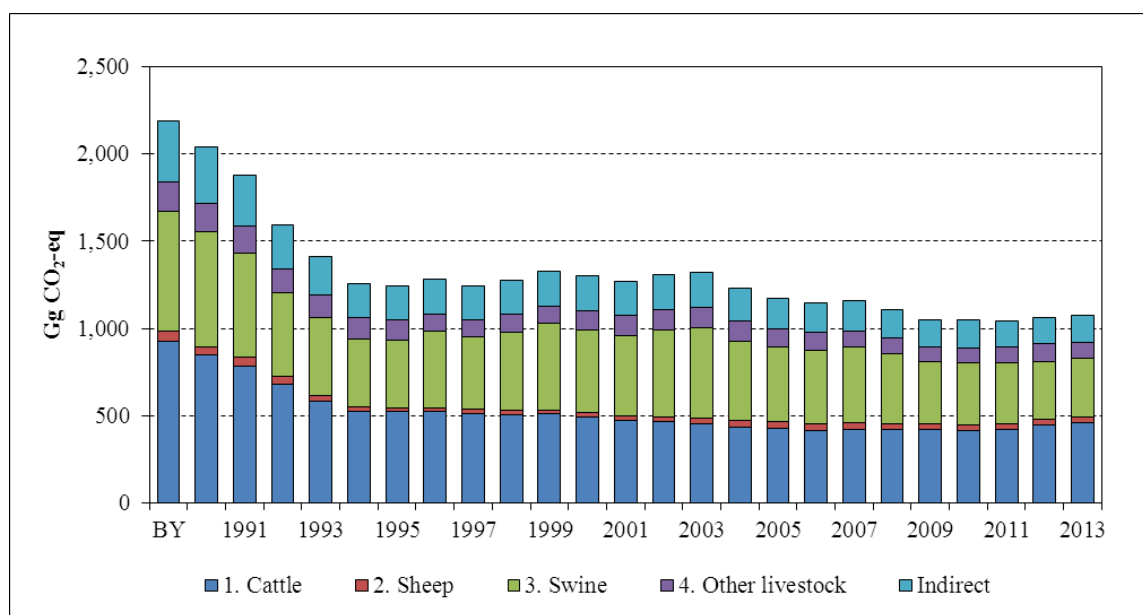


Figure 5.3.1 Emissions from 3.B Manure management by sources BY-2014

Emissions from 3.B Manure management have decreased by 49% since the BY (**Table 5.1.2**). Considering CH₄ and N₂O emissions separately, they have decreased by 48% and 52% over the inventory period, respectively. The significant decrease in the emissions reflects the decreasing swine and cattle livestock between 1985 and 1994. In the period 1995-2003 emissions fluctuated to some extent on yearly basis, following the annual changes in swine population. Emissions have decreased again in the period 2004 to 2010 reflecting again the falling swine livestock numbers over that period. Since 2011 emissions from 3.B slightly increased due to the increasing non-dairy cattle livestock. CH₄

and N₂O emissions from 3.B are shown in *Table 5.3.1* and *Table 5.3.2*.

Table 5.3.1 Trend in CH₄ emissions from 3.B Manure Management by livestock categories

Year	CH ₄ emissions from 3.B				
	Dairy Cattle	Non-Dairy Cattle	Sheep	Swine	Other livestock
BY	14.73	10.35	0.74	20.41	3.51
1990	13.88	8.76	0.58	19.98	3.22
1991	12.50	8.40	0.60	18.02	3.04
1992	11.31	6.78	0.55	14.46	2.65
1993	10.20	5.26	0.43	13.53	2.45
1994	9.49	4.47	0.32	11.73	2.36
1995	9.19	4.43	0.30	11.83	2.26
1996	9.12	4.47	0.28	13.55	2.18
1997	9.10	4.28	0.27	12.92	2.17
1998	9.12	3.96	0.28	14.10	2.24
1999	9.23	3.94	0.29	15.69	2.17
2000	8.82	3.78	0.35	14.97	2.38
2001	8.67	3.46	0.34	14.73	2.47
2002	8.55	3.39	0.34	16.16	2.56
2003	8.19	3.40	0.36	16.98	2.58
2004	7.73	3.39	0.41	14.93	2.49
2005	7.62	3.35	0.43	13.94	2.24
2006	7.22	3.45	0.40	13.86	2.08
2007	7.20	3.58	0.38	14.40	1.90
2008	7.30	3.59	0.37	13.18	1.82
2009	7.20	3.72	0.37	11.76	1.68
2010	6.95	3.92	0.35	11.71	1.68
2011	7.46	3.80	0.34	11.55	1.79
2012	7.82	4.09	0.34	11.05	1.93
2013	7.66	4.56	0.36	11.10	1.60
2014	7.82	4.75	0.37	11.59	1.57
Trend BY-2014	-47%	-54%	-50%	-43%	-55%

Table 5.3.2 Trend in N₂O emissions from 3.B Manure Management by sources

Year	N ₂ O emissions from 3.B					
	Dairy Cattle	Non-Dairy Cattle	Sheep	Swine	Other livestock	Indirect emissions
BY	0.48	0.52	0.14	0.59	0.29	1.17
1990	0.50	0.44	0.11	0.54	0.28	1.08
1991	0.45	0.43	0.11	0.49	0.26	0.99
1992	0.42	0.35	0.10	0.39	0.24	0.83
1993	0.38	0.28	0.08	0.37	0.22	0.74
1994	0.35	0.24	0.06	0.31	0.21	0.67
1995	0.37	0.24	0.06	0.31	0.19	0.66
1996	0.37	0.24	0.05	0.34	0.15	0.67

Year	N ₂ O emissions from 3.B					
	Dairy Cattle	Non-Dairy Cattle	Sheep	Swine	Other livestock	Indirect emissions
1997	0.37	0.23	0.05	0.31	0.15	0.64
1998	0.38	0.22	0.05	0.33	0.15	0.66
1999	0.38	0.21	0.06	0.36	0.15	0.67
2000	0.37	0.21	0.07	0.33	0.17	0.68
2001	0.37	0.19	0.07	0.30	0.18	0.65
2002	0.36	0.19	0.07	0.32	0.18	0.67
2003	0.35	0.19	0.08	0.33	0.18	0.67
2004	0.33	0.19	0.09	0.28	0.18	0.63
2005	0.33	0.19	0.09	0.26	0.16	0.59
2006	0.31	0.19	0.09	0.25	0.17	0.58
2007	0.30	0.20	0.09	0.26	0.16	0.58
2008	0.29	0.20	0.09	0.23	0.15	0.56
2009	0.28	0.21	0.09	0.21	0.14	0.53
2010	0.26	0.21	0.09	0.21	0.15	0.53
2011	0.26	0.21	0.08	0.20	0.15	0.51
2012	0.27	0.22	0.09	0.19	0.17	0.51
2013	0.26	0.24	0.09	0.19	0.18	0.51
2014	0.28	0.25	0.10	0.19	0.19	0.53
Trend BY-2014	-42%	-51%	-32%	-67%	-35%	-54%

5.3.2 Methodological issues

5.3.2.1 Calculation method

CH₄ emissions from manure management were estimated using Tier 2 methodology, except Rabbit, which contribution is less than 1% to the source category. Direct N₂O emissions were calculated using Tier 2 method for the important livestock categories in Hungary, such as Dairy Cattle, Non-Dairy Cattle and Swine. For these livestock categories country-specific nitrogen excretion rates, but IPCC default values of emission factors were applied. For the other livestock categories Tier 1 method was adopted. Indirect N₂O emissions were estimated based on the national air pollution inventory (i.e. reported NH₃ and NO_x emissions), which meet the requirement of the IPCC Tier 2 method. A detailed description of the methods applied for the calculation of NH₃ and NO_x emissions is given in the report 'Hungary's Informative Report, 2016' – Submission under the UNECE/CLRTAP.

5.3.2.2 Activity Data

Animal Waste Management System Distribution

Activity data on allocation of manure to animal waste management systems is based on processing and synthesizing of statistics from the HCSO's General Agricultural Censuses conducted in 2000 and 2010, Farm Structure Surveys, conducted in 2003, 2005, 2007, 2013, annual data for the period 2004-2013 from the Nitrate Database, reports on agricultural waste such as manure and compost from the National Waste Database for the period 2004-2013 and data on biogas production from Energy Statistics. Expert judgments were drawn on to the further stratification of primarily data e.g. to stratify liquid/slurry by natural crust cover and deep litter by mixing and frequency of removals.

In Hungary the first comprehensive study on animal waste management system distribution for emission inventory purposes was carried out by Ráky in 2003 based on the HCSO's General Agricultural Census 2000. This study focused on product producer farms and provides data by farm-

size structure. The results of the HCSO's General Agricultural Census 2010 provided comprehensive information on the manure management distribution again. The census provide 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

Farm Structure Survey data was applied to get representative activity data from the different datasets published by farm size structure and it was applied as surrogate data to the interpolation of the 2000-2010 time-series. Farm structure survey conducted in 2013 contained a more detailed data collection on grazing than former surveys. This data on proportion of grazing animals as well as grazing period was also taken into account in the inventory preparation.

Agricultural census is taken every 10 years, thus for the recent years statistics from the Nitrate Database provides the most reliable data. Annual statistics from the Nitrate Database are supplied by the National Food Chain Safety Office (NFCSO) to the inventory. Data collection for the Nitrate 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 on 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. Nitrate Database probably will provide a much improved representation of animal waste allocation among the relevant waste management systems in the future, because numbers of the received questionnaires have been increasing gradually by annual 2000 pieces in the recent years. Besides, the former paper questionnaires were 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 'Nitrate 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.

Implementation of methodologies of 2006 IPCC Guidelines required data on further AWMSs, such as

anaerobic digesters and composting. Statistics from the reports on agricultural waste such as manure and compost from the National Waste Database for the period 2004-2014 data on biogas production from Energy Statistics were processed to get the required activity data on the proportion of the use of anaerobic digesters and composting. Although, waste statistics prove that composted manure is reported as by-product of biogas plants. The 2006 IPCC Guidelines require more disaggregated data on liquid manure and deep litter. Expert judgments of Mészáros, 2015 were drawn on to the further stratification of primarily data e.g. to stratify liquid/slurry by natural crust cover and deep litter by mixing and frequency of removals.

The applied data sources sometimes 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. Data on sheep and goats were updated by a survey for sheep and goats in 2011 (Borka et al., 2010).

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.

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 proportions of the farms holding at least 100 animals and biogas production. Increasing proportion of grazing probably is the results of the high fodder prices.

Activity data for the base year and 2014 are presented in *Table 5.3.3* and *Table 5.3.4*, respectively. In case of cattle and swine extrapolation and surrogate data were used to complete the time-series. For the other livestock categories data for the year 2000 were used for the period 1985-1999 due to lack of information.

Table 5.3.3 Animal waste management distribution for the base year per livestock categories

BY	Liquid	Solid	Pasture	Anaero- bic digesters	Other	Deep litter	Yard	Poultry manure with bedding	Poultry manure without bedding
Dairy Cattle	3.64%	40.89%	8.00%	0.00%	47.47%	44.04%	3.43%	-	-
Non-Dairy Cattle	2.55%	39.84%	16.05%	0.00%	41.57%	38.25%	3.31%	-	-
Swine	39.50%	59.00%	0.00%	0.00%	1.50%	0.00%	1.50%	-	-
Poultry	8.50%	22.22%	0.25%	0.00%	69.03%	-	-	56.98%	12.05%
Sheep	0.85%	44.91%	54.25%	0.00%	0.00%	-	-	-	-
Goats	0.85%	55.74%	43.42%	0.00%	0.00%	-	-	-	-
Horses	0.00%	60.00%	40.00%	0.00%	0.00%	-	-	-	-

Table 5.3.4 Animal waste management distribution for the year 2014 year by livestock categories

2014	Liquid	Solid	Pasture	Anaero- bic digesters	Other	Deep litter	Yard	Poultry manure with bedding	Poultry manure without bedding
Dairy Cattle	10.14%	31.51%	8.55%	1.43%	48.36%	44.07%	4.30%	-	-
Non-Dairy Cattle	4.47%	29.55%	18.28%	1.43%	46.27%	39.11%	7.16%	-	-
Swine	57.39%	26.24%	0.00%	2.17%	14.20%	12.40%	1.81%	-	-
Poultry	1.23%	16.23%	0.05%	0.68%	81.81%	-	-	67.44%	14.37%
Sheep	0.00%	61.88%	38.12%	0.00%	0.00%	-	-	-	-
Goats	0.00%	56.58%	43.42%	0.00%	0.00%	-	-	-	-
Horses	0.00%	60.26%	39.74%	0.00%	0.00%				

Data on manure treated in biogas plants

Data on the share of manure digested in biogas plants was derived from the harmonization of energy and the waste statistics. The first biogas plant treated animal manure was installed in 2004 in Hungary. According to our data, 17 biogas plants digested animal manure in 2014. The amounts of digested manure are provided in *Table 5.3.5*.

Table 5.3.5 Amounts of digested manure 2004-2014

Year	Annually digested manure [tonnes]				
	Swine		Cattle		Poultry
	Liquid/slurry	Solid	Liquid/slurry	Solid	Solid
2004	NO	NO	3,550	10,604	860
2005	NO	NO	5,980	9,491	2,016
2006	NO	NO	2,220	7,963	NO
2007	9,662	879	7,525	5,220	NO
2008	42,169	1,604	15,136	4,641	NO
2009	35,650	2,629	38,195	2,538	NO
2010	61,508	994	79,049	13,792	56
2011	128,026	4,775	140,364	53,957	3,507
2012	141,063	12,858	152,111	70,247	12,595
2013	163,668	2,824	200,124	99,440	6,243
2014	159,803	34,232	150,602	35,707	3,787

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 5.3.6*.

Table 5.3.6 Swine population and trends from the BY to 2014

Year	Animal Population 1,000 head						Sows mated for the first time
	Piglets under 20 kg	Young pigs, 20-50 kg	Pigs for fattening over 50 kg	Breeding boars	Breeding sows	Guilts not yet mated	
BY	2,015	1,718	4,341	25	691	76	96
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
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
2013	723	683	1,246	5	194	44	43
2014	762	724	1,291	5	199	43	43
Trend BY-2014	-62%	-58%	-70%	-80%	-71%	-43%	-55%

Annual Average Nitrogen Excretion Rates (N_{ex})

For the values of annual average nitrogen excretion rates country specific (Tier 2) coefficients derived based on the Equation 10.31 of the 2006 IPCC Guidelines were used for Dairy Cattle, Non-Dairy Cattle and Swine. To the above equation Nitrogen intakes were determined from the crude protein content of each feed ingredient in the diet for all sub-categories of these animal species. The crude protein intakes were multiplied by 0.16, which is the value of N content in protein, to convert the protein content into N-content. Data on crude protein contents 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. In the case of cattle nitrogen intakes were determined in conjunction with the examination of gross energy intake (see also section 5.2.2.2).

Values of fraction of annual N-intakes that is retained by animals ($N_{\text{retention}}$) and their sources are summarized in **Table 5.3.7**. The resulted values of N-excretion for Dairy Cattle and Non-Dairy Cattle are provided in Table 5.2.5, Table 5.2.8 and Table 5.2.9, respectively, while values of N excretion for Swine are presented in **Table 5.3.8**.

Table 5.3.7 $N_{\text{retention}}$ rates and their sources

Animal species	$N_{\text{retention}}$	Source
Dairy Cattle	0.20	2006 IPCC GLs
Non-Dairy Cattle	0.07	2006 IPCC GLs
Swine	0.37	weighted average (2014)
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	2006 IPCC GLs
Breeding boars	0.30	2006 IPCC GLs
Guilts not yet mated	0.34	Fébel and Gundel, 2007
Sows mated for the first time	0.34	Fébel and Gundel, 2007

Table 5.3.8 Annual average Nitrogen excretion rates (N_{ex}) for Swine

Sub-categories	Body weight	N_{ex}
	kg	[kg head ⁻¹ year ⁻¹]
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 (2014)	180	19.4
Guilts not yet mated	87	9.9
Sows mated for the first time	150	13.8
Swine, weighted average (BY)	69.5	10.1
Swine, weighted average (2014)	64.1	9.5

For other livestock categories the default values of nitrogen excretion provided in Table 10.19 of the 2006 IPCC Guidelines were used except Buffalos for which the EMEP/EEA Guidebook (EEA, 2013) were applied (Table 3.7). It should be noted that in the case of nitrogen excretion rate of Buffalo the 2006 IPCC Guidelines refer to the EEA, 2002, thus the use of the 2013 EMEP/EEA Guidebook, which is the most up-to-date emission inventory guidebook of the EEA, seems to be reasonable. Nitrogen excretion rates for 'Other animals' and the related body weights are shown in **Table 5.3.9** and **Table 5.3.10**.

Table 5.3.9 Annual average Nitrogen excretion rates (N_{ex}) for 'Other livestock'

Animal Category	N_{ex} [kg head⁻¹ year⁻¹]	Source
Buffalo	82*	2013 EMEP/EEA GB / 2006 IPCC GLs
Sheep	16	2006 IPCC GLs, Eastern Europe
Goats	18	2006 IPCC GLs, Eastern Europe
Horses	41	2006 IPCC GLs, Eastern Europe
Asses & Mules	14	2006 IPCC GLs, Eastern Europe
Poultry	0.56	Weighted average for 2014
<i>Laying hens</i>	0.54	2006 IPCC GLs, Eastern Europe
<i>Broilers</i>	0.36	2006 IPCC GLs, Eastern Europe
<i>Turkey</i>	1.84	2006 IPCC GLs, Eastern Europe
<i>Ducks</i>	0.82	2006 IPCC GLs, Eastern Europe
<i>Geese</i>	0.55**	2013 EMEP/EEA GB
Rabbit	8.1	2006 IPCC GLs

*2006 IPCC GLs refer to the 2002 EMEP/EEA GB. Therefore, the 2013 EMEP/EEA GB as the more updated version of the GB was applied.

**There is no value provided in the 2006 IPCC GLs

Table 5.3.10 Weights for other livestock category

Livestock	Weight [kg]	Source/Note
Buffalo	380	Table 10A-6 of 2006 IPCC GLs
Sheep	48.5	Table 10A-9 of 2006 IPCC GLs
Goats	38.5	Table 10A-9 of 2006 IPCC GLs
Horses	377	Table 10A-9, Developed, 2006 IPCC GLs
Asses and Mules	130	Table 10A-9, Developed, 2006 IPCC GLs
Poultry	1.8	Weighted average for 2014
<i>Laying hens</i>	1.8	Table 10A-9 of 2006 IPCC GLs
<i>Broiler</i>	0.9	Table 10A-9 of 2006 IPCC GLs
<i>Turkey</i>	6.8	Table 10A-9 of 2006 IPCC GLs
<i>Ducks</i>	2.7	Table 10A-9 of 2006 IPCC GLs
<i>Geese</i>	NA	Weight is not applied in the calculation
<i>Guinea fowls</i>	0.9	As Broiler due to lack of information
Rabbit	1.6	Table 10A-9 of 2006 IPCC GLs

5.3.2.3 Emission factors

Emission factors for CH₄

As Manure Management is a key source the Tier 2 method was applied to calculate the CH₄ emission factors, except Rabbit, for which a default value of 0.08 is given in the Table 10A-9 of 2006 IPCC Guidelines was used. According to the Equation 10.23 of 2006 IPCC Guidelines, development of country-specific emission factors involves determining a weighted average methane conversion factor (MCF) using the estimates of the manure managed in each AWMS and the volatile solid excretion

(VS), which means the organic material in livestock manure. The CH₄ emission factor also depends on the maximum methane producing capacity (B₀) for the livestock categories. The values of these components in the above mentioned equation were calculated as it is delineated in the following sub-sections.

Volatile solid excretion per day (VS)

Country-specific values of VS for Cattle, Laying hens and Broilers were calculated according to the Equation 10.24 of 2006 IPCC Guidelines. Values needed for this calculation are the gross energy intake (GE), and its fractional digestibility, DE. The estimation of these values 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 taken from the Hungarian Nutrition Codex, 2004.

For the ash content of the manure the IPCC default value (8%) was applied due to lack of country-specific values. Similarly, the urinary energy which is also required to the Equation 10.24 was calculated as 0.04·GE according to the 2006 IPCC Guidelines.

The time-series of volatile solid excretion rates and CH₄-emission factors for Manure Management for Dairy Cattle are shown in *Table 5.3.11*.

Table 5.3.11 Volatile solid excretion rates and CH₄-emission factors for Manure Management for Dairy Cattle 1985-2014

Year	VS	CH ₄ - Emission Factor
	kg DM/day	kg/head*yr
BY	4.49	24.85
1990	4.41	24.48
1991	4.26	23.60
1992	4.24	23.45
1993	4.21	23.25
1994	4.19	23.10
1995	4.21	23.16
1996	4.23	23.29
1997	4.24	23.34
1998	4.33	23.79
1999	4.34	23.84
2000	4.40	24.17
2001	4.45	24.41
2002	4.50	24.64
2003	4.50	24.63
2004	4.49	24.78
2005	4.53	25.17
2006	4.63	25.95
2007	4.72	26.63
2008	4.80	27.34
2009	4.81	27.60

Year	VS	CH ₄ - Emission Factor
	kg DM/day	kg/head*yr
2010	4.85	28.03
2011	5.04	29.39
2012	5.12	30.14
2013	5.10	30.27
2014	5.12	30.40

Table 5.3.12 and *Table 5.3.13* contain the values of volatile solid excretion rate and the emission factors for non-dairy cattle for the BY and 2014, respectively.

Table 5.3.12 Volatile solid excretion rate and CH₄-Emission Factor for Non-Dairy Cattle in the BY

		<1 year		1-2 year			>2 year		
BY		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
VS excretion	kg DM/day	1.6	1.5	3.2	3.3	3.4	3.6	3.5	2.8
CH ₄ -Emission Factor	kg/head*yr	6	6	18	12	20	21	20	14

Table 5.3.13 Volatile solid excretion rate and CH₄-Emission Factor for Non-Dairy Cattle in 2014

		<1 year		1-2 year			>2 year		
2014		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
VS excretion	kg DM/day	1.6	1.6	3.4	3.4	3.5	3.9	3.7	3.0
CH ₄ -Emission Factor	kg/head*yr	9	9	18	13	16	19	18	12

For the other livestock categories, as Swine, Buffalo, Sheep, Horses, Asses and Mules, Ducks and Geese the IPCC default values provided for Eastern Europe or Developed countries in the Table 10A-6-10A-9 in the 2006 IPCC Guidelines was used. IPCC default values for geese and guinea fowls are not available; hence values for ducks and broilers were used, respectively. In the case of swine in the previous submission the default VS for breeding swine provided in the Table 10A-8 of the 2006 IPCC Guidelines was applied. This value was replaced with the default VS for Market Swine from Table

10A-7 of the 2006 IPCC Guidelines in this submission due to a findings of the Step 1 ESD review, 2016. According to the 2006 IPCC Guidelines the body mass of breeding swine and market swine are 180 and 50 kg, respectively. In Hungary the average body mass of swine is 64 kg, thus in the absence of country-specific value of VS the use of the market swine VS is reasonable.

Maximum CH₄ producing capacity (B₀) values

Due to lack of country-specific data default values listed in Tables 10A-4-10A-9 of the 2006 IPCC Guidelines were applied.

Methane conversion factors (MCF)

Default MCFs for different manure management systems by average annual temperatures provided in Table 10.17 of 2006 IPCC Guidelines were used. The annual mean temperature in most parts of Hungary is between 10 and 11 °C. Thus, MCFs values provided for cool climate zone were applied for Pasture/Range/Paddock, Solid and both Poultry manure.

The choice of MCFs for liquid manure and deep litter required the disaggregation of livestock categories by annual average temperatures. However, Hungary does not have either large animal populations or multiple climate regions. To the further stratification the annual mean temperature and animal livestock data by counties were used. The detailed climate data (i.e. annual mean temperatures for 19 counties of Hungary) were taken from the HMS climate database, while the detailed livestock data from the Farm Structure Survey, conducted in 2013. The resulted proportion of animal population by average annual temperature and livestock categories are provided in **Table 5.3.14**.

Table 5.3.14 Distribution of main livestock categories by average annual temperatures

Average annual temperature	Proportion of animal population				
	Dairy Cattle	Other Cattle	Swine	Laying Hens	Broiler
11	67%	67%	81%	69%	64%
≤10	33%	33%	19%	31%	36%

Beyond the average annual temperature the IPCC methodology differentiates between liquid manure with natural crust cover and without, as well as 'deep litter < 1 month' and 'deep litter > 1 month'. According to the expert judgment from the NARIC Institute of Agricultural Engineering (Mészáros, 2015), 80% of cattle liquid manure is covered with natural crust in Hungary and 20% is not. In the case of swine manure 73% of sows' and 52% of fattening pigs' liquid manure are covered by natural crust and the remainder is not, which equates to 54% of total swine liquid manure on average. Therefore the pig liquid/slurry was further stratified between 'with natural crust cover' and without. Poultry liquid manure was assumed to be not covered with natural crust. Duration of deep litter is generally longer than one month in Hungary.

IPCC Guidelines provide no methane conversion factor for Yard therefore the MCF of Solid was applied for yard manure. For Anaerobic digesters a range of 0-100% is given by the 2006 IPCC Guidelines and equations are provided to calculate the country-specific values. In this submission biogas treated manure is taken into account as liquid/slurry due to the lack of data available on the storage of manure in the biogas plants, which would be required for the detailed calculation. This assumption is in line with the 2006 IPCC Guidelines. Probably, the MCF value has to be lower for biogas treated manure compared to liquid manure, but currently there is not enough information to estimate the emission reduction arising from biogas plants. Additionally, there are only a few biogas plants using animal manure as fuel in Hungary. Therefore, the overall CH₄ emission from anaerobic digester treated manure is about 0.5 Gg CH₄. Consequently the neglected emission reduction can be considered as negligible. For more details on the verification of our assumptions on anaerobic digesters see Section 5.3.4. Methane conversion factors used in the inventory are provided in **Table 5.3.15**.

Table 5.3.15 Methane conversion factors for manure management systems

Manure Management System	MCF [%]
Pasture range and paddock	1
Solid storage and dry lot	2
<i>Liquid system</i>	
Cattle	12.2
Swine	14.4
Poultry	18.3
Anaerobic digesters	as liquid/slurry
<i>Other AWMS</i>	
Cattle deep bedding	18.3
Swine deep bedding	18.6
Yard	2
Poultry manure with litter	1.5
Poultry manure without litter	1.5

Emission factors for direct N₂O emissions

Default emission factors from 2006 IPCC Guidelines were used. In the case of cattle and swine liquid manure ‘with natural crust cover’ and ‘without natural crust cover’ were distinguished, similarly to the selection of MCF values (see section above for further details). Mixing of cattle and swine deep bedding does not occur in practice in Hungary (expert opinion, Fenyvesi, 2015). Therefore, for cattle and swine deep bedding ‘no mixing’ was assumed.

In the IPCC Guidelines emission factor is unavailable for Yard, therefore the emission factor for solid manure was applied. Emission factors used in the inventory to estimate N₂O emissions from manure management are listed in **Table 5.3.16**.

Table 5.3.16 Emission factors used for the estimation of N₂O emissions

Manure management system	N ₂ O-N emission factors [kg N ₂ O-N kg ⁻¹ N _{ex}]
Solid storage and dry lot	0.005
<i>Liquid system</i>	
Cattle	0.004
Swine (implied)	0.003
Sows	0.003
Fattening pigs	0.004
Poultry	0.000
Anaerobic digesters	0.000
<i>Other AWMS</i>	
Cattle deep bedding	0.010
Swine deep bedding	0.010
Yard	0.005

Manure management system	N ₂ O-N emission factors
	[kg N ₂ O-N kg ⁻¹ N _{ex}]
Poultry manure with litter	0.001
Poultry manure without litter	0.001

Emission factors for indirect N₂O emissions

In accordance with the 2006 IPCC Guidelines in order to estimate indirect N₂O emissions fractions of nitrogen losses due to volatilization and leaching/runoff, and two indirect N₂O emissions factors associated to these losses (EF₄ and EF₅) are needed. Fractions of nitrogen losses due to volatilization were calculated based on the 2013 EMEP/CORINAIR Inventory Guidebook. While nitrogen losses due to leaching was not estimated due to lack of a Tier 1 methodology in the 2006 IPCC Guidelines. However, in Hungary manure is managed in line with strict environmental rules and regulations arising from the Nitrates Directive (91/676/EEC), requiring avoiding N-leaching and use of impermeable barriers on the underlying strata, therefore this emissions should be negligible.

To estimate the indirect emissions from volatilization default value of 0.01 kg N₂O-N (kg NH₃-N + kg NO_x-N volatilized)⁻¹ for EF₄ are given in Table 11.3 of 2006 IPCC Guidelines was used.

5.3.3 Uncertainties and time-series consistency

5.3.3.1 CH₄ emissions

Uncertainty of activity data (animal population) was estimated based on the confidence intervals for each animal species and livestock survey provided 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 CH₄ emissions from manure management was assumed to be ±20% for Cattle and ±30% for all livestock categories except rabbit, for which ±50% was applied. The 2006 IPCC Guidelines provide ±30% for T1 and ±20% for T2 methods, thus the estimated uncertainties are in line with the IPCC values. The Tier1 uncertainty analysis gives an overall uncertainty of ±15 % for the CH₄ emission from manure management.

5.3.3.2 Direct N₂O emissions

Uncertainties of ±25% are assumed relating 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 2006 IPCC Guidelines. The uncertainty of the manure management system usage (MS_{T,S}) data was assumed to be ±25% in accordance with the default value provided by 2006 IPCC Guidelines. The uncertainty of the EFs are -50%/+100% according to the 2006 IPCC Guidelines, therefore the lower combined uncertainty of the direct N₂O emissions from Manure management is 37% and the upper one is 70%.

5.3.3.3 Indirect N₂O emissions

Currently, Hungary does not have uncertainty assessment on the reported air pollutant emissions. However, uncertainties in emission factor (EF₄) are likely to dominate these emissions, thus uncertainties in the volatilized nitrogen are comparatively less important in terms of emissions. Consequently, due to lack of country-specific uncertainties the default uncertainty ranges for the Frac_{GasMS}, and default uncertainty of the emission factor (EF₄), taken from the 2006 IPCC Guidelines were applied. The lower combined uncertainty of the direct N₂O emissions from Manure management is 89% and the upper one is 404%.

The overall combined uncertainty in the N₂O emissions from 3.B is -39%/+147%.

5.3.4 Source specific QA/QC

Assumptions on manure treated in biogas plants were verified using data from the energy sector. According to the energy statistics, other biogas (i.e. other than landfill gas or sewage sludge gas) production in 2014 was 2018 TJ. In 2014 the Research Institute of Agricultural Economics and the Hungarian Energy Office conducted a joint sample survey to collect data on agricultural wastes treated in biogas plants. This data collection revealed that about 40 per cent of dry matter content of waste treated in biogas plants using animal manure as fuel was animal manure. Thus, the biogas production from animal manure can be estimated about 883TJ, which equates to 18 kt CH₄. Consequently, the estimated 0.52 kt CH₄ emission from anaerobic digesters under sector 3.B means about 3% of the total biogas production from animal manure, which seems to be reasonable.

Nitrogen excretion rates 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 to verify the annual value of N excretion. Firstly, the N excretion was estimated based on the body mass and milk yields according to the methodology provided in Fébel and Gundel, 2007. This methodology indicates a value of 116 kg N/head/year for the year 2014, which is higher than the value applied in the inventory. In comparison, the methodology suggested by the 2006 IPCC Guidelines for calculation of country-specific value of N_{retention} resulted in a significantly lower value of 94.7 kg N/head/year for the N_{excretion} for 2014. According to the 2006 IPCC Guidelines data on the protein content of the milk was also taken into account in this calculation. The value of 105.9 kg N/head/year, which was applied in this inventory submission, is in the range of the values resulted by the methodologies described above.

In case of Non-Dairy Cattle and Swine the methodology provided in Febel and Gundel, 2007 indicates lower values. However, the difference for Swine is insignificant. Nitrogen excretion rates were compared with the values reported by other EU Member States. This verification revealed that the Hungarian values are in the range of values reported by EU Member States.

N₂O emissions are calculated and reported consistently with the NH₃ and NO_x inventory under the UNECE/LRTAP convention. To calculate the NH₃ and NO_x emissions the 2013 EMEP/EEA Guidebook was applied.

5.3.5 Source-specific recalculations

Numerous minor revisions have been implemented to calculate CH₄ and N₂O emissions from 3.B for the 2016 submission in response to the recommendations of the Trial EU ESD review, 2015 and the Step 1, EU ESD Review, 2016. The most important revisions affected the CH₄ emissions. In contrast, recalculations of N₂O emissions from 3.B are less significant. The resulted changes by gases and sources are outlined below:

CH₄ emissions

As a consequence of a finding of the Step 1 ESD review, 2016 the volatile solid excretion rate (VS) for Swine was revised. The formerly applied default value of the 2006 IPCC Guidelines for breeding swine (0.5 kg head⁻¹ day⁻¹) was replaced with another default from the Guidelines for market swine (0.3 kg head⁻¹ day⁻¹) for the whole time series. Revisions of CH₄ emissions from swine resulted in 25% (545.6 kt CO₂-eq) and 26% (273.5 kt CO₂-eq) decrease in the total emissions from 3.B in the BY and in 2013, respectively (**Table 5.3.17**).

Table 5.3.17 Impact of recalculation of CH₄ manure management emissions from Swine on total emissions from 3.B

	BY	1990	1995	2000	2005	2010	2011	2012	2013
Submission 2015 (kt CO ₂ -eq)	1,055.9	1,034.2	613.7	764.0	709.5	590.0	577.6	550.2	551.1
Submission 2016 (kt CO ₂ -eq)	510.3	499.5	295.8	374.1	348.5	292.8	288.8	276.2	277.6
Difference (kt CO ₂ -eq)	-545.6	-534.7	-317.9	-389.8	-361.0	-297.2	-288.8	-274.0	-273.5
Percentage change*	-25%	-24%	-26%	-30%	-31%	-28%	-28%	-26%	-26%

As a result of the Step 1 ESD review, 2016 CH₄ emissions from 3.B Manure management from non-dairy cattle was recalculated due to the revised values of maximum methane producing capacity (B₀) for Non-Dairy Cattle. The formerly incorrectly applied value of 0.24 was replaced with 0.17 for the whole time series. The overall effect of recalculations of CH₄ emissions from Non-Dairy Cattle on total emissions from 3.B were decreased by 6.5% (142.1 kt CO₂-eq) and 5.8% (62.0 kt CO₂-eq) in the BY and 2013, respectively. Impacts of revisions for Non-Dairy Cattle on the total emissions from 3.B for certain years are shown in **Table 5.3.18**.

Table 5.3.18 Impact of recalculation of CH₄ manure management emissions from Non-Dairy Cattle on total emissions from 3.B

	BY	1990	1995	2000	2005	2010	2011	2012	2013
Submission 2015 (kt CO ₂ -eq)	400.9	341.5	175.5	151.1	133.0	153.4	148.1	158.2	175.9
Submission 2016 (kt CO ₂ -eq)	258.7	219.0	110.8	94.5	83.6	97.9	94.9	102.3	113.9
Difference (kt CO ₂ -eq)	-142.1	-122.5	-64.7	-56.6	-49.3	-55.4	-53.2	-55.9	-62.0
Percentage change	-6.5%	-5.6%	-5.2%	-4.3%	-4.2%	-5.3%	-5.1%	-5.3%	-5.8%

Methane conversion rate (MCF) for Dairy Cattle liquid manure was recalculated, because the Trial ESD review, 2015 revealed that the fractions of natural crust cover was taken into account inconsistently in the calculation of CH₄ and N₂O emissions. For the 2016 submission this error was corrected, which resulted in an increase of the MCF for Dairy Cattle liquid manure from 10.7% to 12.2%. However, the informal recommendation of the trial review related to Swine, the inconsistencies were corrected for Dairy Cattle and Non-dairy Cattle as well. This revision resulted in an increase in the CH₄ emissions, which are shown in **Table 5.3.19**.

Table 5.3.19 Impact of recalculation of CH₄ manure management emissions from Dairy Cattle on total emissions from 3.B

	BY	1990	1995	2000	2005	2010	2011	2012	2013
Submission 2015 (kt CO ₂ -eq)	366.2	344.9	228.4	219.2	188.3	170.2	181.9	189.8	185.2
Submission 2016 (kt CO ₂ -eq)	368.3	347.0	229.7	220.5	190.6	173.8	186.5	195.4	191.4
Difference (kt CO ₂ -eq)	2.2	2.1	1.3	1.2	2.3	3.6	4.6	5.6	6.2
Percentage change	0.1%	0.1%	0.1%	0.1%	0.2%	0.3%	0.4%	0.5%	0.6%

Additionally, in response to a finding of the Trial ESD review, 2015 the MCF for Cattle, Swine and Poultry manure treated in anaerobic digesters was revised, and the formerly applied value of 2% was replaced with the values for liquid slurry due to the lack of enough information to calculate MCF

values according to the equations of the 2006 IPCC Guidelines. This revision resulted in an insignificant increase in the resulted CH₄ emissions. The resulted changes for Poultry are presented in **Table 5.3.20**, while for Cattle and Swine the Tables above present the effect of these revisions together with the other revisions affected the CH₄ emissions from the certain livestock category.

Table 5.3.20 Impact of recalculation of CH₄ manure management emissions from Poultry on total emissions from 3.B

	2005	2011	2012	2013
Submission 2015 (kt CO ₂ -eq)	47.6	33.6	30.5	28.4
Submission 2016 (kt CO ₂ -eq)	49.3	37.6	40.0	32.0
Difference (kt CO ₂ -eq)	1.7	4.0	9.5	3.6
Percentage change	0.08%	0.18%	0.76%	0.28%

CH₄ emissions from 3.B Manure Management decreased by 36.3% on average (426.0 kt CO₂-eq in total) in the period 1990-2013 (**Table 5.3.21**). The impact of these revisions resulted in a 0.6% decrease in national total emissions (excluding as well as including LULUCF) in 2013.

Table 5.3.21 Changes in the CH₄ emissions from 3.B due to recalculations for the BY and the period 1990-2013

Year	Submission 2015 [Gg CO ₂ -eq]	Submission 2016 [Gg CO ₂ -eq]	Difference [Gg CO ₂ -eq]	Percentage change
BY	1,929	1,244	-686	-35.5%
1990	1,816	1,161	-655	-36.1%
1991	1,663	1,064	-599	-36.0%
1992	1,378	894	-484	-35.1%
1993	1,234	797	-437	-35.4%
1994	1,088	709	-379	-34.8%
1995	1,081	700	-381	-35.3%
1996	1,164	740	-425	-36.5%
1997	1,121	719	-403	-35.9%
1998	1,171	743	-428	-36.6%
1999	1,251	783	-468	-37.4%
2000	1,203	758	-445	-37.0%
2001	1,176	742	-434	-36.9%
2002	1,244	775	-469	-37.7%
2003	1,276	788	-488	-38.3%
2004	1,158	724	-435	-37.5%
2005	1,096	689	-406	-37.1%
2006	1,082	675	-407	-37.6%
2007	1,108	687	-422	-38.0%
2008	1,043	657	-387	-37.1%
2009	969	618	-351	-36.2%
2010	964	615	-349	-36.2%
2011	957	623	-333	-34.8%
2012	945	631	-315	-33.3%
2013	958	632	-326	-34.0%

**Impact of recalculations on total CH₄ emissions from 3.B*

N₂O emissions

N-excretion rate for rabbit was revised due to a finding of the Trial ESD review, 2015. The formerly applied N-excretion rate was replaced with the default value provided in the 2006 IPCC Guidelines. This revision led to a slight increase (11.3% and 29.3 kt CO₂-eq on average) in the direct N₂O emissions from 3.B in the full time series. The revision of the nitrogen excretion also changes the amount of Nitrogen available for application to agricultural land, and hence also impacts on the emission estimates for 3.D.a Direct and 3.D.b Indirect Soil Emissions.

Indirect N₂O emissions from N losses due to volatilization from manure management were revised due to the revision of NH₃ and NO_x emissions from 3.B in the CLRTAP inventory. The recalculation of indirect emissions from 3.B resulted in a 3.2% and 6.2 kt CO₂-eq increase on average between 1990 and 2013 in the indirect N₂O emissions from 3.B in the full time series (**Table 5.3.22**).

For category 3.B.5 Indirect N₂O emissions due to leaching and run-off for the whole period notation key 'NO' was replaced by 'NE' as these emissions are not reported due to lack of T1 methodology.

Table 5.3.22 Changes in the N₂O emissions from 3.B due to recalculations for the BY and the period 1990-2013

Year	Submission 2015 [Gg CO ₂ -eq]	Submission 2016 [Gg CO ₂ -eq]	Difference [Gg CO ₂ -eq]	Percentage change*
BY	888	947	59	6.6%
1990	819	879	60	7.4%
1991	756	817	61	8.1%
1992	642	697	56	8.7%
1993	562	613	50	8.9%
1994	503	548	44	8.8%
1995	506	545	39	7.7%
1996	516	543	27	5.2%
1997	498	523	25	5.0%
1998	510	534	24	4.8%
1999	522	546	24	4.6%
2000	522	544	22	4.2%
2001	500	525	25	5.1%
2002	506	533	27	5.4%
2003	507	533	25	5.0%
2004	480	507	28	5.7%
2005	459	483	23	5.1%
2006	448	473	25	5.6%
2007	448	472	25	5.5%
2008	432	453	21	4.9%
2009	414	434	20	4.9%
2010	412	433	21	5.2%
2011	399	421	22	5.5%
1012	398	430	32	8.0%
2013	403	440	36	9.0%

**Impact of recalculations on total N₂O emissions from 3.B*

The net effect of recalculations in 3.B resulted in a -22.2% (626 kt CO₂-eq) decrease in the BY and 23.5% (394 kt CO₂-eq) decrease on average in the period 1990-2013. The resulted changes in the emissions are provided in **Table 5.3.23**. The overall effect of recalculations on national total emissions (excluding as well as including LULUCF) is a decrease by 0.6% and 0.5% in the BY and in 2013, respectively.

Table 5.3.23 Net changes in the emissions from 3.B due to recalculations for the BY and the period 1990-2013

Year	Submission 2015 [Gg CO₂-eq]	Submission 2016 [Gg CO₂-eq]	Difference [Gg CO₂-eq]	Percentage change
BY	2,817	2,191	-626	-22.2%
1990	2,634	2,040	-595	-22.6%
1991	2,419	1,881	-538	-22.2%
1992	2,019	1,591	-428	-21.2%
1993	1,797	1,409	-387	-21.6%
1994	1,592	1,257	-335	-21.0%
1995	1,588	1,245	-342	-21.6%
1996	1,681	1,283	-398	-23.7%
1997	1,620	1,242	-378	-23.3%
1998	1,681	1,277	-404	-24.0%
1999	1,772	1,329	-443	-25.0%
2000	1,725	1,301	-423	-24.5%
2001	1,676	1,268	-409	-24.4%
2002	1,749	1,308	-441	-25.2%
2003	1,784	1,320	-463	-26.0%
2004	1,638	1,231	-407	-24.8%
2005	1,555	1,172	-383	-24.6%
2006	1,530	1,148	-382	-24.9%
2007	1,556	1,159	-397	-25.5%
2008	1,475	1,110	-366	-24.8%
2009	1,383	1,052	-331	-23.9%
2010	1,376	1,048	-328	-23.8%
2011	1,356	1,045	-311	-23.0%
2012	1,343	1,060	-283	-21.1%
2013	1,361	1,072	-289	-21.3%

5.3.6 Planned improvements

See Section 5.1.7

5.4 Rice cultivation (CRF sector 3.C)

5.4.1 Source Category Description

Emitted gas: CH₄

Methods: T1

Emission factors: D

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 0.6% of the entire CH₄ emissions from agriculture sector.

5.4.2 Methodological issues

In Hungary the rice is cultivated on poorer quality soil, without organic amendments, the fields are intermittently flooded. Aeration is applied as a pest control during the cultivation. (Apáti, 2003).

Methane emissions from rice cultivation were calculated according to the Equation 5.1 of 2006 IPCC Guidelines. As CH₄ emissions from rice cultivation are not a key category in Hungary, the Tier 1 methodology with default emission factors was applied. The adjusted daily emission factor to the above equation was calculated based on Equation 5.2 of 2006 IPCC Guidelines. The required values of baseline emission factor (EF_c), water regime (SF_w), water regime in the pre-season (SF_p) to this equation were taken from Tables 5.11-5.13 of 2006 IPCC Guidelines. The adjusted CH₄ emission scaling factor for organic amendment (SF_o) was calculated using the Eq. 5.3 of 2006 IPCC Guidelines. The value of conversion factor (CFOA) was taken from Table 5.14 of 2006 IPCC Guidelines. Due to lack of detailed information 'straw incorporated shortly (<30 days) before cultivation' was assumed as a conservative approach.

As activity data, the total size of the production area was taken from the HCSO's statistics.

5.4.3 Uncertainties and time-series consistency

For the uncertainty of the activity data, ±5% has been estimated by expert judgement. Uncertainties of scaling factors and the baseline emission factor were taken from the 2006 IPCC Guidelines. (SF_w ± 26%; SF_o -4%/+5%; SF_p -14%/+15%, EF_c -63%/+69%) Combination of uncertainties listed above resulted in 69%/+75% combined uncertainty for the adjusted daily emission factor. Therefore, the overall lower and upper uncertainty of 69% and 76% can be calculated for the emissions from rice cultivation.

5.4.4 QA/QC Information

See 6.1.5.

5.4.5 Source-specific recalculations

There were no recalculations in this category.

5.4.6 Planned improvements

There are no further improvements planned.

5.5 N₂O emissions from Agricultural soils (CRF sector 3.D)

5.5.1 Source Category Description

Emitted gas: N₂O

Methods: T1

Emission factors: D

Key source: Yes

Particularly significant sub-categories: Inorganic N fertilizers, Crop residue

In 2014 agricultural soils emitted 88% of the total N₂O emissions from the agriculture sector, and 72% of the national total N₂O emissions are generated in agricultural soils (Table 5.5.1). Emissions from agricultural soils contributed 5.7 percent (3,263 Gg CO₂-eq) to the national total GHG emissions in 2014 (Table 5.5.1).

The overall trend in emissions is decreasing. However, trends in emissions from crop production related sectors as 3.D.a.4 and 3.D.a.5 are different from the other subsectors. Emissions from 3.D.a.4 fluctuated significantly depending on crop production, which is determined by the weather conditions. Trends for 3.D.a.5 also seem to be fluctuating. However, emission from this source is low and uncertain.

Table 5.5.1 Trends in emissions from 3. D Agricultural Soils by subcategories

Year	N ₂ O emissions [Gg N ₂ O]									
	3.D.a	3.D.a.1	3.D.a.2	3.D.a.3	4.D.a.4	3.D.a.5	3.D.a.6	3.D.b	3.D.b.1	3.D.b.2
BY	15.40	9.25	3.15	0.76	2.24	0.004	NO	1.64	1.20	0.45
1990	11.45	2.20	2.73	0.63	2.69	0.004	NO	1.29	0.93	0.36
1991	8.26	2.20	2.73	0.63	2.69	0.004	NO	0.85	0.61	0.24
1992	7.07	2.33	2.34	0.56	1.83	0.004	NO	0.73	0.51	0.21
1993	6.61	2.53	2.06	0.45	1.57	0.004	NO	0.67	0.47	0.20
1994	7.88	3.49	1.85	0.38	2.16	0.004	NO	0.73	0.49	0.24
1995	7.29	3.00	1.83	0.36	2.09	0.004	NO	0.72	0.51	0.22
1996	7.40	3.19	1.80	0.35	2.05	0.004	NO	0.73	0.51	0.21
1997	7.70	3.24	1.73	0.35	2.38	0.004	NO	0.73	0.52	0.21
1998	8.28	3.90	1.77	0.35	2.26	0.004	NO	0.78	0.55	0.23
1999	8.17	4.12	1.80	0.35	1.90	0.004	NO	0.77	0.56	0.21
2000	7.92	4.05	1.81	0.38	1.67	0.004	NO	0.79	0.55	0.24
2001	8.91	4.32	1.76	0.37	2.46	0.004	NO	0.82	0.56	0.26
2002	8.91	4.76	1.79	0.36	2.00	0.004	NO	0.86	0.60	0.26
2003	8.32	4.54	1.79	0.37	1.62	0.004	NO	0.85	0.60	0.26
2004	9.60	4.60	1.73	0.38	2.88	0.004	NO	0.90	0.61	0.28
2005	8.86	4.09	1.67	0.38	2.73	0.000	NO	0.80	0.56	0.24
2006	9.03	4.54	1.63	0.37	2.49	NO	NO	0.84	0.59	0.25
2007	8.91	5.03	1.62	0.36	1.90	NO	NO	0.87	0.60	0.26
2008	9.50	4.62	1.57	0.35	2.96	NO	NO	0.78	0.51	0.26
2009	8.60	4.32	1.51	0.35	2.42	NO	NO	0.72	0.48	0.25
2010	8.37	4.42	1.51	0.34	2.11	NO	NO	0.73	0.49	0.24
2011	9.01	4.74	1.50	0.34	2.43	0.003	NO	0.76	0.51	0.26
2012	8.84	4.92	1.54	0.35	2.03	0.008	NO	0.78	0.51	0.26
2013	9.85	5.39	1.58	0.36	2.51	0.012	NO	0.87	0.58	0.29
2014	10.10	5.13	1.64	0.38	2.93	0.017	NO	0.85	0.57	0.29

Year	N ₂ O emissions [Gg N ₂ O]									
	3.D.a	3.D.a.1	3.D.a.2	3.D.a.3	4.D.a.4	3.D.a.5	3.D.a.6	3.D.b	3.D.b.1	3.D.b.2
Share of national total N ₂ O emissions in BY	40%	24%	8.2%	2.0%	5.8%	0.01%	NO	4.3%	3.1%	1.2%
Share of national total N ₂ O in 2014	67%	34%	10.8%	2.5%	19.4%	0.08%	NO	5.7%	3.8%	1.9%
Trend BY-2014	-34%	-44%	-48%	-50%	31%	320%	NO	-48%	-53%	-36%

The total emissions from 3.D Agricultural soils have reduced by 36 per cent of the BY levels until 2014 (See Table 6.1.2). A significant drop had occurred in the period 1985-1993 due to the significant decrease in synthetic fertilizer use and livestock population which resulted in less N-input (**Figure 5.5.1**). After reaching the lowest point of the emission levels in 1993 there was a slight increase until 1998 due to a small rise in synthetic fertilizer use. After that emission levels remained quasi stable in the period 1998-2013 as a result of compensatory processes between the different sources of N input. As the **Figure 5.5.1** reveals emissions are primarily driven by the amount in synthetic fertilizer used. At the beginning of the time series the second most important source was the organic manure. In contrast, in the recent years N in crop residues has exceeded the amount of organic N, reflecting the restructuring in the Hungarian agricultural. Namely, the animal husbandry has declined in importance in the agricultural production, while crop production has become more meaningful. For more details on trends see also Section 5.1.1. Emissions from 3.D Agricultural soils and their trends by sub-categories are shown in **Table 5.5.1**.

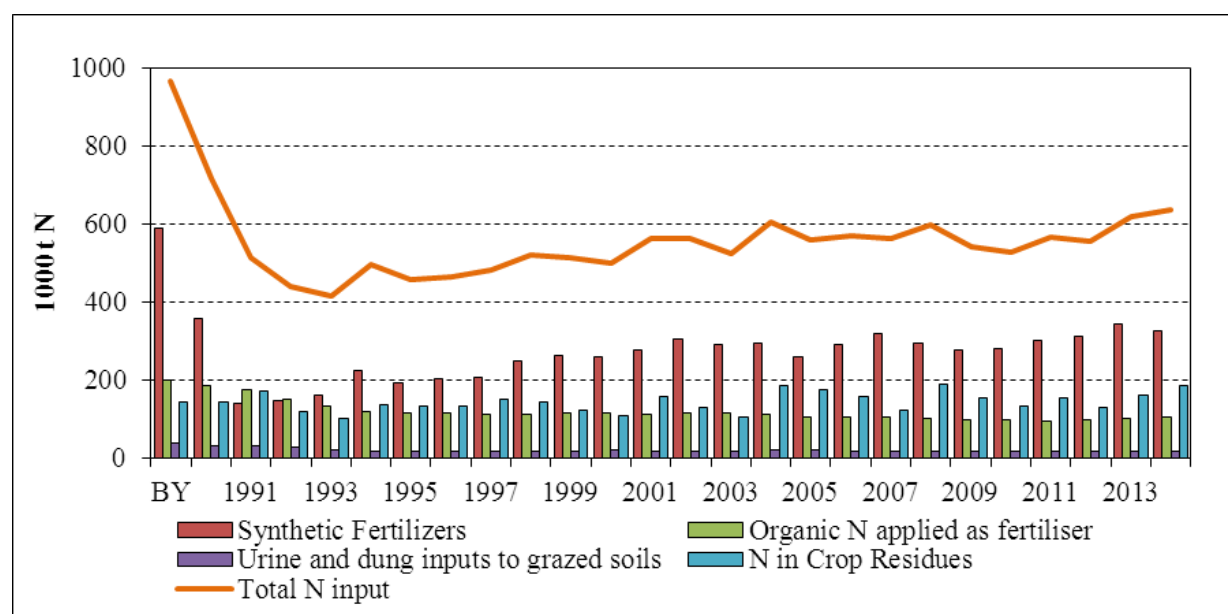


Figure 5.5.1 Trends in nitrogen input to soils

5.5.2 Methodological issues

Direct soil (CRF sector 3.D.a)

Direct soil emissions are the main source of N₂O in the Hungarian inventory. In 2014, 67% of the national total N₂O emissions originated from this sector (Table 6.5.1), which includes N inputs from synthetic N-fertilizer (3.D.a.1), organic manures as animal manure use and sewage sludge application (3.D.a.2), emissions from urine and dung N deposited on pasture (3.D.a.3) and crop residues (3.D.a.4). Emissions from N mineralization associated with loss of SOM (3.D.a.5) are rather low, but also was taken into account to meet the principle of completeness. Organic soils are protected, thus not cultivated in Hungary. Therefore it is not reported.

Emissions from these sources were calculated using Tier 1 methodology based on the Equation 11.1 of 2006 IPCC Guidelines. The N₂O-N was converted to N₂O by the factor (44/28) in line with the IPCC methodology. Terms of the Equation 11.1 were determined as it is detailed in the following sub-sections, while amounts of various N inputs to soils are provided in **Table 5.5.4**.

N input from synthetic fertilizer use (F_{SN})

Annual amount of synthetic N fertilizer applied to soils was estimated from the total amount of synthetic fertilizer consumed annually. Annual fertilizer consumption data was collected from the official country statistics of the HCSO, recorded as fertilizer sales statistics by the Research Institute on the Agricultural Economic. Collection of this data is executed according to the National Statistical Data Collection Programme (NSDCP). Although, this is a sale 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. Data on synthetic fertiliser applied (F_{SN}) for the period 1985-2014 are provided in **Table 5.5.4**.

Applied organic fertilizers (F_{ON})

The amount of organic N inputs applied to soils other than by grazing animals was calculated using Equation 11.3 of 2006 IPCC Guidelines. In Hungary this includes animal manure and sewage sludge applied to soils. Use of compost (F_{COMP}), as well as other organic amendments (F_{OOA}) was not estimated due to lack of sufficient information. (It should be noted, that according to the 2006 IPCC Guidelines other organic N additions can be included in the calculation if sufficient information is available.) Therefore, the relevant notation key 'NE' is reported in the CRF Table.

Managed manure nitrogen available for application to managed soils (N_{MMS_Avb}) was calculated based on Eq. 10.34 of 2006 IPCC Guidelines. Data required to the calculation of the first term of this equation, such as N excretion and N loss are provided in Chapter 6.3. In the case of straw based systems N inputs with straw were also taken into account in the inventory according to the above equation. Straw N amounts depend on animal categories and housing systems. The 2006 IPCC Guidelines provide default values for Cattle and Swine, which were used in our calculation. For other livestock categories default values taken from the 2013 EMEP/EEA Guidebook were applied. Data used in the calculations to estimate N from bedding materials with their sources is provided in **Table 5.5.2**. Use of managed manure as feed, fuel or for construction is not occurring in Hungary. Therefore fractions (Frac_{FEED}, Frac_{FUEL}, Frac_{CNST}) in Equation 11.4 of 2006 IPCC Guidelines were assumed to be zero.

Table 5.5.2 Nitrogen in bedding materials by animal category and manure management systems

Animal category	N content of bedding materials by manure management systems [(kg N head ⁻¹ yr ⁻¹)]		Source
	Solid	Deep Litter	
Dairy Cattle	7	13	p.10.66 of 2006 IPCC GLs.
Non-Dairy Cattle	5	10	Based on 2013 EMEP/EEA GB
Buffalo	6	-	Based on 2013 EMEP/EEA GB
Sheep	0.08	-	Based on 2013 EMEP/EEA GB
Goats	0.08	-	Based on 2013 EMEP/EEA GB
Horses	2	-	Based on 2013 EMEP/EEA GB
Mules	2	-	Based on 2013 EMEP/EEA GB
Swine	0.9	1.8	p.10.66 of 2006 IPCC GLs
Poultry	0.022*	-	Expert judgments

*Poultry manure with bedding

Data on annual amount of total sewage N that is applied to soils were taken from the HCSO's statistics for the period 1988-2011. For the years 1988 backwards application of sewage was assumed to be 'not occurring', because of the low proportion of wastewater treatment in Hungary. Contrarily, for the last two years the HCSO's statistics indicate a significant decrease in the agricultural use of sewage sludge, in spite of the increasing proportion of wastewater treated, and the increasing trend in the amount of sewage utilized in the agriculture annually, in the period 1988 to 2011. Therefore, in the 2016 submission, it has been decided to extrapolate the long trend observed in the sewage N that is applied to soils to get the required activity data for the years 2012-2014. The N-content of sewage sludge was assumed to be 4% in the calculation. Data on applied organic fertilizers (F_{ON}) was determined in coordinated with the Waste sector. The resulted activity data for the period 1985-2014 are provided in **Table 5.5.4**.

Urine and dung from grazing animals (F_{PRP})

The term F_{PRP} is estimated using Equation 11.5. For the required values of the equation see Chapter 5.3. Annual amount of urine and dung nitrogen deposited by grazing animals on pasture, range and paddock (F_{PRP}) for the period 1985-2014 are provided in **Table 5.5.4**.

Crop residue N including forage/ pasture renewal (F_{CR})

Nitrogen input from crop residues was estimated in accordance with the Tier 1 methodology, Equation 11.7A of the 2006 IPCC Guidelines. Activity data on crop yields and annual area of harvested crops were taken from the HCSO. To estimate the N added to soils from crop residues and forage/pasture renewal mainly default parameters from the Table 11.2 of the 2006 IPCC Guidelines were used. Since yield statistics are reported as field-dry weight a correction factor was applied to estimate dry matter yields in accordance with Equation 11.7 of 2006 IPCC Guidelines. In the case of wheat parameters provided for grains were used, because the default values given for wheat in the 2006 Guidelines are inappropriate for Hungarian wheat species. For rapeseed and sunflower seed, for which default values are unavailable in the 2006 IPCC Guidelines, country-specific values of ratio of above-ground residues dry matter to harvested yield crop and N content of above-ground residues for crop were used, while, N-contents of below-ground biomass for these crops were calculated using default values provided for 'beans and pulses' in the 2006 IPCC Guidelines. Dry matter contents of forage crops as lucerne-hay, red clover-hay, silo maize and grass hay were sourced from the Hungarian Nutrition Codex, 2004. Input factors used to estimate the N added to soils from crop residues are provided in **Table 5.5.3**.

The 2006 IPCC method accounts for the effect of residue burning or other removal of residues. Annual areas of burning for cereals ($\text{Area}_{\text{burnt}(T)}$) were estimated based on expert judgement. It was taken into account for the years before 1990, because burning of crop residues has been banned since 1986 in Hungary. A decreasing proportion of illegal field burning for cereals was assumed for the period between 1986 and 1990. (See also chapter 5.7). Equation 11.7 requires fractions of total area of crops that is renewed annually. For annual crops $\text{Frac}_{\text{Renew}}=1$ was assumed, while for Lucerne hay (Alfalfa) and Red clover hay 25%, as the area of these forage crops are renewed on average every four years. In addition, $\text{Frac}_{\text{Renew}}=0.2$ was assumed for the forage/pasture renewal, assuming five year renewal frequency based on expert judgement (Monori, 2015).

In the fraction of above-ground residues of crops removed annually ($\text{Frac}_{\text{Remove}}$) straw used as bedding materials was taken into account. Proportion of straw used as bedding materials were subtracted here, to avoid double counting, as this N is taken into account in the term of F_{ON} . This fraction was calculated consistently with the 3.B and F_{ON} . There is not comprehensive survey on the amount of crop residues burned as fuel in Hungary. Therefore no removal for burning of fuel was assumed. Amount of N in crop residues, including N-fixing crops, and from forage/ pasture renewal, returned to soils are shown in **Table 5.5.4**.

Table 5.5.3 Parameters used to estimate emissions from crop residues

Crops	Dry matter fraction of harvested product (DRY)	Slope	Intercept	N content of above-ground residues (N_{AG})	Ratio of below-ground residues to above-ground biomass ($\text{R}_{\text{BG-BIO}}$)	N content of below-ground residues (N_{BG})
Wheat ¹	0.880	1.09	0.88	0.0060	0.22	0.009
Maize (corn)	0.870	1.03	0.61	0.0060	0.22	0.007
Rice	0.890	0.95	2.46	0.0070	0.16	0.009
Barley	0.890	0.98	0.59	0.0070	0.22	0.014
Rye	0.880	1.09	0.88	0.0050	0.22	0.011
Oats	0.890	0.91	0.89	0.0070	0.25	0.008
Bean	0.900	0.36	0.68	0.0100	0.19	0.010
Peas	0.910	1.13	0.85	0.0080	0.19	0.008
Soya-bean	0.910	0.93	1.35	0.0080	0.19	0.008
Green peas	0.910	1.13	0.85	0.0080	0.19	0.008
Potatoes	0.220	0.10	1.06	0.0190	0.20	0.014
Sugarbeet	0.220	0.10	1.06	0.0190	0.20	0.014
Sunflower ²	0.800	NA	NA	0.0057	0.19	0.008
Rape ²	0.700	NA	NA	0.0033	0.19	0.008
Lucerne-hay ³	0.864	0.29	0.00	0.027	0.40	0.019
Red Clover-hay ³	0.855	0.29	0.00	0.027	0.40	0.019
Maize (silo) ³	0.317	1.03	0.61	0.006	0.22	0.007
Meadows ³	0.874	0.18	0.00	0.015	0.54	0.012

¹2006 IPCC default for 'grains' was applied, as data for wheat are inappropriate for Hungarian species.

²Dry matter content and R_{AG} are country-specific based on Zsembeli et. al, 2011. $\text{R}_{\text{AGsunflower}}=3.0$, $\text{R}_{\text{AGrape}}=2.0$.

³Values of DRY are country-specific, sourced from Hungarian Nutrition Codex, 2004.

N mineralization associated with loss of SOM (F_{SOM})

F_{SOM} refers to the amount of N mineralised from loss in soil organic C in mineral soils through land-use change or management practices. To estimate the N mineralised as consequence of this loss of soil carbon the Equation 11.8 of 2006 IPCC Guidelines was applied. The activity data was the carbon loss

from management changes under 4.B.1 cropland remaining cropland/ mineral soils. The resulted annual values for F_{SOM} are provided in *Table 5.5.4*.

Table 5.5.4 Amount of N inputs to soils BY-2014

Year	Synthetic Fertilizers	Organic N applied as fertilizer		Urine and dung inputs to grazed soils	N in Crop Residues	N mineralisation associated with loss of SOM
		Animal manure N	Sewage N			
BY	589	201	NO	36	142	0.24
1990	358	185	0.3	30	144	0.26
1991	140	173	0.4	30	171	0.26
1992	148	149	0.5	27	117	0.26
1993	161	130	0.6	22	100	0.26
1994	222	117	1.0	18	137	0.26
1995	191	115	1.3	17	133	0.26
1996	203	113	1.2	16	131	0.26
1997	206	109	1.0	16	151	0.26
1998	248	111	1.2	16	144	0.26
1999	262	114	1.0	17	121	0.26
2000	258	114	1.1	18	106	0.26
2001	275	111	1.0	18	157	0.26
2002	303	113	1.2	17	127	0.26
2003	289	113	1.2	17	103	0.26
2004	293	109	1.3	18	183	0.26
2005	260	104	2.2	19	174	0.02
2006	289	102	2.1	18	159	NO
2007	320	101	2.0	17	121	NO
2008	294	97	2.5	16	188	NO
2009	275	93	2.5	16	154	NO
2010	281	94	2.3	16	134	NO
2011	302	92	3.1	15	155	0.20
2012	313	95	2.7	16	129	0.50
2013	343	98	2.8	16	160	0.77
2014	327	101	2.9	17	187	1.07

Area of drained/managed organic soils (F_{OS})

Cultivation of Histosols is not occurring in Hungary, therefore notation key 'NO' is reported for the N_2O emission. Following the ERT team recommendation in 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 (EC 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).

Indirect Emissions (CRF 3.D.b)

In addition to the direct emissions of N_2O from managed soils, emissions of N_2O also take place through two indirect pathways. The first of these pathways is the volatilization of N as NH_3 and NO_x , and the subsequent deposition of these gases and their products onto soils and water surfaces. The sources of N volatilization are not confined to agricultural fertilizers and manures, but also include fossil fuel combustion, biomass burning, and processes in the chemical industry. In the Hungarian inventory reporting of volatilization of N and the deposition of NH_3 and NO_x is confined to agricultural sources.

The second pathway of indirect emissions is the leaching and runoff from land of N from agricultural inputs.

Atmospheric deposition of N volatilized

The N_2O emissions from atmospheric deposition of N volatilized from managed soil was calculated based on Tier 1 methodology, following the Equation 11.9 of 2006 IPCC Guidelines. The activity data are the same as those under 3.D.b.

The method requires values for the fractions of N that are lost through volatilization ($Frac_{GASF}$, $Frac_{GASM}$) and the emission factor (EF_4). The volatilization rates for Hungary were determined based on the air pollutant inventory for agriculture (Hungary's IIR, 2016). In the Hungarian air pollutant inventory nitrogen lost as NH_3 as well as NO_x were reported. In addition, $Frac_{GASF}$ was calculated as an annual implied value of N losses from different fertilizers types defined in the EMEP/EEA Guidebook (EEA, 2013). The 2013 value of $Frac_{GASF}$ was 0.07, which is lower than the IPCC default value, because of the decline in the proportion of Urea in the total fertilizer use. (Detailed data on fertilizer consumption by fertilizer types is not published in the Hungary's IIR, 2016 either this report because of data confidentiality.) Similarly, $Frac_{GASM}$ is also an annual implied value of N-losses referring to NH_3 -N as well as NO_x -N losses from animal manures in housing, storage, landspreading and nitrogen excreted at pasture that is volatilized as NH_3 and NO_x . The 2014 value of $Frac_{GASM}$ is 0.12. Annual NH_3 -N and NO_x -N volatilization losses from synthetic fertilizers and organic N fertilizers (including grazing) for the BY and the period from 1990 to 2014 are provided in Table 5.5.5 together with the resulted values of $Frac_{GASF}$ and $Frac_{GASM}$.

Table 5.5.5 $\text{NH}_3\text{-N}$ and $\text{NO}_x\text{-N}$ volatilization losses from synthetic and organic N fertilizers (including grazing) BY and 1990 to 2014

Year	N losses from mineral fertilizer	N losses from applied organic N fertilizer materials and grazing	Frac _{GASF}	Frac _{GASM}
	kt N	kt N		
BY	47.50	74.29	0.08	0.12
1990	33.15	68.52	0.09	0.12
1991	14.70	62.78	0.10	0.11
1992	12.44	52.88	0.08	0.10
1993	12.17	46.98	0.08	0.10
1994	14.90	42.39	0.07	0.11
1995	15.79	42.27	0.08	0.12
1996	15.46	42.51	0.08	0.13
1997	16.48	40.76	0.08	0.13
1998	17.78	41.85	0.07	0.13
1999	18.32	42.66	0.07	0.14
2000	17.94	43.10	0.07	0.13
2001	19.12	41.60	0.07	0.13
2002	21.06	42.48	0.07	0.13
2003	20.65	42.60	0.07	0.13
2004	22.95	40.26	0.08	0.12
2005	20.36	37.62	0.08	0.12
2006	22.63	36.96	0.08	0.12
2007	23.62	36.84	0.07	0.12
2008	18.19	35.47	0.06	0.12
2009	16.40	33.64	0.06	0.12
2010	16.70	33.84	0.06	0.13
2011	18.14	32.76	0.06	0.13
2012	18.70	32.24	0.06	0.13
2013	22.80	32.52	0.07	0.12
2014	21.78	33.75	0.07	0.12

Leaching and runoff

The N₂O emissions from the N lost through leaching and runoff was calculated based on the Tier 1 methodology and Equation 11.10 of 2006 IPCC Guidelines. The activity data are the same as those under 3.D.a.

In accordance with the 2006 IPCC Guidelines for humid regions and in regions where irrigation is used, the default value of $Frac_{LEACH-H}$, 0.3 was applied in the calculation of emissions. For dryland regions, where precipitation is lower than evapotranspiration throughout most of the year, $Frac_{LEACH}$ was assumed to be zero. According to the IPCC methodology the determination of proportion of irrigated areas and humid regions are required. Thus, the Equation 11.10 of the 2006 IPCC Guidelines can be considered as the same as Equation 5.3

$$N_2O_{(L)}-N=(F_{SN}+F_{ON}+F_{PRP}+F_{SOM}) \cdot (Frac_{irr}+Frac_{wet}) \cdot Frac_{LEACH-H} \cdot EF_5 \quad (\text{Equation 5.3})$$

Where:

N_2O-N =annual amount of N₂O-N produced from leaching and run-off of N additions to managed soils in regions where leaching/runoff occurs, kg N₂O-N

F_{SN} =annual amount of synthetic fertilizer N applied to soils in regions where leaching/runoff occurs, kg N yr⁻¹

F_{ON} =annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils in regions where leaching/runoff occurs, kg N yr⁻¹

F_{PRP} = annual amount of urine and dung N deposited by grazing animals in regions where leaching/runoff occurs, kg N yr⁻¹

F_{CR} = amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage, pasture renewal, returned to soils annually in regions where leaching/runoff occurs, kg N yr⁻¹

F_{SOM} = annual amount of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management in regions where leaching/runoff occurs, kg N yr⁻¹

$Frac_{irr}$ = fraction of irrigated agricultural areas

$Frac_{wet}$ = fraction of humid agricultural areas

$Frac_{LEACH-H}$ =fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs

EF_5 =emission factor for N₂O emissions from N leaching and runoff, kg N₂O-N (kgN leached and runoff)⁻¹

Derivation of fraction of irrigated areas ($Frac_{irr}$)

Proportions of irrigated areas were derived annually from HCSO's statistics on irrigated, utilized and total agricultural areas. The 2006 IPCC Guidelines require to distinguish the drip irrigated areas within the irrigated areas, because according to the methodology N-leaching is assumed to be unlikely on drip irrigated areas. The HCSO publishes the total irrigated areas annually, which include the drip irrigated areas as well for the period 1989-2014. Unfortunately, the drip irrigated areas are not reported separately in this statistics. For the period before 1989 data on the total irrigated areas and within this the drip irrigated areas are available, separately. Therefore, in the 2016 submission it has been decided to account the total irrigated areas, i.e. areas of drip irrigation are not subtracted from the total irrigated areas, due to lack of reliable and consistent statistics on drip irrigation for the whole time-series. As the fraction of drip irrigation was 1.5% of the total irrigated areas on average for the period 1985-1989, inclusion of drip irrigation in the emission estimation probably cause a negligible overestimation of emissions.

Because it is assumed that N is applied only on utilized agricultural areas, annual fractions of irrigated areas were calculated as a fraction of utilized agricultural areas. (Calculation of irrigated areas as fraction of the total agricultural areas could result in an underestimation of the amount of N leached and run-off.) Utilized areas were taken from the HCSO's censuses for the year 2000, 2010 and 2013. Annual areas for years between censuses data has been based on linear interpolation between data points. For the period before 1990 the total agricultural area was assumed to be utilized, as agricultural areas started to be abandoned as a result of the change of the regime in the 90's.

In 2014 99.3 thousand hectares (2.1% of the utilized agricultural areas) were irrigated. Although, the National Water Authority indicates a total area with water right permit 222.8 ha (about 4% of total agricultural areas) for 2014, according to the HCSO's statistics 45% of the irrigable areas were irrigated actually in 2014. One of the reasons for this low proportion is probably, that 2014 was a

relatively rainier year than an average. In Hungary the fraction of irrigated areas is significantly lower than the average of the EU Member States' because of the limited and outdated irrigation system. In 2010 5.8% of the Member States' utilized agricultural areas were irrigated. In contrast this proportion was 2.4% for Hungary in that year according to the EUROSTAT statistics. Because of this low proportion of irrigation the improvement of water management efficiency and irrigation systems are among the priorities of the Hungarian Rural Development Programme for the period 2014-2020. Additionally, the large inter-annual fluctuations in the harvested crop productions also reflect the high dependence on weather conditions (e.g. droughts) partially due to the low proportion of irrigated areas. The resulted fractions of irrigated areas are shown in *Table 5.5.6*.

Table 5.5.6 Derivation of activity data on irrigated agricultural areas, from the BY to 2014

Year	Total irrigated areas ha	Total agricultural areas 1000 ha	Utilised agricultural areas (UAA) 1000 ha	Irrigated areas as % of UAA (Frac _{irr})
BY	147,871	6186	6186	2.4%
1990	216,937	6132	6132	3.5%
1991	148,669	6116	5989	2.5%
1992	177,808	6091	5839	3.0%
1993	180,088	6080	5702	3.2%
1994	160,384	6064	5562	2.9%
1995	146,541	6048	5422	2.7%
1996	126,344	6028	5278	2.4%
1997	81,908	6008	5137	1.6%
1998	93,431	5990	4997	1.9%
1999	44,822	5972	4858	0.9%
2000	125,866	5745	4555	2.8%
2001	104,172	5729	4598	2.3%
2002	117,035	5698	4629	2.5%
2003	148,642	5667	4660	3.2%
2004	120,596	5632	4686	2.6%
2005	75,161	5604	4718	1.6%
2006	78,193	5570	4744	1.6%
2007	121,064	5536	4769	2.5%
2008	80,149	5503	4794	1.7%
2009	107,106	5471	4820	2.2%
2010	114,550	5261	4686	2.4%
2011	101,046	5256	4681	2.2%
2012	124,944	5257	4682	2.7%
2013	118,934	5259	4657	2.6%
2014	99,335	5266	4663	2.1%

Derivation of fraction of humid regions (Frac_{wet})

To estimate the fraction of humid regions is also required to calculate the emissions from N-leaching. Proportion of humid regions was determined based on the analysis of the 30 year climate means (1981-2010) of the monthly precipitation and evaporation data from the HMS climate database.

According to the definition of the Frac_{LEACH-(H)} in the 2006 IPCC Guidelines, the determination of 'rainy seasons' are required based on the data on precipitation and Pan Evaporation (E_{PAN}). The Guidelines define the 'rainy seasons' as periods when rainfall > 0.5 · Pan Evaporation, which criteria is equal to that P/E_{PAN} > 50%, where P is the monthly precipitation.

Table 5.5.7 Data for the derivation of ‘rainy seasons’ to calculate emissions from 3.D.2.2

Month	Potential Evaporation (PE)	Pan Evaporation (E _{PAN})	Precipitation (P)	P/E _{pan}	P/PE
January	22.9	-	33.2	-	145%
February	29.4	-	32.8	-	112%
March	54	-	35.3	-	65%
April	83.7	93.8	44.4	47%	53%
May	115.2	128	63.7	50%	55%
Jun	129.1	141.6	73.6	52%	57%
July	157.8	172.3	65	38%	41%
August	148.1	148	63.3	43%	43%
September	94.2	93.1	54.7	59%	58%
October	61.2	62.7	42.6	68%	70%
November	33	-	49.8	-	151%
December	22.3	-	47	-	211%

Source: HMS

Pan Evaporation data is registered from April to October in Hungary. To avoid underestimation of emission it has been decided to examine the Potential Evaporation instead of Pan Evaporation for the remainder months, from November to March. Analysis of data in **Table 5.5.7** reveals Jun and the period from September to March can be considered as ‘rainy seasons’ in Hungary, according to the definition of the 2006 IPCC Guidelines.

According to the 2006 IPCC Guidelines N-leaching could occur where:

$$\sum(\text{rain in rainy season}) - \sum(\text{PE in same period}) > \text{soil water holding capacity} \quad (\text{Equation 5.4})$$

Where:

PE = potential evaporation

Because the soil water holding capacity is generally greater than zero, the following equation can be derived from Equation 5.4:

$$\sum(\text{P in rainy season}) - \sum(\text{PE in same period}) > 0 \quad (\text{Equation 5.5})$$

Where:

P=precipitation

Evaporation is the process whereby liquid water is converted to water vapour and removed from the evaporating surface. Water evaporates from different surfaces, such as water, soils and wet vegetation. On agricultural areas the soil and plants are the evaporating surfaces. Thus, evaporation on agricultural areas depends on the weather conditions, soil properties, management practices and crop type. Consequently, PE could be highly different within a country and can not be expressed with a representative value. To analyse the climatic conditions of leaching and run-off the 30 year means of monthly precipitation and reference evapotranspiration (ET_o) from station data were determined by the HMS as high resolution gridded data over Hungary. It is important to note that the 2006 IPCC Guidelines on p.11.23 also use the potential evapotranspiration instead of potential evaporation to distinguish between dryland and humid regions.

The FAO Penman-Monteith method was used to determine ET_o for each month. The definition and concept of ET_o is as follows:

‘The evapotranspiration rate from a reference surface, not short of water is called the reference crop evapotranspiration or reference evapotranspiration and is denoted as ET_0 . The reference surface is a hypothetical grass reference crop with specific characteristics. The concept of the reference evapotranspiration was introduced to study the evaporative demand of the atmosphere independently of crop type, crop development and management practices. As water is abundantly available at the reference evapotranspiring surface, soil factors do not affect evapotranspiration (ET). Relating ET to a specific surface provides a reference to which ET from other surfaces can be related. It obviates the need to define a separate ET level for each crop and stage of growth. ET_0 values measured or calculated at different locations or in different seasons are comparable as they refer to the ET from the same reference surface. The only factors affecting ET_0 are climatic parameters. Consequently, ET_0 is a climatic parameter and can be computed from weather data. ET_0 expresses the evaporating power of the atmosphere at a specific location and time of the year and does not consider the crop characteristics and soil factors. The method has been selected because it closely approximates grass ET_0 at the location evaluated, is physically based, and explicitly incorporates both physiological and aerodynamic parameters.’ (FAO, ET_0 calculator.)

Consequently, in the Equation 5.5 the PE was replaced with the ET_0 , and the data of P/ET_0 for June and $\sum P/\sum ET_0$ for the period September to March were generated with a spatial resolution of 30 arc-seconds (≈ 1 km) to the analysis. The resulted maps are shown on **Figure 5.5.2** and **Figure 5.5.5**. Subsequently, areas where in the ‘rainy seasons’, namely June, and the September-March period in Hungary, $\sum P/\sum ET_0 > 1$ were determined from GIS analysis of the gridded climate data and the resulted areas were superimposed on the CORINE 2012 land cover database.

Figure 5.5.2 *The ratio of average precipitation and average reference evapotranspiration (P/ET_0) for June*

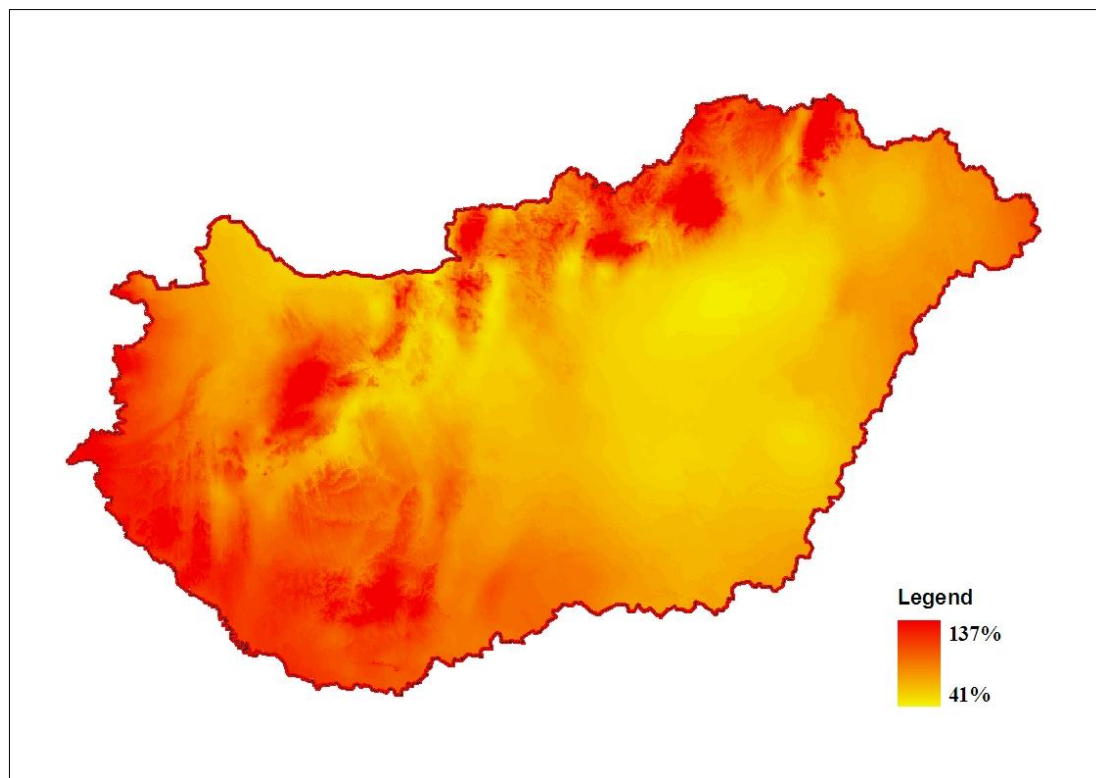
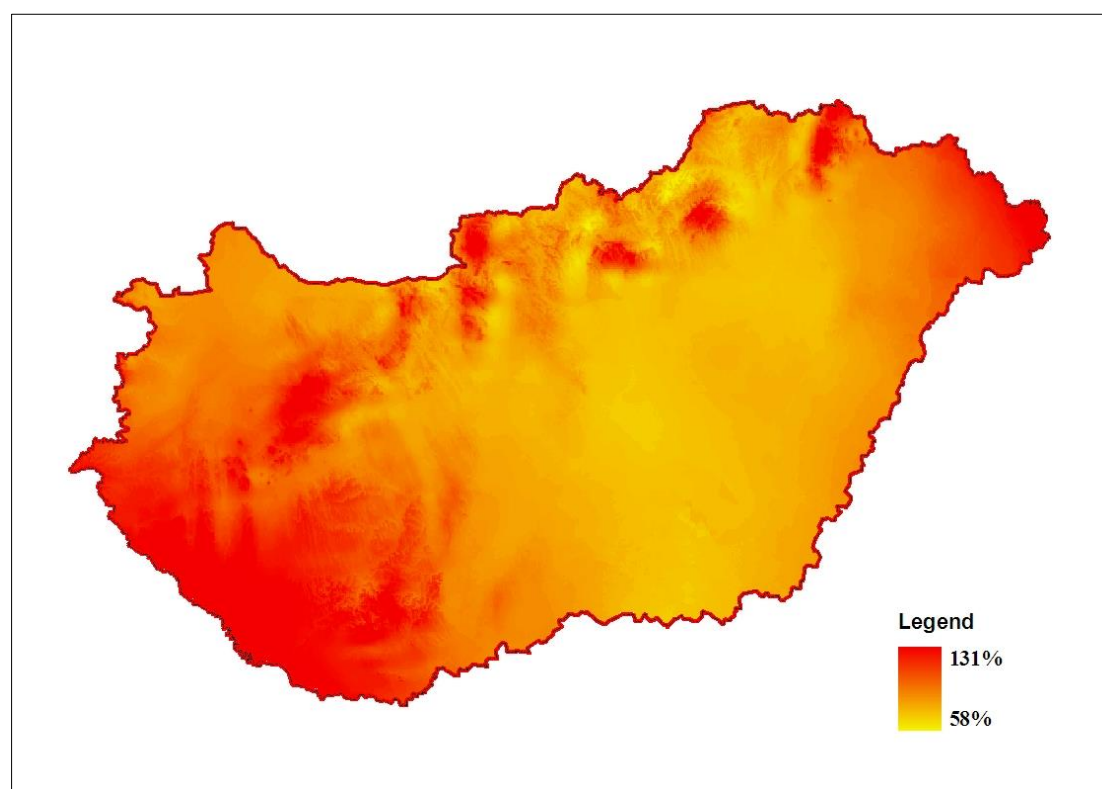


Figure 5.5.3 The ratio of total average precipitation and total average reference evapotranspiration ($\Sigma P/\Sigma ET_0$) for the period September to March



From the CORINE 2012 land cover database croplands, grasslands and agricultural mosaics (200<CLC codes<300) were considered to be agricultural lands.

As a result of the GIS analysis of climate and land cover maps (**Figure 5.5.4** and **Figure 5.5.5**) fraction of agricultural lands where N-leaching could occur because of the potential existence of precipitation surplus is 1,516 ha in June, which equates to 0.02% of the agricultural lands in the CORINE database, and 659,439 ha (10.65%) in the September-March period (**Table 5.5.8**). As humid regions analysed for the September-March period include the affected areas in June, the total fraction of humid regions is 10.65%. In other words, the resulted areas for Jun and September-March period were not added, because the humid regions in Jun are also humid in the September to March period.

Table 5.5.8 Resulted areas from GIS analysis of climate and CLC, 2012 land cover databases

	Area	
	ha	As % of the total area of the country
Total area of humid regions in June	22,460	0.24%
Total area of humid regions in September-March period	544,345	5.86%
Agricultural lands from CORINE, 2012	6,190,940	67%
	Area	
	ha	As % of the total area of agricultural lands
Humid agricultural lands in June	1,516	0.02%
Humid agricultural lands in the September-March period	659,436	10.65%
Total area of humid agricultural lands in 'rainy seasons' for Hungary	659,436	10.65%

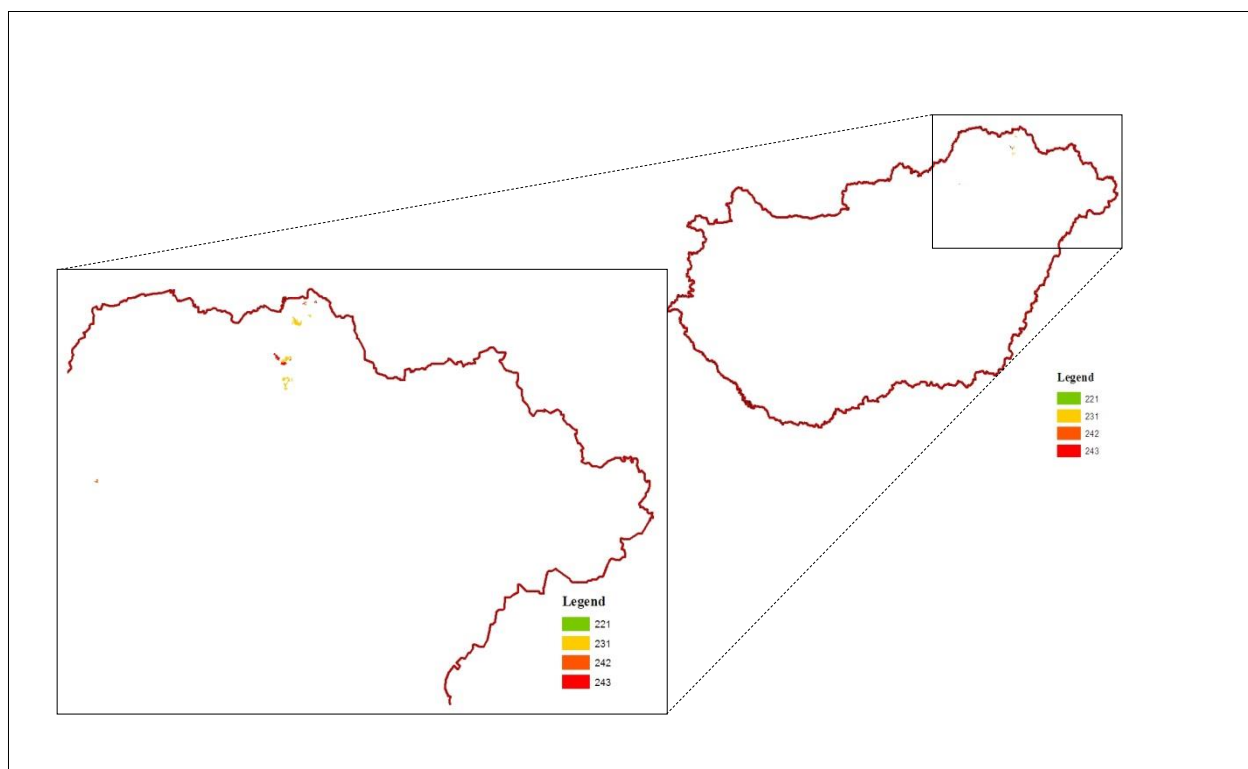


Figure 5.5.4 Humide ($P/ET_o > 1$) agricultural areas by CORINE land cover codes in June

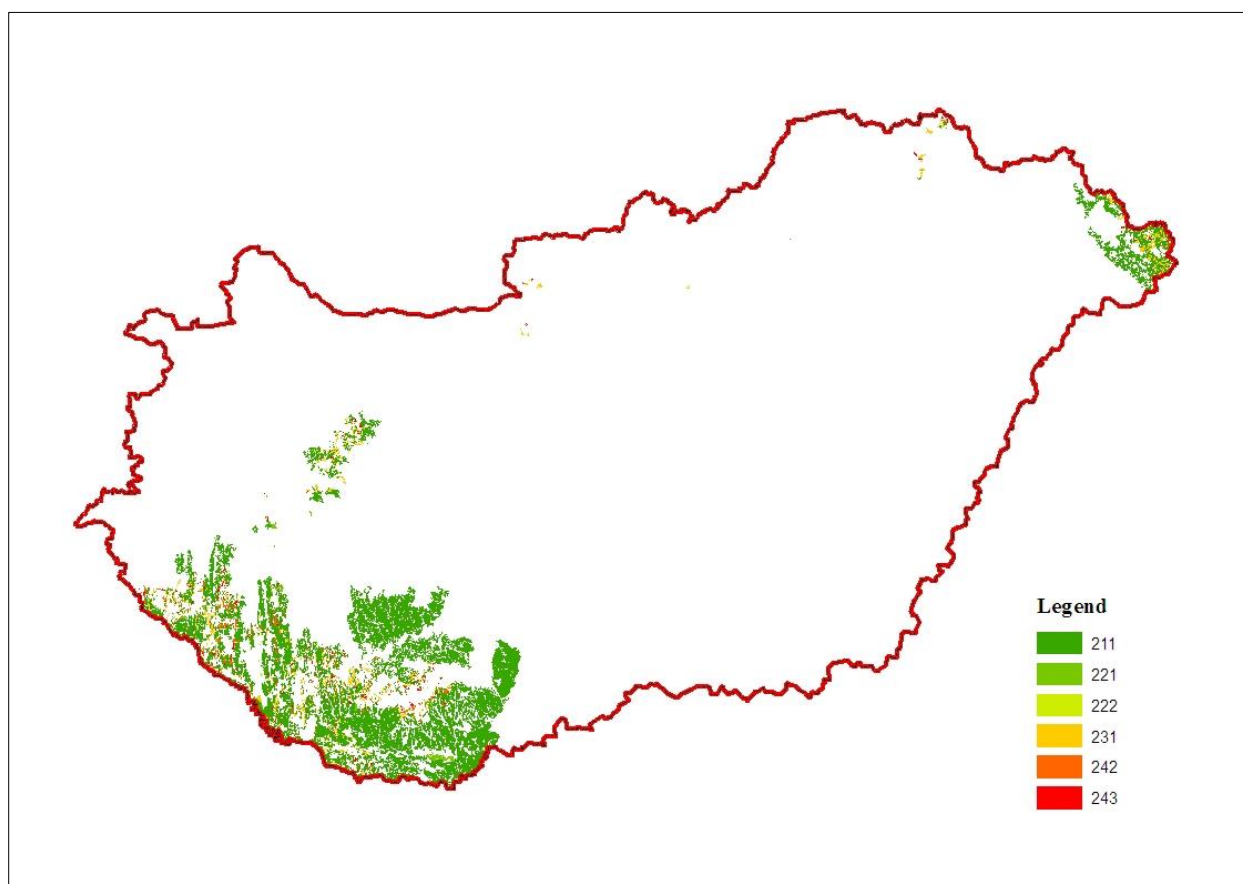
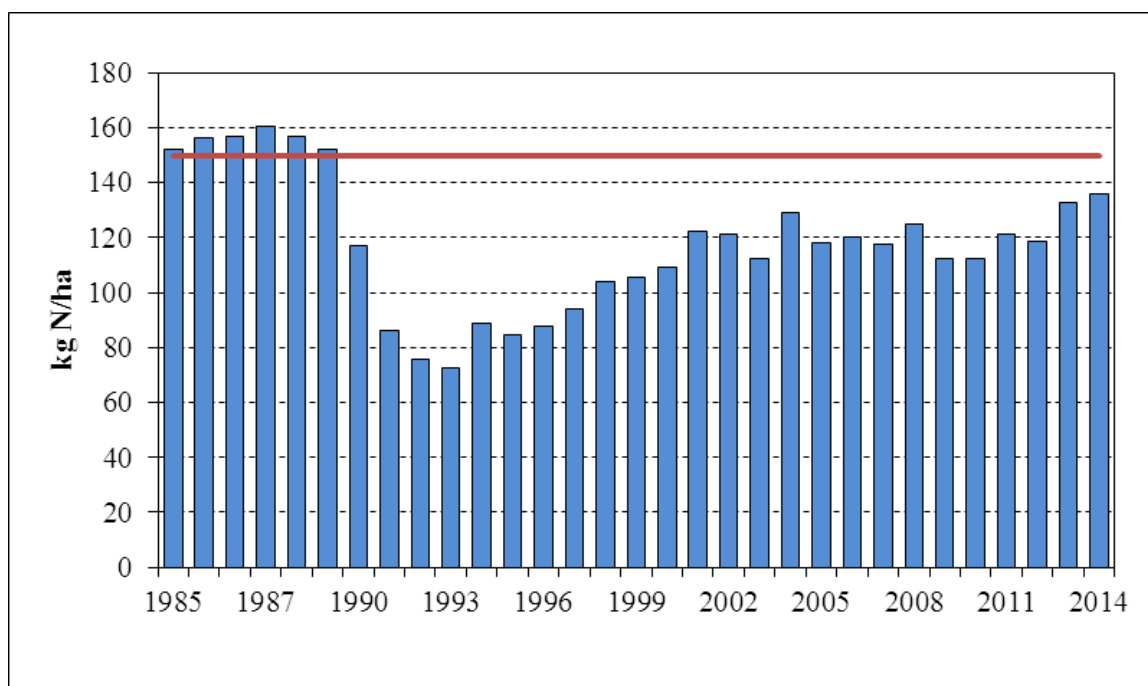


Figure 5.5.5 Humide ($\Sigma P / \Sigma ET_o > 1$) agricultural areas by CORINE land cover codes in the September-March period

The results of the GIS analysis of climate data indicate that emissions from N-leaching and run-off could not be significant in Hungary, because the precipitation is lower than the evapotranspiration throughout most of the year. Beyond the water surplus the N-surplus is the other precondition for nitrate leaching. The leaching process of nitrate was studied in a long-term field experiment in Hungary started in 1980. According to the results of the field trials at annual fertilizer rates of 0-50 kgN ha⁻¹ y⁻¹ no nitrate accumulation was observed. Nitrate accumulation occurred when fertilizer N rate more than 100 kg ha⁻¹ y⁻¹ was applied, and the leaching of nitrate ions was detectable at 150 kgN ha⁻¹ y⁻¹ or higher N application. This result, that N leaching is not occurring at fertilizer rates lower than 150 kg ha⁻¹ y⁻¹, coincides with the outcome of other international studies (Fülek, 2014). To get a general picture about the existence of the potential N-surplus on the Hungarian agricultural lands, the average N fertilizer rates was estimated based on the total amount of N applied/mineralized ($F_{SN}+F_{ON}+F_{PRP}+F_{SOM}$) from the inventory and the utilized agricultural areas, where the N is assumed to be applied. The outcome of this simple verification is shown on **Figure 5.5.6**. As the figure reveals the average N application rates at the time of the base year were about 150 kg N ha⁻¹ y⁻¹, which is the lowest limit for N-leaching according to Hungarian field experiments. At the beginning of the 90's it was below the accumulation threshold (100 kgN ha⁻¹ y⁻¹) and in the period 2000-2014 it was higher than the accumulation rate, but it remained below the threshold of N-leaching (150 kgN ha⁻¹ y⁻¹).

Figure 5.5.6 The average N-input per hectare for the period 1985-2014



Note: the brown line indicates the value of 150 kgN/ha which is the lowest rate limit for N-leaching according to Hungarian field experiments

According to the European field experiments 2-8% or 1-16% of the applied N was lost by leaching (Fülek, 2014). Therefore, the IPCC default value of 30% for $Frac_{LEACH-H}$ is probably too high even for countries with higher annual precipitation than Hungary. Thus, accounting lower proportion of N addition than the default 30% in the light of climate data as well as the amount of N applied seems to be reasonable. In spite of this $Frac_{LEACH-H}$ was assumed to be 30% in this inventory submission due to lack of country-specific value. Although, taking into account the proportion of humid and irrigated areas the resultant fraction of all N added to/mineralized in managed soils for 2014 is 3.8%, which is in line with the results of the European field experiments.

5.5.3 Uncertainties and time-series consistency

Implementation of the methodologies of the 2006 IPCC Guidelines resulted in significant reduction in the uncertainties in 3.D N₂O Emissions from Agricultural Soils. Uncertainties in this category are driven by uncertainties related to the emission factors. For the default emission factor for direct emissions (EF₁), a range from -70% up to +200% is assigned by the 2006 IPCC Guidelines. This uncertainty range is significantly narrower than the former one provided in the GPG (IPCC, 2000), leading to significant reduction in the overall uncertainty in the N₂O emissions.

For the uncertainties in the activity data as F_{SN}, F_{ON}, F_{PRP}, F_{CRP}, F_{SOM} ±5%, ±22%, ±26%, ±25%, ±91% were calculated, respectively. The resulted combined uncertainty in the activity data for 3.D.a is ±7.8%, which is negligible comparing with the uncertainty in the emission factor. The estimated combined uncertainties in the emissions from 3.D.a were -65%/+186%.

To estimate uncertainties in indirect emissions the same values of uncertainties were applied for activity data as in the calculation of direct emissions. These uncertainties were combined with the uncertainties in the Frac_{GASM} (±50%) and Frac_{GASF} (±75%). Uncertainty in Frac_{GASF} was estimated based on the EMEP/EEA Guidebook (EEA, 2013). For the EF₄ the default uncertainty range provided in the 2006 IPCC Guidelines was applied. The resulting uncertainty for the indirect emission from agricultural soils ranges from -72% to +284%.

5.5.4 QA/QC Information and verification

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.

NH₃-N and NO_x-N losses are calculated in compliance to the obligations under UNECE/CLRTAP. To estimate the NH₃ and NO_x emissions from 3.D methodologies of 2013 EMEP/EEA Guidebook were applied.

For the general procedure of the QC see 6.1.5.

5.5.5 Source-specific recalculations

The most significant changes for the 2016 submission concerning the 3.D emissions were the recalculations of 3.D.a.2.a Animal manure applied to soils, 3.D.a.4 Crop residues and 3.D.b.2 Nitrogen leaching and run-off due to the recommendations of the Trial EU ESD review, 2015. The overall impact of recalculations in the 3.D Direct and indirect N₂O emissions from agricultural soils sector resulted in a 281.4 kt CO₂-eq (5.9%) increase in the BY emissions, and 190.3 kt CO₂-eq (7.4%) increase on average for the period 1990-2013. Effects of recalculation on 3.D emissions are shown in *Table 5.5.9*.

Table 5.5.9 Changes in the N₂O emissions from 3.D due to recalculations for the BY and 1990-2013

Year	Submission 2015 [Gg CO ₂ -eq]	Submission 2016 [Gg CO ₂ -eq]	Difference [Gg CO ₂ -eq]	Percentage change
BY	4,797	5,079	281	5.9%
1990	3,525	3,798	274	7.8%
1991	2,439	2,712	273	11.2%
1992	2,120	2,323	202	9.5%
1993	1,981	2,171	190	9.6%
1994	2,384	2,563	179	7.5%
1995	2,228	2,389	160	7.2%
1996	2,260	2,421	161	7.1%
1997	2,357	2,510	152	6.5%
1998	2,548	2,698	150	5.9%
1999	2,536	2,665	129	5.1%
2000	2,437	2,594	157	6.4%
2001	2,732	2,899	167	6.1%
2002	2,749	2,913	164	5.9%
2003	2,567	2,735	168	6.5%
2004	2,931	3,127	195	6.7%
2005	2,701	2,880	179	6.6%
2006	2,763	2,942	179	6.5%
2007	2,728	2,913	186	6.8%
2008	2,849	3,061	212	7.4%
2009	2,584	2,778	194	7.5%
2010	2,509	2,713	204	8.1%
2011	2,696	2,913	216	8.0%
2012	2,646	2,866	220	8.3%
2013	2,937	3,193	256	8.7%

The reasons for the recalculations and the resulted changes in the emissions by sub-categories are as follows:

Recalculation of emissions from 3.D partly arose from revisions in 3.B. Change in the nitrogen excretion rate for Rabbit for the full time series caused an increase in the total amount of organic N fertilizers applied to soils (F_{ON}), while the modification of the indirect emissions slightly overbalanced the resulted overall increase in F_{ON}. As a result of these revisions emissions from 3.D.a.2.a increased by 9.8% (83.8 kt CO₂-eq) in the BY and 8.9% (45.2 kt CO₂-eq) on average between 1990 and 2013.

As a result of our standard QC procedure CRF category 3.D.a.3 Urine and dung deposited by grazing animals was recalculated, because in the former submission emissions from Buffalo were calculated

using the emission factor $EF_{3PRP,SO}$ instead of $EF_{3PRP,CPP}$. This recalculation led to an insignificant (less than 1kt CO₂-eq) increase in the emissions.

Recalculations undertaken in the emissions from crop residues and forage/pasture renewal 3.D.a.4 sub-sector for the full time series summed up to 72.2 kt CO₂-eq (12.3%) higher emissions on average in the 1990-2013 time series than those reported in 2015 submission. The change in the BY is 14.5% (84.3 kt CO₂-eq). Recalculations were due to the findings of the Trial EU ESD review, 2015. Parameters to estimate N added to soils for some crops were revised in line with TERT's suggestions. Additionally, the formerly used estimate on fraction of above-ground residues of crop removed annually for burning in power plants was omitted due to lack of sufficient data, thus no removal for burning as fuel was assumed in this submission.

Emissions from 3.D.b.1 were updated in line with the emissions/removals from 4.B.1.1. This recalculation resulted in a negligible change in the reported emissions.

NO_x and NO₃ emissions reported under the UNECE/CLRTAP inventory were recalculated for the whole time series, leading to the revision of the amount of N volatilized and the resulted emissions from atmospheric deposition. The changes in the emissions from 3.D.b.1 Indirect emissions from atmospheric deposition are insignificant, and negative in some years and positive in other years. Emissions changed 6.6 kt CO₂-eq on average in the full time series.

There have been a significant changes made within the category 3.D.b.2 Nitrogen leaching and run-off because of the revision of irrigated areas and humid regions, where $Frac_{LEACH-H}$ is non-zero. This revision was a consequence of findings of the Trial EU ESD Review, 2015 and led to a significant increase in the amount of N that is leached annually, and the subsequent N₂O emissions. The increase in the emissions due to the recalculation was 111 kt CO₂-eq in the BY and 66 kt CO₂-eq on average for the whole time series.

5.5.6 Planned improvements

See Section 5.1.7

5.6 Prescribed Burning of Savannas (CRF Sector 3.E)

Category 4.E Prescribed Burning of Savannas is not relevant to Hungary therefore notation keys 'NO' is used relating to all associated emissions in CRF Tables.

5.7 Field burning of agricultural residues (CRF Sector 3.F)

5.7.1 Source Category Description

Emitted gases: CH₄, N₂O

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.23.) is in force relating to field burning of agricultural residues, currently. So according to the above mentioned 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.

5.7.2 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: $\text{Frac}_{\text{BURN}} = 0.11, 0.09, 0.07, 0.04$ and 0.02 (it meant for all plants produced: $\text{Frac}_{\text{BURN}} = 0.05, 0.04, 0.03, 0.02$ and 0.01). To the emission estimation Equation 2.27 of 2006 IPCC Guidelines was applied. As regards other parameters required for the calculation (dry matter, product/by-product ratio, C to N ratio), the default values given in Table 2.5 and Table 2.6 of 2006 IPCC Guidelines were used.

5.7.3 Uncertainties and time-series consistency

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5.7.4 QA/QC Information

See 6.1.5.

5.7.5 Source-specific recalculations

There were no recalculations in this category.

5.7.6 Planned improvements

There are no further improvements planned.

5.8 CO₂ emissions from liming, urea application and other carbon-containing fertilizers (CRF Sectors 3.G, 3.H and 3.I)

Emitted gases: CO₂

Methods: T1

Emission factors: D

Key sources: none

5.8.1 Source Category Description

CRF Sectors 3.G, 3.H and 3.I cover agricultural CO₂ emissions. CO₂ emissions from liming had been reported in the LULUCF sector until the 2014 submission, but in line with the new technical guidelines, it is now merged into Agriculture sector. Reporting of CO₂ emissions from urea application is a new element of the 2006 IPCC Guidelines. This source category has been introduced because the CO₂ removal from atmosphere during urea manufacturing is estimated under the Industrial Processes and Product Use sector (IPPU).

As some types of fertilizers contain liming matters to reduce the soil acidity and improve plant growth, CO₂ emissions from carbonate containing fertilizers has also been reported under the 3.I Other sector to ensure the completeness of the agricultural inventory.

CRF sectors 3.G, 3.H and 3.I are minor sources of CO₂ emissions in Hungary, accounting for 0.5% and 0.3% of the national total CO₂ emissions in the BY and 2014, respectively. The overall agricultural CO₂ emissions decreased by 65 per cent between the BY (421 Gg) and 2014 (146 Gg). The bulk of this decrease occurred in 1991, when the use of all carbon-containing chemical amendments declined sharply, reflecting the effect of suspension of state support of fertilizers. After the period of change in the regime emissions fluctuated annually depending on the fertilizers prices. **Figure 5.8.1** shows the trend in CO₂ emissions from Agriculture from the BY to 2014.

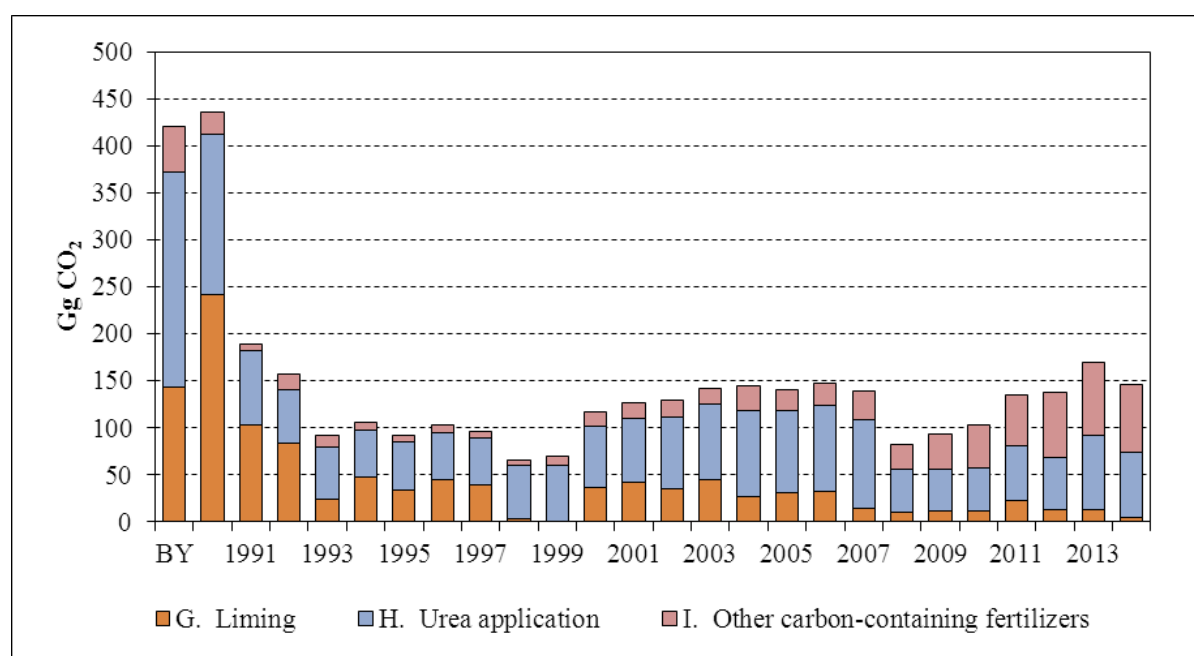


Figure 5.8.1 Trends in the CO₂ emissions from Agriculture

5.8.2 Methodological issues

5.8.2.1 Calculation method

Emissions from additions of carbonate limes and carbonate containing fertilizers to soils were estimated using the Equation 11.12 of the 2006 IPCC Guidelines. Similarly, CO₂ emissions from urea fertilization were estimated using the Equation 11.23 of the 2006 IPCC Guidelines, which is the basic Tier 1 method. Because of the relatively negligible share of CO₂ in total agricultural GHG emissions the use of simple methodologies are reasonable.

5.8.2.2 Activity Data

Liming

Data on the amounts of liming materials applied annually are sourced from the National Plant- and Soil Protection Directorates of the National Food Chain Safety Office's (NFC SO) data collection. The NFC SO collect data on the liming materials based on operative permits which are required before soil reclamation in Hungary.

This data collection is available 2010 onwards. Prior to this expert judgment was needed to estimate the required activity data based on the available surrogate data. The Karcag Research Institute of University of Debrecen was charged to process the data on reclaimed areas as a proxy and to estimate the required activity data.

Urea and Carbon-containing Fertilizers

Annual consumption of fertilizers by fertilizer types such as Urea and Carbon-containing fertilizers were derived from the sales statistics by products reported annually by the Agricultural Economics Research Institute (AERI). AERI's statistics contain the amount of Urea and other ammonium solutions (UAN) and urea ammonium sulphate (UAS) fertilizers. To calculate CO₂ emissions from urea application the annual activity data was derived as the sum of the amount of urea and the urea contents of UAN and UAS fertilizers.

Under the category *3.I Other Carbon containing fertilizers* CO₂ emissions from calcium ammonium nitrate (CAN) are reported. According to the sale statistics CAN fertilizers sold in Hungary are predominantly the so-called 'Pétisó', which is a mixture of ammonium nitrate and very fine dolomite powder (NH₄NO₃ + CaMg (CO₃)₂). This fertilizer is the main product of the 'Nitrogénművek Zrt.' (Information about this fertilizer is available on the website of the producer company:

http://www.nitrogen.hu/nat/index.php?option=com_content&view=article&id=21&Itemid=11&lang=en

http://www.nitrogen.hu/nat/index.php?option=com_content&view=category&layout=blog&id=4&Itemid=235&lang=en

The annual activity data of the emission estimate was the average dolomite content of the soled CAN fertilizers, which was estimated as the 25% of the amount of CAN fertilizers based on the chemical formula of 'Pétisó'.

Activity data used to estimate CO₂ emissions from categories 3.G, 3.H and 3.I are summarized in *Table 5.8.1*.

Table 5.8.1 Activity data for 3.G, 3.H and 3.I

Year	3.G		3.H		3.I
	Limestone	Dolomite	Urea	Urea in UAN and UAS	Carbon containing-fertilizers
	tonnes				
BY	240,586	240,586	312,320	33,045	403,704
1990	399,642	137,995	233,386	9,875	190,768
1991	168,855	59,255	108,967	4,705	55,681
1992	138,109	47,896	78,214	4,301	137,037
1993	40,695	14,279	75,029	5,123	100,290
1994	79,805	25,666	68,827	7,291	71,020
1995	55,855	19,554	69,299	9,460	63,094
1996	74,359	26,220	66,865	7,958	76,704
1997	63,903	22,417	69,220	8,267	54,993
1998	6,484	2,279	76,239	11,709	52,513
1999	107	38	82,028	15,407	85,051
2000	62,522	20,111	88,140	23,190	126,912
2001	59,271	32,991	93,948	24,718	135,275
2002	56,845	21,763	103,514	27,234	149,048
2003	85,107	17,255	109,082	21,576	143,067
2004	44,869	16,422	123,704	18,289	221,374
2005	66,172	4,053	119,242	17,973	181,847
2006	60,920	12,033	124,159	21,930	202,130
2007	30,971	755	129,077	25,887	259,592
2008	22,040	0	62,508	32,394	230,306
2009	26,121	1,311	59,074	31,692	323,781
2010	25,399	491	63,051	27,840	379,529
2011	51,615	761	79,007	31,094	452,342
2012	30,043	577	75,725	33,850	580,401
2013	28,319	578	107,834	42,496	648,440
2014	11,443	167	93,347	44,282	611,755

5.8.2.3 Emission factors

IPCC default values of 0.12 for limestone, 0.13 for dolomite and 0.20 for urea were used. In the case of carbon containing-fertilizers the IPCC default value for dolomite (0.13) was applied, as carbon content of calcium ammonium nitrate (CAN) fertilizers, which is reported here, is in dolomite (see also the section above).

5.8.3 Uncertainties and time-series consistency

Uncertainties in the activity data used to estimate emissions from 3.G, 3.H and 3.I were estimated to be $\pm 10\%$ for liming matters and $\pm 5\%$ for urea and carbon-containing fertilizers. Uncertainties in the emission factors were assumed to be ranging from -20% to 0% . Thus, the estimated combined uncertainties in the emissions for 3.G, 3.H and 3.I are $\pm 22\%$, $\pm 21\%$, $\pm 21\%$, respectively.

5.8.4 QA/QC Information

HCSO publishes the nitrogen content of synthetic fertilizers sold, which report is also based on the RIAE's data collection. Consequently, data on the total annual amount of synthetic N fertilizer applied

to soils (F_{SN}) under the category 3.D are consistent with data used to estimate emissions for CRF 3.H and 3.I.

Emissions from 3.H were cross-checked with the IPPU sector (CRF 2.B.1), to calculate emissions from urea manufacturing consistently.

5.8.5 Source-specific recalculations

Emissions from 3.G Liming was recalculated for the year 2012 due to the revision of the activity data by the data provider authority. The change in the emissions is negligible (0.3 kt CO₂).

5.8.6 Planned improvements

Considering that agricultural CO₂ emissions are of minor importance in Hungary improvements are not planned.

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6. Land-Use, Land-Use Change and Forestry (CRF sector 4)

6.1 Overview of sector

6.1.1 Emission trends

The greenhouse gas inventory of the Land Use, Land Use Change and Forestry (LULUCF) sector covers both CO₂ emissions and removals of due to gains and losses in the relevant carbon pools of the predefined six land-use categories and non-CO₂ emissions from biomass burning and disturbance associated with land-use conversions.

The estimates show that the LULUCF sector in Hungary was a net sink in the last decade. In 2014, removals in the sector corresponded to -8.0 per cent of total GHG emissions in Hungary (excluding LULUCF), compared to its -1.6 % share in the base year, with a rather high variability. In general, Forest Land (FL) is the largest contributor to this net carbon sink, whereas Wetlands (WL) and Settlements (SE) are net source of greenhouse gases. Grassland (GL) and Cropland (CL) are net sources in some years and net sinks in others (Figure 6.1.1). Depending on a category, the bulk of the emissions may be either the “remaining” sub-category (e.g., Forest Land remaining Forest Land, or FL-FL) or the sub-category of a land converted to another category (e.g., Land converted to Grassland, or L-GL).

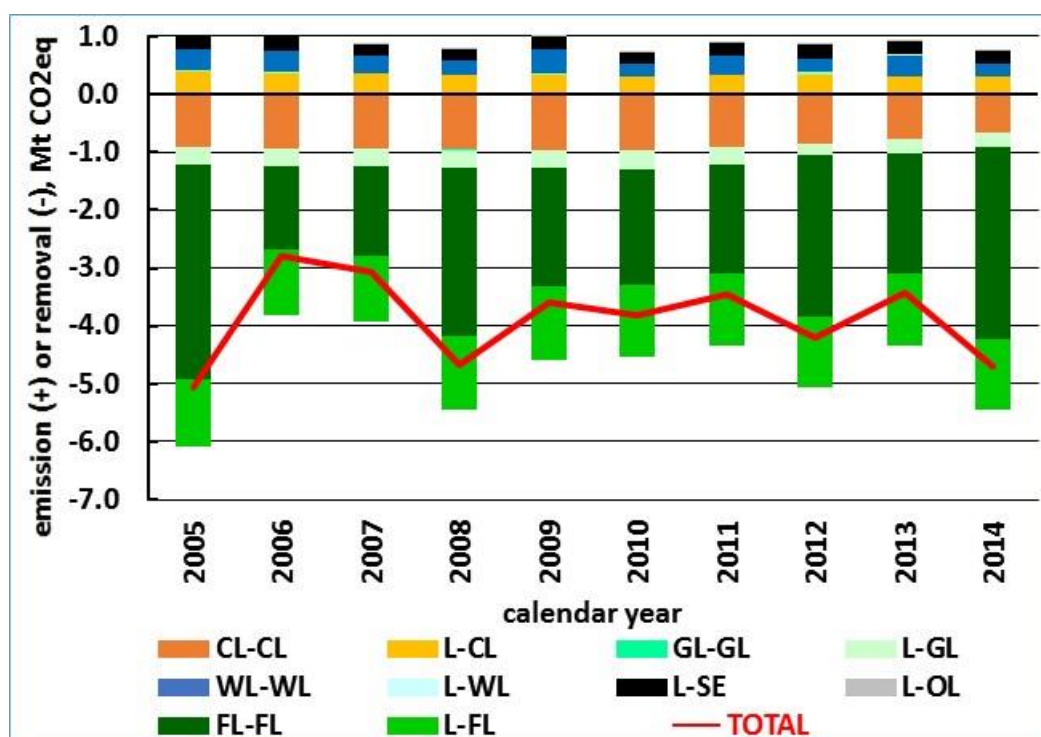


Figure 6.1.1 Trends in emissions/removals from the LULUCF sector by land-use and land-use change subcategories 2005-2014. (CL-CL: Cropland remaining Cropland; L-CL: Land converted to Cropland; GL-GL: Grassland remaining Grassland; L-GL: Land converted to Grassland; WL-WL: Wetland remaining Wetland; L-WL: Land converted to Wetland; L-SE: Land converted to Settlements; L-OL: Land converted to Other Land, FL-FL: Forest land remaining Forest land; L-FL: Land converted to Forest land. In other sub-categories, no emissions and removals are estimated, see text.)

Most removals are generated by biomass gains in the Forest Land remaining Forest Land and the Land

converted to Forest Land categories. The net sink in this category is mainly due to the fact that the forest area has been increasing, and that the total increment of the growing stock in forest lands has been higher than the annual harvest for the last three decades (see Figures 6.5.1, 6.5.4 and 11.1).

Although the reported levels of emissions/removals from the non-forest land uses are smaller, soils in the Cropland and Grassland categories have added to the net sinks in the last decade or so (Figure 6.1.2) which reflects trends in land use changes (see also section 6.3 and 6.6.4).

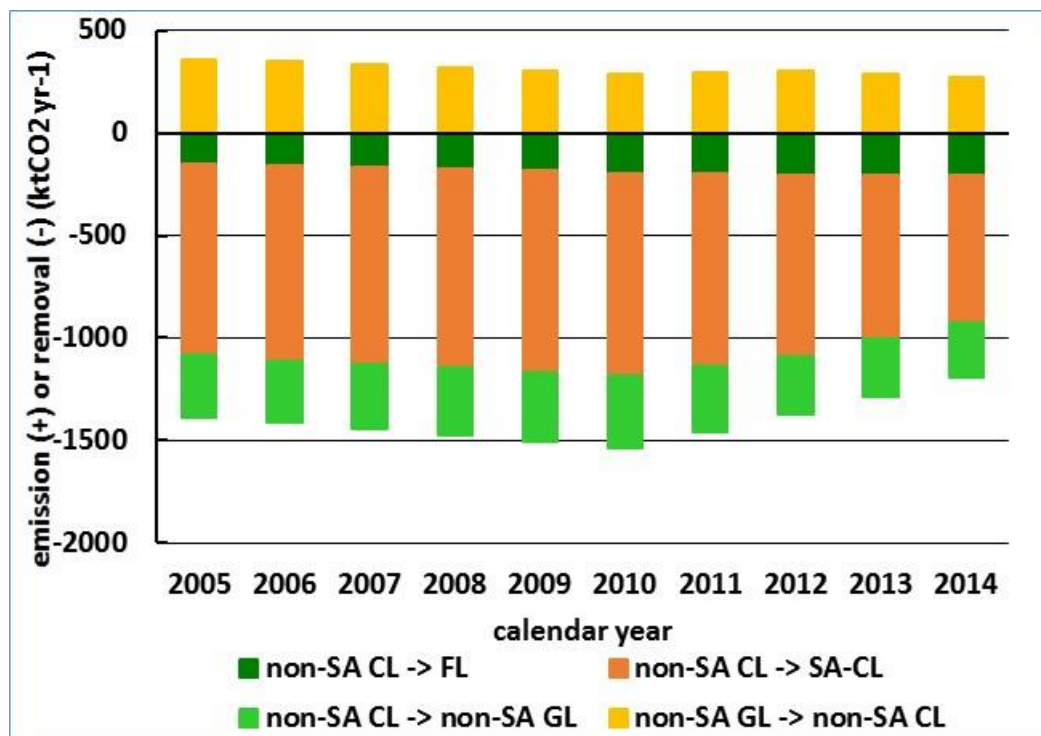


Figure 6.1.2. Emissions and removals in the most important land use change categories due to soil carbon stock changes.

Note that the reported area of the non-forest land-use conversion categories 1985-2004, which should include areas under conversion for the (default) period of 20 years, excludes some areas that were converted before 1985 as we currently have no accurate information on conversion areas before 1985. Therefore, the trend of both the areas and the calculated emissions and removals before 2005 may involve artefacts. In order to exclude these artefacts from the analysis, only data beginning 2005 are depicted in the graphs included in the NIR, and any analysis based on the trends is based on data after 2004. Note, however, that we report on the entire time series in the CRF tables.

6.1.2 Key categories

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

6.1.3 Completeness

In this submission, Hungary reports carbon stock changes as well as greenhouse gas emissions and

removals from Forest Land (CRF 4.A), Cropland (CRF 4.B), Grassland (CRF 4.C), Wetland (CRF 4.D) and Settlements (CRF 4.E). N₂O emissions from N in mineral soils that is mineralized/immobilized in association with loss of soil C are reported in CRF Table 3.D for cropland remaining cropland and in CRF Table 4(III) for all other land use and land use change categories. (Hungary does not report N₂O immobilization associated with gain of organic matter resulting from change of land use or management of mineral soils because we apply a combination of Tier1/Tier 2 to estimate carbon stock changes in soils.) N₂O emissions from fertilization in Wetlands (CRF 4(I)) do not occur in Hungary; N₂O emissions from fertilization in other land use categories, where relevant, are reported under the Agriculture sector (CRF 3). In addition, CO₂ emissions from liming are reported in CRF table 3G, whereas CO, CH₄, N₂O and NO_x emissions from biomass burning are reported in CRF table 4(V).

Apart from a few cases, emissions from Other land (CRF 4F) do not occur because, consistent with the national definition of this category, it contains unmanaged land for which only area data is reported, and rather small areas are sometimes converted to Other land. CH₄ emissions from drainage of soils and Wetlands are not reported, either, because this is an optional reporting category, therefore, the notation key NA and NO were used in CRF Table 4 (II).

6.1.4 Recalculations

In this submission, we have implemented a small number of recalculations. The main reason for the recalculations is that, for years 2006 onwards, we replaced previous extrapolations from the CLC 2006 dataset using the 2012 CLC dataset, which resulted in revised land use and land use change data. A few other recalculations were made due to some minor category-specific issues that are reported in the relevant section. Note that we made a number of recalculations in 2015, which involved recalculations due to switching from the IPCC 2003 Good Practice Guidance to the IPCC 2006 GL, changes in methodology (e.g., the treatment of fires) and emission factors (again, e.g., in case of fires), the revision of area data for peat extraction, and finally, some errors in the calculation of emissions and removals.

6.1.5 Methodology

The description of the methodological details in the subsequent sections follows the structure of the national inventory reports as outlined in the Appendix to Annex I (Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories) of Decision 24/CP.19 (Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention).

In estimating emissions and removals, the IPCC 2006 Guidelines (mainly for reporting under the UNFCCC) and the IPCC 2013 KP Supplement (under the second Commitment Period of the Kyoto Protocol, IPCC 2014a and IPCC 2014b) have been used as a methodological basis since 2015. Note that, previously, we used the IPCC 2003 Guidelines, but replacing that with the new Guidelines does not constitute any major change in the time series of the emission and removal estimates.

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 (i.e., the IPCC 2006 GL).

Due to the complexity of the LULUCF sector, the Hungarian national circumstances and data availability, the methodology of the estimation differs for the various land use and land use change

categories, the various pools and emissions. Therefore, this report is completed with methodology matrices at the beginning of the section of each major land use and land-use change sector which report Tier, other major methodological information, or if a pool (e.g., organic soils) or non-CO₂ emissions are estimated or not. Subsequent methodological sections only provide more detailed methodological description for those pools and non-CO₂ emissions for which estimation has been done.

The estimated emissions and removals are generally only reported in the CRF tables, but they are often also shown in graphs for the major land use and land use change categories.

6.2 Land use definitions and classification systems

The land-use categories in the Hungarian inventory are consistent with the requirement of both the AFOLU (IPCC, 2006, Volume 4, Chapter 2) and the GPG for LULUCF (IPCC, 2003). Consistently also with the definitions of national land use categories, the following definitions are used for the various land-use categories:

Forest land is defined as land spanning more than 0.5 hectares with trees higher than five meters and a canopy cover of more than 30 percent, or trees able to reach these thresholds, *in situ*. It does not include land that is predominantly under agricultural or urban land use, but in addition to areas covered by trees, it includes roads and other areas that have no tree cover but are under forest management. See section 6.5.1 for details.

Cropland contains arable lands, kitchen gardens, orchards and vineyards, as well as set-aside croplands. *Arable lands* are any land area under regular cultivation irrespective of the rate or method of soil cultivation and whether the area is under crop production or not due to any reason, such as temporary inland waters or fallow. Areas under tree nurseries (including ornamental and orchard tree nurseries, vineyard nurseries, forest tree nurseries excluding those for the own requirements of forestry companies grown in the forest), permanent crops (e.g. alfalfa and strawberries), herbs and aromatic crops are included. *Kitchen gardens* are areas around residential houses where, in addition to meeting the owners' demand, owners may produce some surplus of low amount which is usually traded. *Orchards* are land under fruit trees and bushes that may include several fruit species (e.g.: apples, pears, cherries, etc.). Included are non-productive orchards and orchards of systematic layout in kitchen gardens if the area is 200 m² or above in case of berries and 400 m² or above in case of fruit trees. *Vineyards* are areas where grapes are planted in equal row width and planting space, and include non-productive areas and vineyards in kitchen gardens (e.g. trellises) if grapes are planted in equal row width and planting space, and the size of the area is at least 200 m². *Set-aside cropland* is land that is abandoned (i.e., temporarily unmanaged) but not converted to any other land use.

Grassland includes meadows, i.e., land under grass (artificial planting included) where the production is utilized by cutting, irrespective of whether it is used for grazing sometimes, and pasture, i.e., land under grass (artificial planting included) that is utilized for grazing irrespective of whether it is used for cutting sometimes. Grassland includes areas with trees which are utilized for grazing and unmanaged grasslands which are not in use for agricultural purposes.

Wetland includes the wetlands and water bodies as defined by the CORINE land-cover databases and 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), water courses (natural or artificial water-courses including those serving as water drainage) and water bodies (natural or artificial lakes, ponds etc.).

Settlements are areas matching the 'Artificial surfaces' category of the CORINE land-cover database, which comprises the urban and other residential areas, industrial, commercial and transport units, as

well as mines, dump and construction sites and artificial non-agricultural vegetated areas.

Other Land includes areas matching the ‘Open spaces with little or no vegetation’ category of the CORINE land-cover database, which comprises any area not included in any of the above categories.

6.3 Land identification and land transition matrices

This chapter describes data sources, the national adaptation of the IPCC land-use categories and the resulting land-use change matrices that are used to estimate emissions and removals from the LULUCF sector.

Note that the reported total area of all land use categories is equal to the total official land area of Hungary as published by the annual HCSO’s land-use statistics (i.e., 9,303,266 ha). (There are very little changes in the annually reported total land area in land-use statistics, which are due to movements of natural borders of Hungary based on between-country agreements, and improvements of mapping techniques.) To avoid inconsistency, the average of the annually published total areas is reported for each inventory year in the GHG inventory.

6.3.1 Methodology of land identification

The development of the annual land use and land use change data in Hungary involves elements of both Approach 1 and 2. The identification of IPCC land-use categories, which is based on Hungarian statistical categories as well as the main data sources (together with a reference with respect to the Approach it allows for), are reported in Table 6.3.1.

Table 6.3.1. Identification of IPCC land-use categories in Hungary based on national statistical categories and data sources to meet respective data requirements. Acronyms used: HCSO: Hungarian Central Statistical Office; NFI: National Forest Inventory; CLC: Corine Land Cover; HLC85: satellite-based land use change database of FÖMI (see text for details).

IPCC land-use categories	Category used in the respective database	Data sources (and associated Approach)
Forest Land	Land under Forest Management	NFI (maintained by the Forest Directorate of the National Food Chain Safety Office hereafter, or NFCSO, Approach 2)
Cropland	Arable land	HCSO’s land-use statistics, and General Agricultural Censuses of 1991, 2000 and 2010, Vineyard and Orchard Censuses of 2001 and 2012 (Approach 1)
	Kitchen gardens	
	Orchards	
	Vineyards	
	Set-aside Cropland	HCSO’s land-use statistics, General Agricultural Censuses of 1991, 2000 and 2010, (Approach 1)
Grassland	Grassland (meadows and pastures)	HCSO’s land-use statistics, General Agricultural Censuses of 1991, 2000 and 2010, (Approach 1)
	Set-aside Grassland (Unmanaged Grassland)	HCSO’s land-use statistics, General Agricultural Censuses of 1991 and 2000, (Approach 1)

Wetlands	Wetlands and water bodies	CLC2012, HLC-change1985-1990, CLC-change1990-2000, CLC-change 2000-2006, CLC-change 2006-2012 (Approach 1/2)
Settlements	Artificial surfaces	CLC2012, HLC-change1985-1990, CLC-change1990-2000, CLC-change 2000-2006, CLC-change 2006-2012 (Approach 1/2)
Other Land	all areas not included above	HLC85, CLC90, CLC2000, CLC2006, CLC2012 (Approach 1/2)

Land use changes are identified using both national statistics and Corine Land Cover (CLC) change information (for mapping the main CLC land-cover categories to the IPCC categories, see Tables 6.3.2-6.3.5). For *Forest Land*, the main source of national statistics is National Forest Inventory (NFI) data that includes information on conversions both from and to forests. For other land use change categories, it was necessary to use the statistics of the Hungarian Central Statistical Office (HCSO; HCSO Statistical Yearbooks for Agrigulcutre) and all other datasets while ensuring consistency between them. Unlike the HCSO reports, the CLC data sets include statistics on land cover change. It was assumed that, for any period between two CLC assessments (1990, 2000, 2006 and 2012), the difference between the area of the various land-cover categories corresponds to the change in the respective IPCC land-use change category.

Table 6.3.2 *Classification of the CLC 1990 land-cover categories into IPCC land-use categories*

CLC land-cover categories (Simplified nomenclatures)	IPCC category
311, 312, 313, 324 (310)	Forest land
211, 212, 213, 221, 222 (210, 220)	Cropland
231, 321 (230)	Grassland
111, 112, 121, 122, 123, 124, 131, 132, 133, 141, 142 (100)	Settlements
411, 412, 511, 512 (400, 500)	Wetlands
331, 332, 333 (330)	Other land

For *non-set-aside Cropland (non-SA CL)*, *non-set-aside Grassland (non-SA GL)*, *Settlements (SE)*, *Wetlands (WL)* and *Other Land (OL)*, the above databases directly include the necessary statistics. Separating set-aside lands is necessary for the estimation of carbon stock changes in soils. For this, the differences between Category 330 of the CLC databases and the Uncultivated land area category of the HCSO statistics (which include SE and WL together with set-asides) were taken as the *total area* of set-aside agricultural areas. This area (available for the period 1984-2014) was then split into *set-aside croplands (SA CL)* and *unmanaged grasslands* (i.e., set-aside grassland, SA GL, for both total areas and annual changes) using *expert judgment*.

For land use changes that were estimated using the CLC database, it was necessary to map the CLC codes to the respective IPCC categories. 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 (CLC Programme). Therefore, conversions listed in Table 6.3.3 below 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, highly exceeds the precipitation of the other years.

Table 6.3.3 Areas classified as 'Grassland converted to Wetlands'

Period	CLC code	Explanation
1990-2000	231-411	Pastures converted to inland marshes
	231-512	Pastures converted to water bodies
	321-411	Natural grasslands converted to inland marshes
	321-512	Natural grasslands converted to water bodies
2000-2006		
	231-512	Pastures converted to water bodies
	321-411	Natural grasslands converted to inland marshes
	321-512	Natural grasslands converted to water bodies
2006-2012		
	231-512	Pastures converted to water bodies

The Settlements converted to Wetland category mainly contains the area of sandpits and gravel pits. The area of these conversions is small, and the emissions from these land-use change conversions are probably zero.

Table 6.3.4. Areas classified as 'Settlements converted to Wetlands'

Period	CLC code	Explanation
1990-2000	131-512	Mineral extraction sites converted to water bodies
	133-511	Construction sites converted to water courses
2000-2006		
	131-512	Mineral extraction sites converted to water bodies
	133-512	Construction sites converted to water bodies
2006-2012		
	131-512	Mineral extraction sites converted to water bodies
	132-512	Dump sites converted to water bodies
	133-512	Construction sites converted to water bodies

Conversions in Table 6.3.5 below also include conversions of water courses and water bodies which are not covered by soil and living biomass, therefore could not be source of anthropogenic CO₂ emissions.

Table 6.3.5. Areas classified as 'Wetland converted to Settlements'

Period	CLC code	Explanation
1990-2000	411-142	Inland marshes converted to sport and leisure facilities
	511-142	Water courses converted to sport and leisure facilities
	412-133	Peat bogs converted to construction sites
	511-133	Water courses converted to construction sites
2000-2006		
	411-122	Inland marshes converted to road and rail networks and associated land
	411-133	Inland marshes converted to construction sites
	411-142	Inland marshes converted to sport and leisure facilities
	512-122	Water bodies converted to road and rail networks and associated land
	512-131	Water bodies converted to mineral extraction sites
	512-133	Water bodies converted to construction sites
2006-2012		
	411-122	Inland marshes converted to road and rail networks and associated land
	411-131	Inland marshes converted to Mineral extraction sites
	511-133	Water courses converted to construction sites

6.3.2 Land use statistics and land use change matrices

Forestry statistics are in general available since 1985 and are detailed in Sections 6.5.1-6.5.2. Some statistics on land use conversions from and to forests are partly available even before 1985.

Concerning the CLC data, the CLC-change 1990-2000 and CLC-change 2000-2006 databases (FÖMI, 2004; FÖMI, 2009a), as well as the CLC-change 2006-2012 databases (FÖMI, 2014) were supplemented with the database (HCL85 and HLC-changes 1985-1990) on land use changes of FÖMI (Institute of Geodesy, Cartography and Remote Sensing, FÖMI, 2009b) that was developed for 1985-1990 using satellite images according to the requirements of the LULUCF GHG inventory, in order to get higher accuracy.

The annual statistics on land use by the HCSO is published at its website (http://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_omf001a.html). The HCSO's land-use statistics record the whole official area of the country divided into the following nine land-use categories: Arable land, Kitchen gardens, Orchards, Vineyards, Grassland, Forest, Reed, Fishpond and Uncultivated land area. Lands not in use for agricultural purposes in the year of the statistic (including set-aside areas (SA), unmanaged grassland (UGL), Settlements and some parts of Wetlands) are reported aggregately as Uncultivated land area. The data acquisition is based on questionnaires, and land-use data are available since 1853. There have been changes in the methodology since the beginning of the data collection (Kecskés, 1997), but the data set was adjusted considering these methodological changes in order to achieve consistency over time. The adjustment, which was implemented in consultation with the HCSO's expert, included the following steps and assumptions:

- Between 1965 and 1990 the system of landowners and data collection can be considered to be in steady state, therefore, the annual data was accepted without adjustment.
- Significant changes occurred in land ownership in the period 1990-2000 (i.e., after the political changes in the country), making the HCSO statistics less accurate. Therefore, with the exception of orchards and vineyards, the annual dataset for all categories was replaced with values that were interpolations between the statistics of two General Agricultural Censuses of 1991 and 2000. For the vineyards and orchard category, the results of the more detailed and reliable census on vineyards and orchards were accepted instead of the results of the general agricultural census.
- For the period 2000-2010, the annual Cropland and Grassland areas were interpolated between the areas reported for the years of General Agricultural Censuses conducted in 2000 and 2010. Vineyard and Orchard areas were interpolated between the years for which the most detailed survey data are available (2001 and 2012).
- For the period after 2012, an extrapolation is applied until new data is available.

The area of the land use/land cover categories that come from the different statistical sources differ somewhat. Inconsistencies mainly occur because of differences in definition (including differences in the definition of land use vs land cover) and data collection methodology. For example, the HCSO's and CLC forest land data only refer to areas that are covered by trees, whereas the forestry statistics also include areas that are managed in the forestry sector but are not covered by trees (see various sections on forests in Chapters 6.5.1-6.5.2 and 11 for more details).

Also, it was also necessary to consider the possible uncertainty of the various data sources that, among others but importantly, is not only affected by the methodology used but also the size of the land pieces that are converted annually from one to another land use category. This size shows large differences. With an average (in the last 20 years) annual area of 1246 ha, FL-L is the smallest, whereas CL-L is the largest with about 15,695 ha. Even this latter area is only 0.169 percent of the total area. Also considering that the size of the converted units is also small, it can generally be stated that the use of remote sensing currently involves very large uncertainties. Therefore, we mostly rely on data from administrative statistics, which also involves uncertainties but probably much less.

In order to develop the most accurate overall area estimates for the entire AFOLU sector, the statistical sources on the various land use/change categories were treated hierarchically during the compilation of land use change matrices. Since the forestry statistics are regarded as the most accurate and forests are the most important for the overall accuracy in the LULUCF sector, the hierarchy of the available sources was established as follows:

- Forestry statistics
- CLC data
- HCSO land-use statistics.

In developing the land use change matrices for years beginning 1985, first, periodic land use changes (for the periods 1986-1992, 1992-2000, 2000-2006 and 2006-2012) were estimated using the CLC database. (Note that data for various years, i.e., 1985 and 1990, from the original databases, see above, were converted to the above years, i.e., 1986 and 1992, respectively, to match with the years of the CLC database.) Annual land use change values were then calculated from periodic ones using interpolation (until 2012) and extrapolation (after 2012) so that the sum of the land-use changes in each land-use categories in the time period is equal to the land-cover changes indicated by the land-cover database in that category for the given period. For other databases (e.g., NFI) where annual land use change data is available, these data were used without any further adjustment.

The arising net changes were then compared with the net changes in the HCSO's land-use statistics calculated for the similar periods. The difference between the net change in the HCSO's land-use

statistics and the land-cover change dataset in a certain land-use category were taken to happen due to the conversions on set-aside agricultural areas. In other words, the above-mentioned differences were eliminated with the estimated conversions on the set-aside grassland and cropland areas.

Areas in the land use change categories were calculated applying the default assumption that all land-use transitions that originated from the remaining categories take place in a period of 20 years, and the areas in the conversion categories are not converted again during the 20 year transition period. All land in all conversion categories are moved to the respective 'remaining' category in the 21th year after the conversion.

Note that, as mentioned in Section 6.1.1 above, the reported area of the land-use conversion categories 1985-2004, which should include areas under conversion for the (default) period of 20 years, excludes areas that were converted before 1985 as we currently have no accurate information on conversion areas before 1985. Therefore, the trend of both the areas and the calculated emissions and removals before 2005 most probably involves artefacts. Therefore, also we report on the entire time series in the CRF tables, only data beginning 2005 are typically reported on the graphs with LUC information in this report.

The resulting time series of land use data are shown in Figure 6.3.1, whereas areas in the 'land remaining' and 'land converted to' subcategories are reported in Figures 6.3.2 and 6.3.3.

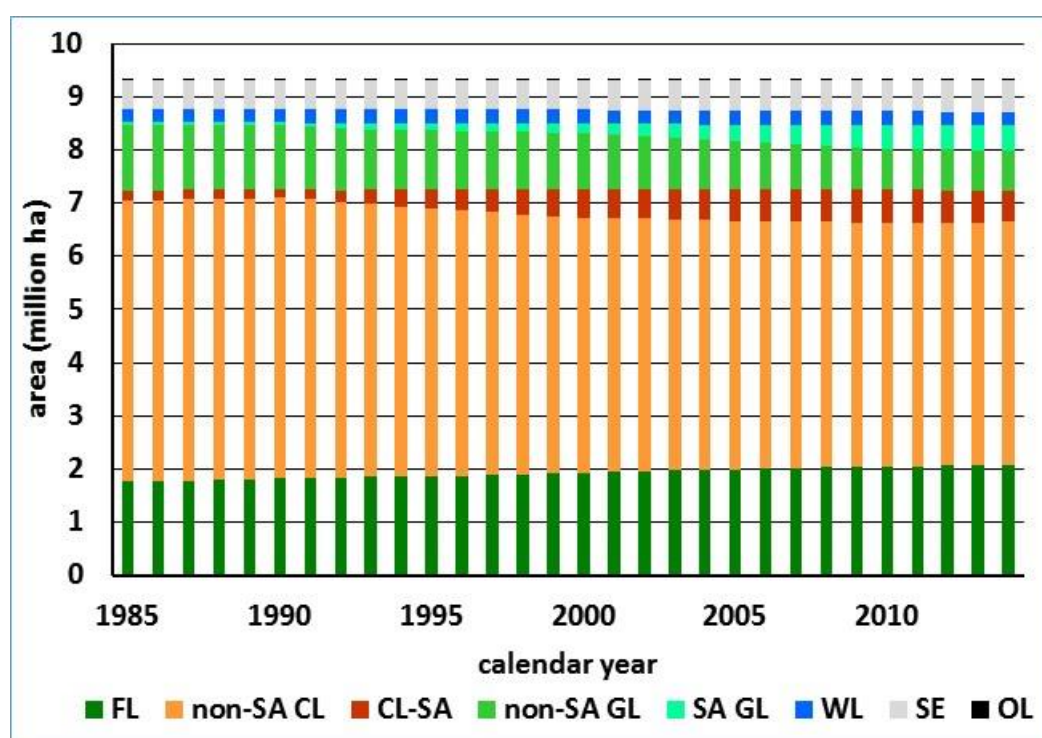


Figure 6.3.1. The evolution of the area of the land use categories. Note that CL and GL categories are split into non-SA and SA subcategories in order that carbon stock changes can include those from to and from non-SA – SA conversions, and N₂O emissions due to such conversions can also be estimated.

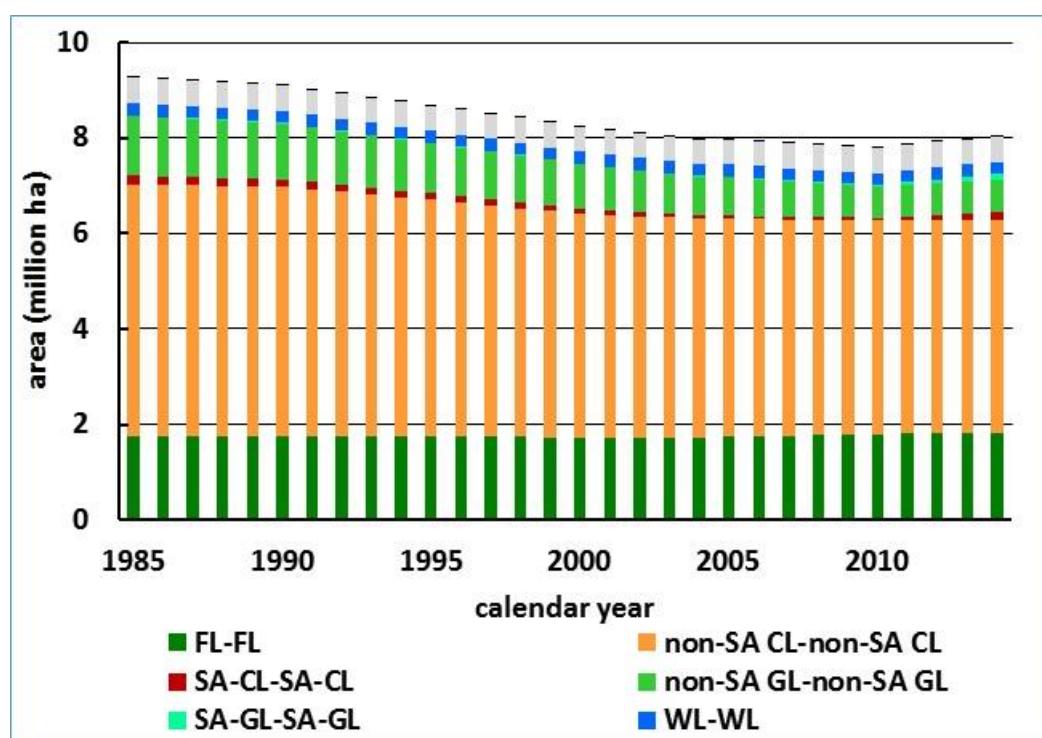


Figure 6.3.2. The evolution of the area of the 'land remaining' categories. Note that the CL and GL categories are split into non-SA and SA sub-categories as on Figure 6.3.1.

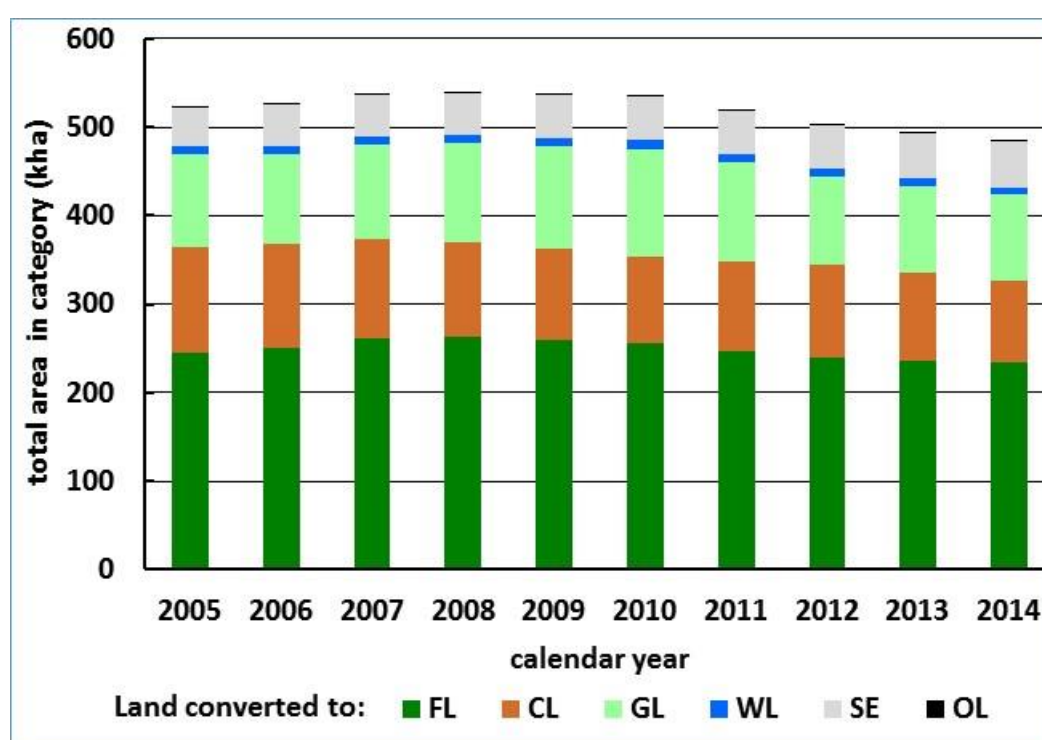


Figure 6.3.3. The evolution of the area of the 'land converted to' categories.

The above area estimates of the various land use and land use change categories include all areas in the land use change categories for a default transition period of 20 years. For reasons of transparency,

Figure 6.3.4 demonstrates annual conversion areas, and Table 6.3.6 below reports matrices of the *annual* land-use changes over the period 1985 to 2014. Also, for reasons of transparency, the data in the table includes forests that are newly identified in the various inventory years (“found forests”, FF). For further information on FF, see Section 6.5.2.

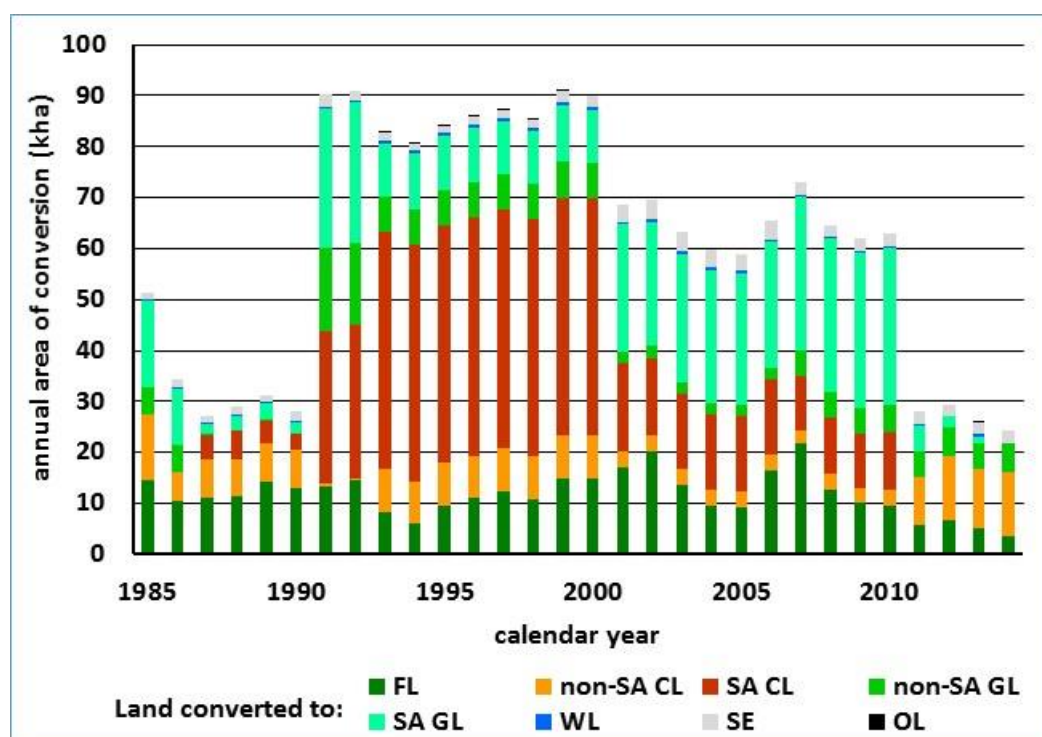


Figure 6.3.4. Annual area of the ‘land converted to’ categories.

Note also that land use and land use change categories are further subdivided by climate, soil, management and input for the estimation of soil carbon stock changes, see relevant sections, e.g., Section 6.4.1 for more details.

Finally, we note that for the period 1965-1983, only the statistics of the HCSO are available for non-forest land that include the sum of the non-SA-CL and non-SA-GL categories and the perennial cropland data (separately for orchards and vineyards). SA-CL and SA-GL were estimated by multiplying the non-SA data with the average ratio of SA-CL/non-SA-CL and SA-GL/non-SA-GL for 1984-1990, respectively, assuming that these ratios were constant in the period 1965-1983 (given that agriculture was quite stable in that period, this assumption can be considered quite accurate). For forest land converted to other land uses, the rate of 1989 (i.e., the first data available from a survey) is used for all years 1965-1989. However, given the uncertainties in the currently available data, the time series back to 1965 is not used in the GHG inventory.

Table 6.3.6. Annual land use change matrix for the period of 1985-2014.

	FL	non-SA CL	SA-CL	non-SA GL	SA-GL	WL	SE	OL
1984	1 741 288	5 289 600	202 647	1 264 900	25 000	251 775	525 612	2 444
FL	1 740 962	95	0	21	0	0	210	0
non-SA CL	2 778	5 280 646	0	5 338	0	0	838	0
SA-CL	8 388	7 640	186 619	0	0	0	0	0
non-SA GL	1 864	4 910	0	1 240 924	16 811	0	391	0
SA GL	1 515	0	0	0	23 187	298	0	0
WL	16	0	0	0	0	251 745	14	0
SE	118	9	0	117	0	23	525 344	0
OL	0	0	0	0	0	0	0	2 444
1985	1 755 640	5 293 300	186 619	1 246 400	39 997	252 067	526 798	2 444
FL	1 755 314	95	0	21	0	0	210	0
non-SA CL	2 778	5 284 346	0	5 338	0	0	838	0
SA-CL	5 223	540	180 856	0	0	0	0	0
non-SA GL	1 864	4 910	0	1 228 224	11 011	0	391	0
SA GL	558	0	0	0	39 142	298	0	0
WL	11	0	0	0	0	252 041	14	0
SE	84	9	0	117	0	23	526 563	0
OL	0	0	0	0	0	0	0	2 444
1986	1 765 833	5 289 900	180 856	1 233 700	50 152	252 363	528 018	2 444
FL	1 765 507	95	0	21	0	0	210	0
non-SA CL	2 778	5 281 530	4 753	0	0	0	838	0
SA-CL	5 730	0	175 126	0	0	0	0	0
non-SA GL	1 864	7 366	0	1 222 162	1 918	0	391	0
SA GL	711	0	0	0	49 143	298	0	0
WL	12	0	0	0	0	252 337	14	0
SE	90	9	0	117	0	23	527 777	0
OL	0	0	0	0	0	0	0	2 444
1987	1 776 691	5 289 000	179 879	1 222 300	51 061	252 658	529 232	2 444
FL	1 776 365	95	0	21	0	0	210	0
non-SA CL	2 778	5 279 930	5 453	0	0	0	838	0
SA-CL	5 774	0	174 105	0	0	0	0	0
non-SA GL	1 864	7 366	0	1 209 762	2 918	0	391	0
SA GL	724	0	0	0	50 039	298	0	0
WL	12	0	0	0	0	252 632	14	0
SE	90	9	0	117	0	23	528 991	0
OL	0	0	0	0	0	0	0	2 444
1988	1 787 607	5 287 400	179 558	1 209 900	52 957	252 954	530 446	2 444
FL	1 787 281	95	0	21	0	0	210	0
non-SA CL	2 778	5 279 130	4 653	0	0	0	838	0
SA-CL	7 989	0	171 570	0	0	0	0	0
non-SA GL	1 864	7 366	0	1 197 162	3 118	0	391	0
SA GL	1 395	0	0	0	51 264	298	0	0
WL	15	0	0	0	0	252 924	14	0
SE	114	9	0	117	0	23	530 182	0
OL	0	0	0	0	0	0	0	2 444

1989	1 801 435	5 286 600	176 223	1 197 300	54 382	253 246	531 636	2 444
FL	1 800 822	180	0	40	0	0	393	0
non-SA CL	2 778	5 280 045	2 938	0	0	0	838	0
SA-CL	7 172	0	169 051	0	0	0	0	0
non-SA GL	1 864	7 366	0	1 185 442	2 237	0	391	0
SA GL	1 147	0	0	0	52 937	298	0	0
WL	14	0	0	0	0	253 218	14	0
SE	105	9	0	117	0	23	531 381	0
OL	0	0	0	0	0	0	0	2 444
1990	1 813 902	5 287 600	171 989	1 185 600	55 174	253 539	533 017	2 444
FL	1 812 085	454	0	98	0	0	1 266	0
non-SA CL	2 778	5 237 950	30 021	16 013	0	0	838	0
SA-CL	7 354	0	164 636	0	0	0	0	0
non-SA GL	1 864	0	0	1 155 932	27 414	0	391	0
SA GL	1 202	0	0	0	53 672	300	0	0
WL	14	0	0	0	0	253 511	14	0
SE	107	9	0	117	0	23	532 760	0
OL	0	0	0	0	0	0	0	2 444
1991	1 825 404	5 238 413	194 656	1 172 160	81 086	253 834	535 269	2 444
FL	1 823 956	512	0	108	0	0	827	0
non-SA CL	2 778	5 188 704	30 079	16 013	0	0	838	0
SA-CL	8 163	0	186 493	0	0	0	0	0
non-SA GL	1 864	0	0	1 142 482	27 424	0	391	0
SA GL	1 447	0	0	0	79 339	299	0	0
WL	15	0	0	0	0	253 804	14	0
SE	116	9	0	117	0	23	535 004	0
OL	0	0	0	0	0	0	0	2 444
1992	1 838 339	5 189 225	216 572	1 158 720	106 763	254 127	537 075	2 444
FL	1 838 011	13	0	83	0	0	233	0
non-SA CL	3 349	5 131 728	46 503	6 707	0	0	938	0
SA-CL	3 356	0	213 216	0	0	0	0	0
non-SA GL	1 291	8 269	0	1 138 312	10 550	0	297	0
SA GL	70	0	0	0	106 095	597	0	1
WL	18	0	0	0	0	254 101	8	0
SE	244	28	0	178	0	16	536 609	0
OL	0	0	0	0	0	0	0	2 444
1993	1 846 338	5 140 038	259 719	1 145 280	116 645	254 714	538 086	2 445
FL	1 846 120	28	0	27	0	0	163	0
non-SA CL	3 349	5 082 525	46 519	6 707	0	0	938	0
SA-CL	1 498	0	258 221	0	0	0	0	0
non-SA GL	984	8 269	0	1 124 928	10 802	0	297	0
SA GL	0	0	0	0	116 048	597	0	1
WL	13	0	0	0	0	254 693	8	0
SE	176	28	0	178	0	16	537 688	0
OL	0	0	0	0	0	0	0	2 445

1994	1 852 141	5 090 851	304 739	1 131 840	126 850	255 305	539 094	2 446
FL	1 851 783	53	0	61	0	0	244	0
non-SA CL	3 349	5 033 313	46 543	6 707	0	0	938	0
SA-CL	4 410	0	300 329	0	0	0	0	0
non-SA GL	1 291	8 269	0	1 111 454	10 528	0	297	0
SA GL	284	0	0	0	125 968	597	0	1
WL	21	0	0	0	0	255 276	8	0
SE	282	28	0	178	0	16	538 590	0
OL	0	0	0	0	0	0	0	2 446
1995	1 861 421	5 041 664	346 872	1 118 400	136 496	255 889	540 077	2 447
FL	1 860 804	140	0	141	0	0	335	0
non-SA CL	3 349	4 984 039	46 631	6 707	0	0	938	0
SA-CL	5 460	0	341 412	0	0	0	0	0
non-SA GL	1 291	8 269	0	1 097 934	10 608	0	297	0
SA GL	497	0	0	0	135 400	597	0	1
WL	24	0	0	0	0	255 857	8	0
SE	320	28	0	178	0	16	539 536	0
OL	0	0	0	0	0	0	0	2 447
1996	1 871 746	4 992 476	388 043	1 104 960	146 009	256 471	541 114	2 447
FL	1 871 224	192	0	90	0	0	240	0
non-SA CL	3 349	4 934 800	46 682	6 707	0	0	938	0
SA-CL	6 590	0	381 452	0	0	0	0	0
non-SA GL	1 291	8 269	0	1 084 545	10 558	0	297	0
SA GL	727	0	0	0	144 684	597	0	1
WL	27	0	0	0	0	256 436	8	0
SE	361	28	0	178	0	16	540 531	0
OL	0	0	0	0	0	0	0	2 447
1997	1 883 569	4 943 289	428 135	1 091 520	155 242	257 049	542 014	2 448
FL	1 883 167	89	0	42	0	0	271	0
non-SA CL	3 349	4 885 716	46 579	6 707	0	0	938	0
SA-CL	5 342	0	422 793	0	0	0	0	0
non-SA GL	1 291	8 269	0	1 071 153	10 509	0	297	0
SA GL	473	0	0	0	154 171	597	0	1
WL	23	0	0	0	0	257 017	8	0
SE	316	28	0	178	0	16	541 477	0
OL	0	0	0	0	0	0	0	2 448
1998	1 893 962	4 894 102	469 372	1 078 080	164 680	257 630	542 991	2 449
FL	1 892 515	98	0	332	0	0	1 017	0
non-SA CL	3 349	4 836 519	46 588	6 707	0	0	938	0
SA-CL	8 725	0	460 647	0	0	0	0	0
non-SA GL	1 291	8 269	0	1 057 423	10 799	0	297	0
SA GL	1 160	0	0	0	162 920	599	0	1
WL	32	0	0	0	0	257 589	8	0
SE	439	28	0	178	0	16	542 331	0
OL	0	0	0	0	0	0	0	2 449

1999	1 907 512	4 844 915	507 235	1 064 640	173 719	258 204	544 591	2 450
FL	1 906 326	112	0	93	0	0	982	0
non-SA CL	3 349	4 787 318	46 602	6 707	0	0	938	0
SA-CL	8 602	0	498 633	0	0	0	0	0
non-SA GL	1 598	8 269	0	1 044 222	10 254	0	297	0
SA GL	828	0	0	0	172 292	598	0	1
WL	32	0	0	0	0	258 164	8	0
SE	434	28	0	178	0	16	543 935	0
OL	0	0	0	0	0	0	0	2 450
2000	1 921 170	4 795 727	545 235	1 051 200	182 546	258 778	546 160	2 451
FL	1 919 873	153	0	251	0	0	893	0
non-SA CL	5 638	4 768 881	17 396	1 847	0	0	1 965	0
SA-CL	8 641	0	536 594	0	0	0	0	0
non-SA GL	2 597	2 985	0	1 020 123	24 957	0	538	0
SA GL	0	0	0	0	182 058	487	0	0
WL	11	0	0	0	0	258 732	35	0
SE	185	1	0	119	0	30	545 825	0
OL	0	0	0	0	0	0	0	2 451
2001	1 936 944	4 772 020	553 990	1 022 340	207 016	259 249	549 256	2 451
FL	1 935 088	317	0	260	0	0	1 280	0
non-SA CL	5 638	4 747 392	15 177	1 847	0	0	1 965	0
SA-CL	11 167	0	542 823	0	0	0	0	0
non-SA GL	3 057	2 985	0	991 254	24 506	0	538	0
SA GL	0	0	0	0	206 528	488	0	0
WL	13	0	0	0	0	259 201	35	0
SE	218	1	0	119	0	30	548 888	0
OL	0	0	0	0	0	0	0	2 451
2002	1 955 180	4 750 696	558 000	993 480	231 034	259 719	552 706	2 451
FL	1 953 928	54	0	93	0	0	1 105	0
non-SA CL	5 638	4 726 331	14 915	1 847	0	0	1 965	0
SA-CL	5 775	0	552 225	0	0	0	0	0
non-SA GL	2 076	2 985	0	962 561	25 321	0	538	0
SA GL	0	0	0	0	230 547	487	0	0
WL	8	0	0	0	0	259 675	35	0
SE	148	1	0	119	0	30	552 408	0
OL	0	0	0	0	0	0	0	2 451
2003	1 967 573	4 729 371	567 139	964 620	255 868	260 192	556 052	2 451
FL	1 966 187	109	0	175	0	0	1 103	0
non-SA CL	5 638	4 704 952	14 969	1 847	0	0	1 965	0
SA-CL	2 311	0	564 829	0	0	0	0	0
non-SA GL	1 446	2 985	0	933 619	26 033	0	538	0
SA GL	0	0	0	0	255 384	484	0	0
WL	6	0	0	0	0	260 151	35	0
SE	103	1	0	119	0	30	555 799	0
OL	0	0	0	0	0	0	0	2 451

2004	1 975 690	4 708 047	579 798	935 760	281 416	260 665	559 440	2 451
FL	1 974 831	149	0	56	0	0	654	0
non-SA CL	5 638	4 683 588	15 009	1 847	0	0	1 965	0
SA-CL	1 944	0	577 854	0	0	0	0	0
non-SA GL	1 379	2 985	0	904 878	25 980	0	538	0
SA GL	0	0	0	0	280 925	491	0	0
WL	6	0	0	0	0	260 624	35	0
SE	98	1	0	119	0	30	559 191	0
OL	0	0	0	0	0	0	0	2 451
2005	1 983 896	4 686 722	592 863	906 900	306 905	261 145	562 384	2 451
FL	1 982 569	116	0	54	0	0	1 157	0
non-SA CL	5 638	4 662 296	14 976	1 847	0	0	1 965	0
SA-CL	8 011	0	584 852	0	0	0	0	0
non-SA GL	2 483	2 985	0	876 020	24 875	0	538	0
SA GL	0	0	0	0	306 418	487	0	0
WL	10	0	0	0	0	261 099	35	0
SE	177	1	0	119	0	30	562 057	0
OL	0	0	0	0	0	0	0	2 451
2006	1 998 887	4 665 398	599 828	878 040	331 293	261 616	565 753	2 451
FL	1 997 534	91	0	202	0	0	1 061	0
non-SA CL	7 499	4 641 327	10 622	4 703	0	0	1 246	0
SA-CL	13 197	0	586 631	0	0	0	0	0
non-SA GL	964	2 609	0	844 087	30 095	0	285	0
SA GL	0	0	0	0	331 176	117	0	0
WL	0	0	0	0	0	261 611	5	0
SE	0	47	0	188	0	53	565 465	0
OL	0	0	0	0	0	0	0	2 451
2007	2 019 194	4 644 073	597 253	849 180	361 271	261 781	568 062	2 451
FL	2 018 042	380	0	138	0	0	635	0
non-SA CL	7 499	4 619 714	10 911	4 703	0	0	1 246	0
SA-CL	4 321	0	592 933	0	0	0	0	0
non-SA GL	689	2 609	0	815 291	30 306	0	285	0
SA GL	0	0	0	0	361 155	117	0	0
WL	0	0	0	0	0	261 776	5	0
SE	279	47	0	188	0	53	567 495	0
OL	0	0	0	0	0	0	0	2 451
2008	2 030 830	4 622 749	603 844	820 320	391 461	261 946	569 666	2 451
FL	2 029 340	184	0	336	0	0	970	0
non-SA CL	7 499	4 598 585	10 716	4 703	0	0	1 246	0
SA-CL	1 539	0	602 306	0	0	0	0	0
non-SA GL	776	2 609	0	786 233	30 418	0	285	0
SA GL	0	0	0	0	391 344	117	0	0
WL	0	0	0	0	0	261 941	5	0
SE	194	47	0	188	0	53	569 184	0

OL	0	0	0	0	0	0	0	2 451
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2009	2 039 347	4 601 424	613 021	791 460	421 762	262 111	571 690	2 451
FL	2 036 995	670	0	526	0	0	1 155	0
non-SA CL	7 499	4 576 774	11 202	4 703	0	0	1 246	0
SA-CL	651	0	612 370	0	0	0	0	0
non-SA GL	483	2 609	0	757 183	30 901	0	285	0
SA GL	0	0	0	0	421 645	117	0	0
WL	0	0	0	0	0	262 106	5	0
SE	766	47	0	188	0	53	570 636	0
OL	0	0	0	0	0	0	0	2 451
2010	2 046 394	4 580 100	623 572	762 600	452 546	262 276	573 327	2 451
FL	2 044 791	388	0	140	0	0	1 075	0
non-SA CL	5 036	4 569 115	0	4 703	0	0	1 246	0
SA-CL	0	6 192	617 380	0	0	0	0	0
non-SA GL	751	2 609	0	753 842	5 113	0	285	0
SA GL	0	0	0	0	452 429	117	0	0
WL	0	0	0	0	0	262 271	5	0
SE	83	47	0	188	0	53	572 955	0
OL	0	0	0	0	0	0	0	2 451
2011	2 050 662	4 578 351	617 380	758 874	457 542	262 441	575 566	2 451
FL	2 048 948	248	0	852	0	0	614	0
non-SA CL	5 815	4 566 587	0	4 703	0	0	1 246	0
SA-CL	0	9 665	607 715	0	0	0	0	0
non-SA GL	770	2 609	0	753 117	2 093	0	285	0
SA GL	0	0	0	0	457 425	117	0	0
WL	0	0	0	0	0	262 436	5	0
SE	99	47	0	188	0	53	575 179	0
OL	0	0	0	0	0	0	0	2 451
2012	2 055 632	4 579 155	607 715	758 860	459 518	262 606	577 329	2 451
FL	2 054 386	270	0	274	0	0	702	0
non-SA CL	3 918	4 569 287	0	4 703	0	0	1 246	0
SA-CL	0	8 705	599 011	0	0	0	0	0
non-SA GL	863	2 609	0	753 897	1 207	0	285	0
SA GL	0	0	0	0	459 030	487	0	0
WL	0	0	0	0	0	262 601	5	0
SE	286	47	0	188	0	53	576 755	0
OL	0	0	0	0	0	0	0	2 451
2013	2 059 453	4 580 918	599 011	759 062	460 237	263 141	578 993	2 451
FL	2 057 952	383	0	241	0	0	878	0
non-SA CL	2 181	4 572 787	0	4 703	0	0	1 246	0
SA-CL	0	9 559	589 452	0	0	0	0	0
non-SA GL	959	2 609	0	755 209	0	0	285	0
SA GL	0	0	0	573	459 664	0	0	0
WL	0	0	0	0	0	263 136	5	0
SE	339	47	0	188	0	53	578 367	0
OL	0	0	0	0	0	0	0	2 451
2014	2 061 432	4 585 384	589 452	760 915	459 664	263 189	580 780	2 450

6.4 Generic methodological steps to estimate emissions and removals

In this section, general methodological description is provided for those methodological elements that are used for many land use and land use change sub-categories. Activity data and emissions/removal factors are usually sub-category specific, and their description can be found in the respective sections below.

6.4.1 Soil carbon stock change estimation

Soil carbon stocks may change due to conversion of land to other land use, conversion of land within a land use sub-category to another sub-category (non set-aside to set-aside), together referred to below as conversion sub-categories, or change of the management within a specific land use sub-category over time. These two types of sub-categories are together referred to below as soil carbon stock change sub-categories. For the entire land use sector, the sum of all soil carbon stock changes is estimated using the below formula:

$$\Delta C = \sum_i \Delta C_i$$

where

ΔC = total carbon stock changes in mineral soils due to land conversion or changes of soil management, tC; and
 i = a “from”-“to” soil carbon stock change category.

Except for those that are mentioned explicitly, the estimation follows the Tier 1 approach in which ΔC_i was estimated using the first formula in Equation 2.25 of the IPCC 2006 GL:

$$\Delta C_i = (SOC_0 - SOC_{0-T})_i / D$$

where

ΔC_i = annual area-specific soil organic carbon stock change in a soil carbon stock change sub-category, tCha⁻¹yr⁻¹;
 SOC_0 = area-specific SOC soil organic carbon stock in the inventory year, tC ha⁻¹;
 SOC_{0-T} = area-specific SOC soil organic carbon stock T years prior to the inventory year, tC ha⁻¹;
 T = number of years over a single inventory time period, yr, $T = 1$ yr; and
 D = default time period for transition between equilibrium SOC values, yr (the default value of 20 years is applied).

For estimating SOC (for both the inventory year and T year before), the second formula in Equation 2.25 of the IPCC 2006 GL was used:

$$SOC = A_i * SOC_{REF} * F_{LU} * F_{MG} * F_I$$

where

A_i = land area in the soil carbon stock change sub-category in the inventory year, ha
 SOC_{REF} = area-specific reference soil organic carbon, tCha⁻¹
 F_{LU} , F_{MG} and F_I are specific land-use, management and input stock change factors for which default values are used. (Note that F_{LU} changes due to land use change, whereas F_{MG} and F_I change due to changes in management.)

The land area values (A_i) are respective values in the land use change matrix in the inventory year, and include all area in the year in a 'remaining' category, or all areas for conversion category i that have been in the category for a maximum period of default length of 20 years (see section 6.2 for details).

Note that the above means that we applied Formulation B (in Box 2.1, p. 2.34) of Section 2, Volume 4 of the IPCC 2006 GL.

Note also that the formula applied above differs from the formula applied in the reporting years before 2015 when 20 years were used for T , whereas beginning 2015, based on the IPCC 2006 GL and as reported above, we use $T=1$ year because we apply annual land use change information. Relative to the estimates reported in 2014 and before, this change of the definition of T called for the recalculation of the estimates of the various years and of the trends of emissions and removals for several sub-categories, and resulted in relatively large changes for some conversion categories and for some years. However, we consider the recalculated values consistent with the trends in the activity data, and thus more accurate than before.

According to the above formulas, the SOC values were all estimated from the SOC_{REF} values for which country-specific values were developed in the course of a research project (Zsembeli et. al, 2013). The estimation was based on the Hungarian Soil Protection and Monitoring System (hereafter referred to as TIM). Based on physiographical-soil-ecological units, 877 representative observation points have been selected on agricultural lands (Figure 6.4.1). The representative sampling sites had been 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 were determined from humus content (Hu, %) values (Füleky Gy.-Filep Gy., 1999), which were measured for the uppermost 30 cm of the soil, using a standard conversion value of 0.58 tC/ha / Hu%:

$$SOC = Hu * 0.58.$$

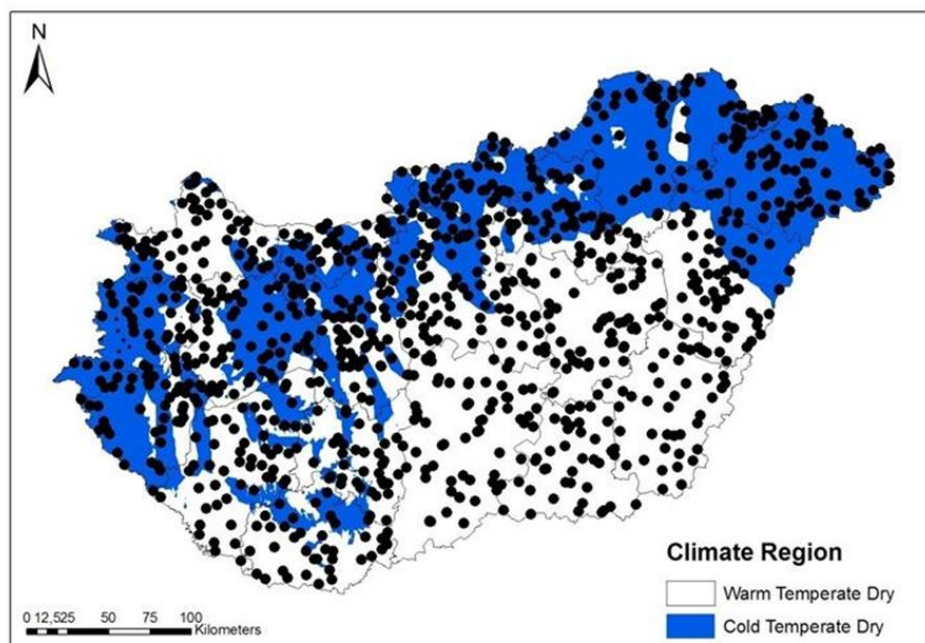


Figure 6.4.1. Sample plots of the Soil Protection and Monitoring System (TIM) by climate zones.

The soil types of the investigated TIM points and the area of the different soil types were determined using a Hungarian digital soil map (called AGROTOPO map). This map used the Hungarian national

soil classification system which classifies soils by genetic types. The 79 soil types identified from the TIM and the soil map cannot directly be allocated to the IPCC soil types, therefore, they were converted into the soil types of the FAO soil classification system in a dedicated study (Michéli, 1999). Then, the FAO (WRB) soil types were converted to the IPCC soil types using the IPCC soil carbon tools. Altogether, 14 different WRB soil types were identified that corresponded to 3 IPCC soil types, i.e., high activity clay soil, sandy soil and aquic soils.

The sample plots were also classified into the IPCC climate zones by the Hungarian Meteorological Service, using the methodology of the GPG (IPCC, 2003), based on the climate map of the Hungarian Meteorological Service. Note that, as the annual mean temperature in Hungary is about 10 degrees Celsius, and the difference between the sites in the cold and the warm IPCC climate zones is only a few tenth of a degree, the soil organic carbon content varies less due to climate, and more due to land use and the history of soil formation. The warm climate zone in Hungary is mainly situated in a lowland called the Great Hungarian Plain (GHP). The lowlands along the rivers are inundated almost every spring before the rivers flows were controlled. (The Danube and Tisza, i.e., the main rivers of Hungary that cross the GHP, have been mostly controlled since the 19th century in Hungary.) The regular flooding had resulted in the formation of wetlands and high organic content of the soil, but most of these wetlands were drained 1-2 centuries ago. The other typical types of vegetation were forest and forest steppe which, centuries ago, also contributed to the evolution of the organic carbon content of the soil.

According to the TIM data, the SOC content of the various above soil types varies quite substantially. This needs to be duly considered because, in the methodology applied as described above, SOC changes are calculated as differences in SOC that are estimated as averages at different time points. Considering these averages, the Guidelines (Volume 4, Chapter 2.3.3.1, page 2.38 of IPCC, 2006) require that sites included in a soil carbon stock change sub-category should have similar histories and management as well as similar ecological properties (including topographic position and soil physical properties) for both time points.

In order to meet requirements, the average SOC values for FL, CL and GL, which are the most important land use categories with respect to land use changes, were calculated based on the following considerations. First, SOC values were separately computed for the major 'from-to' conversion sub-categories for which activity data (i.e., area) is available using data from areas for which the conversion is *possible* (see Table 6.4.2 below). This is necessary because, in Hungary, conversion may not be possible in all sub-categories between the IPCC land-use categories. For example, there are some croplands on aquic soils in Hungary but there are no forests on such soils, therefore, it would be inappropriate to calculate the average SOC for the entire cropland area and also for the entire forest area to estimate carbon stock changes for cropland-forest land conversions and vice versa. Instead, the average SOC for cropland for the case of forest-cropland conversions was calculated for only about 84.6% of all cropland, i.e. only for non aquic sites that could be used to establish forests, and on which forests are actually found, that is, where forest-to-cropland and cropland-to-forest conversions are possible. For similar reasons, for forest-grassland conversions, the SOC content of forest soils were calculated considering forest and grassland areas between which conversion is possible.

In order to check where conversions are possible, we checked the distribution of the area of the various soil carbon stock change sub-categories by climate and soil type (Table 6.4.1). The data shows that CL and GL have similar distributions, while the distribution of FL somewhat differs from that of the others, and that SOC_{REF} (i.e., SOC for forests) is significantly different for the various soil and climate types. The data suggest that forests occupy the poorer sites within the possible CL-FL and GL-FL conversion paths, and that SOC differences due to conversions should not be calculated along an *average* CL-FL carbon stock change trajectory.

Table 6.4.1. The relative distribution of area and estimated SOC_{REF} by soil and climate type for those areas that could be converted to and from other land uses.

soil type	climate type	Land use type			SOC _{REF} (tCha ⁻¹)
		FL	CL	GL	
HAC	CD	0.54	0.38	0.39	48
	WD	0.36	0.56	0.56	58
sandy	CD	0.10	0.03	0.02	15
	WD	0.01	0.03	0.03	21

Based on the above considerations, we developed conversion-specific SOC values for land use categories. Although it is not currently possible to remove all possible bias due to lack of data, and further analysis is necessary, we consider them estimates “as far as practicable”. Using these SOC values, it was possible to develop what might be called a specific soil carbon stock change conversion matrix (Table 6.4.2) which, for FL, CL and GL, includes conversion-specific differences between average SOC values. The matrix is not entirely symmetrical for these land uses due to the above consideration. - For the SOC of land under Settlement, 80% of the SOC of the pre-conversion category was used, based on the Tier 1 approach by the IPCC 2006 GL. For Wetland (which is only involved in very small conversions), no methodology is provided in the 2006 GL. For the sake of completeness only, the SOC of Wetland is set to equal to that of Grassland. The changes of SOC to and from Other land is set to zero. Using these considerations, SOC changes involving SE and WL could also developed and are included in the below matrix.

Table 6.4.2. Sub-categories for which different SOC values are calculated depending on „from” and „to” land use (non-SA: non set-aside; SA: set-aside), and the area-specific average SOC change values (over D=20 years, tC ha⁻¹yr⁻¹) for the inventory year 2014 by the resulting conversion types. (Values for OL are not reported as conversions to and from OL are NO. Values for WL are also reported only for the sake of completeness.)

FROM	TO						
	FL	non-SA CL	SA CL	non-SA GL	SA GL	SE	WL
FL		-11.0	-3.6	0.1	0.1	-9.6	20.7
non-SA CL	11.0		9.4	16.6	16.6	-10.4	16.6
SA CL	3.6	-9.4		7.2	7.2	-12.3	7.2
non-SA GL	-0.1	-16.6	-7.2		0.0	-13.8	0.0
SA GL	-0.1	-16.6	-7.2	0.0		-13.8	0.0
SE	9.6	10.4	12.3	13.8	13.8		13.8
WL	-20.7	-16.6	-7.2	0.0	0.0	-13.8	

It is to be noted here that once the conversion-specific average SOC change values are fixed, the calculations of the carbon stock changes in the various conversion sub-categories depend on, and are thus sensitive, to the estimated annual area of these sub-categories. Uncertainties in this regard are, however, reduced for longer periods (for which the area of the conversions can be more accurately estimated) and for trends.

6.4.2 N₂O emissions from mineral soils as a result of loss of soil carbon through change in land use or management

According to the IPCC 2006 Guidelines, N mineralizes when there is loss of soil organic C stocks in

mineral soils through land-use change or management practices, and this loss also leads to N₂O emissions. For each land use and land use change sub-category and for each year when carbon is lost from mineral soils, these emissions were estimated using the following Equations of the IPCC 2006 GL:

Equation on page 11.10:

$$N_2O = N_2O-N * 44/28$$

where

N₂O = N₂O emissions, kg N₂O yr⁻¹

N₂O-N = annual direct N₂O-N emissions produced from managed soils, kg N₂O-N yr⁻¹;

Equation 11.1:

$$N_2O-N = F_{SOM} * EF_1$$

where

F_{SOM} = annual amount of N in mineral soils that is mineralized, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N yr⁻¹

EF₁ = emission factor for N₂O emissions from N inputs, kg N₂O-N (kg N input)⁻¹ (the value 0.01 was taken from Table 11.1 of the IPCC 2006 GL); and

Equation 11.8:

$$F_{SOM} = \Delta C_{Mineral} / R * 1000$$

where

ΔC_{Mineral} = average annual loss of soil carbon for each land-use type (LU), tonnes C; and

R = C:N ratio of the soil organic matter. Due to lack of more specific data for the area, the default value of 15 is used for situations involving land-use change from Forest Land or Grassland to Cropland, and the default value of 10 is used for situations involving management changes on Cropland Remaining Cropland (page 11.16 of the IPCC 2006 GL).

6.4.3 Non-CO₂ emissions from wildfires

With the exception of slash burning in forests, and in accordance with Government Decrees No. 21/2001(II.14) and No. 306/2010. (XII.23.), the on-site burning of living biomass is prohibited in Hungary. Therefore, the controlled burning of biomass is reported as “not occurring” for Hungary for land-use categories other than Forest Land, and only emissions from wildfires in Forest Land, Cropland and Grassland are reported. With the exception of forests (where emissions from wildfires are separately reported for FL-FL and L-FL, all such emissions are reported in the “remaining land” categories that include any emissions in the conversion categories.

In estimating these emissions, the Tier 1 method and Equation 2.27 were used as follows:

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3}$$

where:

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG

A = area burnt, ha

M_B = mass of fuel available for combustion, tonnes ha⁻¹

C_f = combustion factor, dimensionless

G_{ef} = greenhouse-gas specific emission factor g (kg.d.m.)⁻¹.

Data on the areas affected by wildfires (A) is derived 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 only 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 applied to the trends before 2007. For the period 1985-1997 the average of the emissions since 1998 are reported, due to lack of data.

The amount M_B and C_f is sector-specific, see the relevant sections for details.

6.4.4 Conversion-related biomass carbon stock changes

Conversion-related biomass carbon stock changes occur both on land remaining land (e.g., with converting perennial crops to annual ones and when wetland areas are opened for peat extraction) and due to land conversions (e.g., converting land to Forest land). The estimation of carbon stock changes in these cases is done using Equation 2.16 of the IPCC 2006 GL:

$$\Delta C = A_{\text{conv}} * (B_{\text{After}} - B_{\text{Before}}) * CF$$

where

ΔC = carbon stock change, tonnes C yr⁻¹

A_{conv} = the area undergoing conversion, ha yr⁻¹

B_{After} = biomass after the conversion, t biomass d.m. ha⁻¹

B_{Before} = biomass before the conversion, t biomass d.m. ha⁻¹

CF = conversion factor, tonnes C tonnes biomass⁻¹.

6.5 Forest Land (CRF sector 4.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 used together with supplementary information in Section 11 where some information is reported in more details. Thus, the consideration of both sections may be necessary to understand methods and data in this section.

6.5.1 Category description

Forest land is managed in Hungary by a well-developed and 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 and http://www.mgszh.gov.hu/data/cms/140/140/Forest_database_2.pdf

. 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.

Forests in Hungary are predominantly managed in units of relatively homogenous tree cover, i.e. stands (or sub-compartments), with a mean area of about four ha. The geographical location of all known stands, which 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 NFC SOFD at

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.

Forest management has a long history in the country, and most forests are more or less intensively managed. The area of forests that could be considered as “unmanaged” under the UNFCCC is negligible. There are some forests where no forestry operations have taken place for about two decades to a century. 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.

Forest land is subdivided into sub-categories under the UNFCCC and the KP. The definitions that are generally applied to identify the areas of these sub-categories, and to estimate emissions and removals in these sub-categories, are the following:

“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 at maturity of more than 30 percent. It does not include land that is predominantly under agricultural or urban land use.

In contrast, **„Forest land”** (which includes both the *Forest Land remaining Forest Land, FL-FL*, and the *land converted to forest land (L-FL)* sub-categories) includes areas covered by trees, as well as roads and other areas that are under forest management but not covered by trees (see Table 6.5.1 below).

“Afforestation” (which includes **“reforestation”**) is an activity that leads to the conversion of non-forest land to forest land. From a domestic administrative point of view, conversions can take place in a period of 3-15 years, depending on tree species and site, but the default transition period of 20 years is used in the GHG inventory to include areas in the L-FL category consistently with the default IPCC methodology. Note that, usually, the area of newly established forests included in the L-FL category under the UNFCCC, which contains all administered forestations, is different from that of the *AR category* under the KP, which only includes areas where the requirement of “direct human induced activity” is fully met in the databases (see also section 11).

“Deforestation” is a conversion of forest land to non-forest land. In Hungary, all such conversions take place within one year. Partly because of this reason, 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, under the UNFCCC, both area covered by trees and all other land that is moved from Forest land to another LU category are reported here, whereas only the area that was covered by trees before the deforestation is reported in the *deforestation (D) category* under the KP. See Section 11 for more details.

Using the above definitions, forest land covers a bit more than one fifth of the terrestrial area of the country. The *total area of land under forestry*, which is considered as forest land area, includes both forest sub-compartments that are at least potentially covered by trees and un-stocked areas like roads, openings, wildlife forage grounds, glades, buildings etc. that indirectly serve forest management purposes. The area of forest land using this definition was 2,061.4 thousand ha by the end of 2014. In order to be consistent with the land-use change matrix, forest land is in the CRF tables using this statistics. However, due to historical reasons and because the actual area covered by forests is smaller than this, we also report other area statistics. The *total area of all forest sub-compartments*, which is the potentially stocked area, amounted to 1,941.0 thousand ha. (As the carbon stock changes actually take place in the forest sub-compartments, the correct implied emission factor and m³/ha data should reflect the area of forest sub-compartments.) Finally, *the area actually covered by trees*, which is the actually stocked area and which appears in several official Hungarian statistics, amounted to 1,867.1 thousand ha (**Table 6.5.1**). This area is calculated from that of the forest sub-compartments by adjusting for gaps and overlaps in the canopy closure, which are measured during surveys as “canopy closure” (%).

Table 6.5.1. *The area of forest land, forest compartments and land covered by trees (ha) over time.*

Reporting year	Total forest area (forest and other subcompartments, 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	1 658 660	1 526 395
1988	1 787 607	1 667 352	1 530 587
1989	1 801 435	1 674 815	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	1 975 690	1 844 988	1 769 988
2005	1 983 896	1 853 642	1 789 648
2006	1 998 887	1 869 452	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
2013	2 059 453	1 938 139	1 863 679
2014	2 061 432	1 941 016	1 867 133

The total area of forests has changed considerably since 1930, from about 11% to 21% today, because of systematic afforestations of around 800 thousand ha and very little deforestation. The reason for these area dynamics is mainly that the country is much less forested than other countries (and, on average, less than e.g. the European Union). Also, the Hungarian Forest Law is really rather rigorous, and it is also rather strictly implemented and inspected with respect to deforestations. 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. The area of forest sub-compartments deforested (i.e., areas with tree cover before the conversion), which is the main source of emissions due to biomass loss, has been typically under 500ha/year for the last decades, which is only about 0.03% of the forest area and about 5% of the average rate of afforestation. Some additional related area (over 500 ha), for which emissions from soils are also estimated, is usually also moved to the other land use categories (**Table 6.5.2**).

Table 6.5.2. *The area of, and emissions from, conversion of forest land to other land use categories. The annual area has been slightly fluctuating e.g. because of varying rate of highway building. (Emissions from biomass and soils are also reported here for information only. Emissions from other sources are also estimated and reported, see tables below.)*

Inventory year	Conversions from FL to other land use			
	Area (ha)		CO ₂ emissions (Gg CO ₂)	
	forest subcompartments	forest and other subcompartments	from biomass	from soils
1985	326.1	326.1	41.0	11.0
1986	326.1	326.1	41.0	11.0
1987	326.1	326.1	41.0	10.9
1988	326.1	326.1	41.0	10.8
1989	326.1	326.1	41.0	10.7
1990	612.9	612.9	77.1	11.1
1991	239.8	1817.0	30.1	13.3
1992	125.6	1447.1	15.8	14.8
1993	328.6	328.6	41.2	14.4
1994	218.2	218.2	27.4	14.2
1995	357.8	357.8	44.8	14.0
1996	345.9	616.7	43.3	13.9
1997	522.0	522.0	65.6	13.9
1998	402.0	402.0	50.2	13.9
1999	395.4	1446.9	49.4	14.3
2000	719.1	1186.6	89.7	15.4
2001	520.9	1297.0	64.9	16.0
2002	637.5	1856.4	79.4	17.5
2003	593.3	1252.1	73.9	18.7
2004	943.8	1386.7	117.4	19.8
2005	411.1	858.8	51.1	20.5
2006	508.6	1326.7	63.2	22.2
2007	245.5	1353.5	30.5	23.1
2008	293.8	1151.9	27.1	24.0
2009	455.0	1490.0	58.0	24.6
2010	208.3	2351.3	27.8	25.3
2011	276.6	1603.5	45.7	24.7
2012	782.4	1713.2	131.6	21.5
2013	532.1	1246.1	61.5	22.3
2014	601.9	1501.3	84.5	21.3

Some of the above net increase of the forest area is also due to the fact that surveys that are done for forest management planning purposes have identified new forests each year for the last three decades, and these forests (called “**found forests**”) were added to the area under forest management. Note that as we know very little about how these forests were established and how they had been managed until they were found, we considered them until reporting year 2014 as forests that do not meet the requirements (for human induced activities) of Article 3.4 Forest Management under the Kyoto Protocol (KP), however, beginning 2015, we include them in this category (see also section 11).

The above trends have all been characteristic for the Hungarian forestry since 1985, affecting both area and standing volume. **Figure 6.5.1** demonstrates these statistics for the FL-FL and L-FL categories.

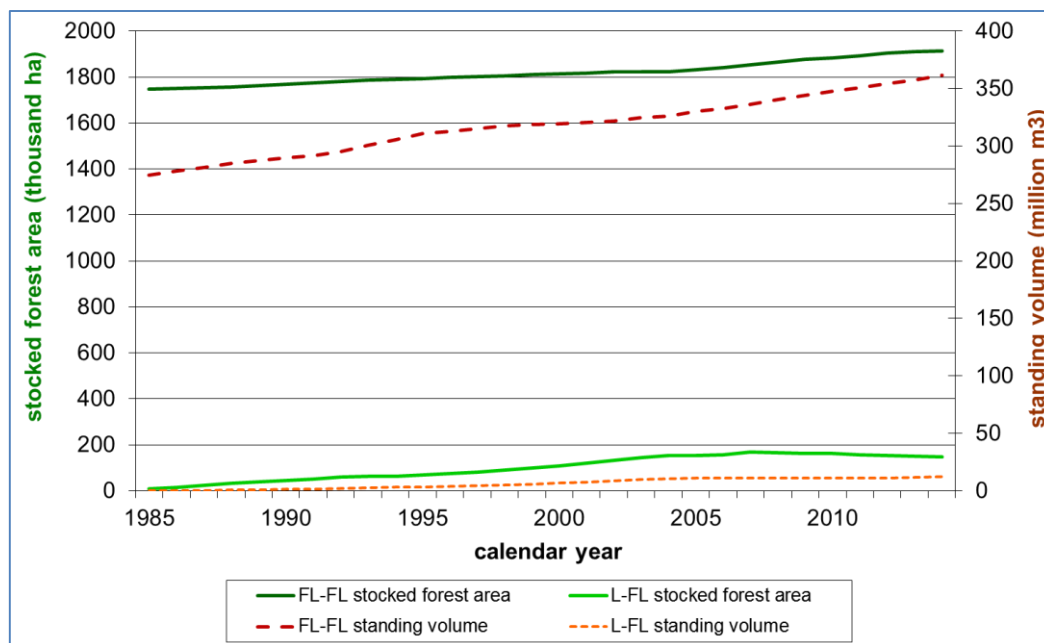


Figure 6.5.1. The area and standing volume of stocked forest on land remaining forest land (FL-FL) and land converted to forest land (L-FL). Note that the values of L-FL are rather small but not zero (see text below).

The Hungarian forests have had a positive carbon stock change balance for the last three decades, mainly due to the above large-scale afforestations, but also due to the distribution of the forest area over age and site fertility classes, and because of the success to manage forests in a sustainable way.

Considering methodological issues in general, activity data for estimating GHG emissions and removals 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 an expert judgment is used.

The following sections describe land identification and how carbon stock changes, as well as non-CO₂ emissions are estimated. Note that beginning 2015, we started to use the IPCC 2006 Guidelines as the basis of the estimations. However, as in most cases the methodology has been country-specific, no changes in the methodology took place relative to earlier years in 2015, thus, there is no major effect of switching from using the IPCC 2003 Good Practice Guidance to using the IPCC 2006 Guidelines.

6.5.2 Land identification

Forest land information together with the description of forestry-related databases of NFCSO FD (National Food Chain Safety Office, Forestry Directorate) is described in English in detail at the following web addresses: <https://www.nebih.gov.hu/en/specialities/erdeszet>, https://www.nebih.gov.hu/data/cms/161/750/Forest_resources_and_forest_management_in_Hungary_2013.pdf and http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT. In short, a continuous forest inventory is conducted whereby each stand is surveyed at least once in

every ten year by the Central Agricultural Office Forestry Directorate and related government services. These services have a staff of about 300 forest engineers. The inventory data is stored by stand in a computerized database, i.e. the National Forest Database (NFD).

Consistent with Section 6.3 above, land in the forestry sector is identified using a combination of Approach 1 and 2 of Chapter 3 of Volume 4 of the IPCC 2006 GL. 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. Due to this planning, practically all *sub-compartments (i.e., forest stands) are surveyed once in every 10 years* (see in more details at 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.). 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. (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.)

Note that all changes in volume stocks of all forests due to any causes from growth through harvests and natural disturbances to deforestation (see below) are captured by the above surveys.

From stand-level information, statistics are produced each year for all forests. Data for stands not surveyed in a particular year is updated using growth and yield models each year. 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 and afforestations, and those in all other forest areas are reported separately in this inventory.* This was made possible by the fact that 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.

It must be underlined here that the forest inventory system in Hungary was, just like that in most other countries, designed and run in the last several decades to to be predominantly be able to capture the (entire) *area* that is deemed to be forest according to laws and regulations in effect at any given point in time, and not to capture *changes* of this area. Therefore, 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. The forest inventory was thus not explicitly designed to capture forest area changes, although it 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.

The vast majority of the increase of the forest area in the FF sub-category over the past decades is due to the following processes and causes (with expert judgment of their possible extent in the last decade in parenthesis):

- 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 due to surpassing the thresholds of “forest” as detailed above,
- re-classification of land (i.e., areas of former “croplands”, “grasslands” or “settlements” etc. that were found during a survey to be covered by trees, possibly due to unregistered earlier afforestation, or where the above thresholds of “forests” were found to be surpassed, about 60% of the cases),
- geodesic re-measurements of the area of previously existing stands at subsequent surveys

(about 20% of the cases).

The identified changes of the total forest area in any inventory year are thus only partly physical and actual increases of the “forest” area, but are partly due to the continuous development of the ability of the forest inventory and the land use inventory in general to identify forests with increasing accuracy.

Most stands in the FF category have been identifiable individually since 2008 (see Table 6.5.3 below and also Figure 6.5.2). A complete assessment of FF with respect to the area and carbon stock changes is presented in Chapter 11.2.2.

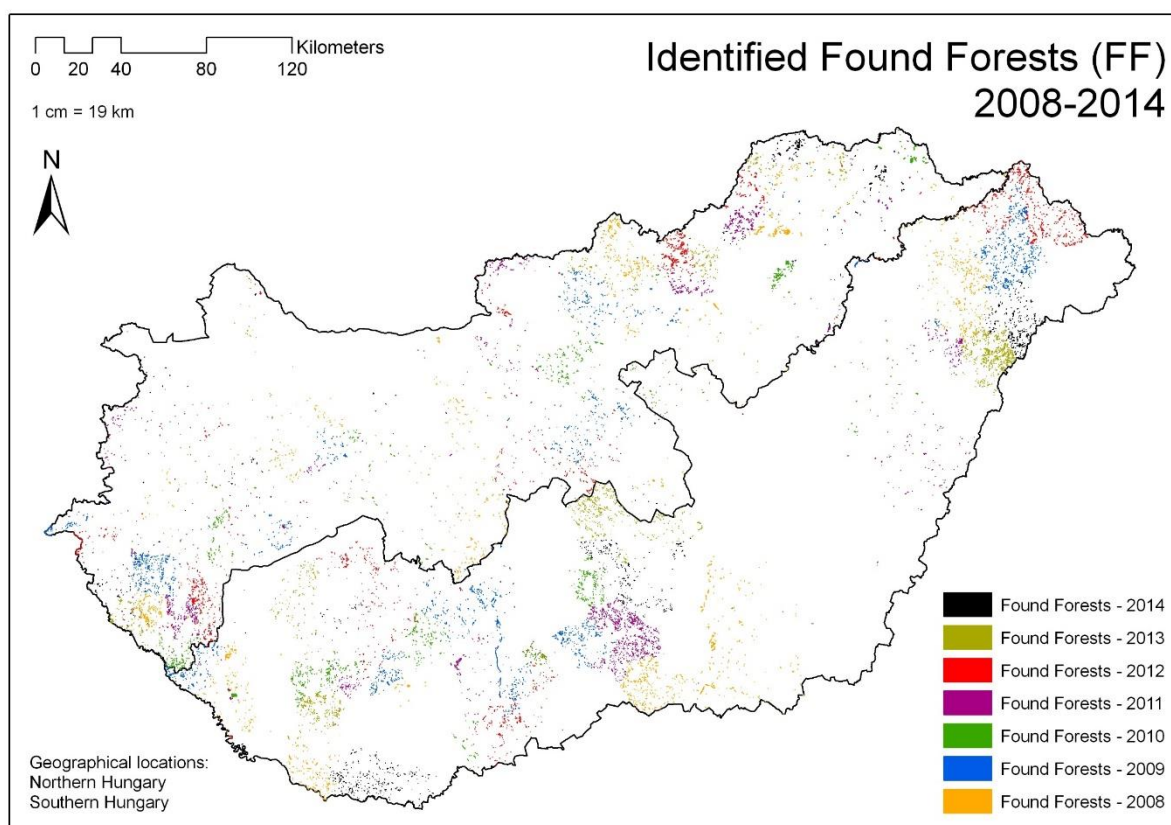


Figure 6.5.2. The distribution of found forests (FF) 2008-2014.

One important issue with found forests (FF) is the need to meet the requirement of the IPCC 2006 Guidelines (section 4.2.1.1) concerning the stock difference method (Equation 2.5 of Chapter 2, Volume 4). According to these Guidelines, when estimating biomass carbon stock changes (and we apply this stock change method, see below), “subsequent inventories must also allow identical area coverage in order to get reliable results”. The area of the sub-category FF has been relatively large in most inventory years, i.e. on average about half of annual afforestations (see Figure 11.1), therefore, it must be, and is indeed kept, for each inventory year separate from the area of forests that were known at the beginning of the inventory year. (Note that, 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.) Under the UNFCCC, these FF become parts of the forest land in the next inventory year because the definition of FL-FL starts over in each calendar year.

Table 6.5.3. 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. Δ is used to denote changes of the value of a land use sub-category between two time points, or changes estimated by using another methodology if the data is taken from the database. (The table is for demonstration only and may include rounding errors; for precise numbers, and for data by geographical locations, see the respective CRF tables.)

Inventory year	AREA, ha												
	FL, all compartments FL = FL-FL + L-FL + new FF			D	new FF	L-FL					FL-FL		
	t_1	t_2	Δ	Δ	Δ	t_1	new	moved to FL-FL	Δ	t_2	t_1	t_2 , w/o FF	t_2 , w/ FF
	from DB	from DB	t_2-t_1	from DB	from DB	from DB	from DB	from DB	new - moved	$t_1 + \Delta$	FL - L-FL	FL - L-FL	FL - L-FL
2008	2 019 194	2 030 830	11 636	1 152	5 567	167 556	7 220	8 484	-1 264	166 292	1 851 638	1 858 970	1 864 537
2009	2 030 830	2 039 347	8 517	1 490	6 489	166 292	3 518	7 285	-3 768	162 525	1 864 537	1 870 332	1 876 822
2010	2 039 347	2 046 394	7 048	2 351	3 138	162 525	6 261	6 494	-233	162 292	1 876 822	1 880 964	1 884 103
2011	2 046 394	2 050 662	4 267	1 604	4 224	162 292	1 647	6 334	-4 687	157 605	1 884 103	1 888 833	1 893 057
2012	2 050 662	2 055 632	4 971	1 713	5 520	157 605	1 164	6 739	-5 575	152 030	1 893 057	1 898 082	1 903 603
2013	2 055 632	2 059 453	3 821	1 246	4 369	152 030	697	3 045	-2 347	149 683	1 903 603	1 905 401	1 909 771
2014	2 059 453	2 061 432	1 978	1 501	2 058	149 683	1 422	2 713	-1 292	148 391	1 909 771	1 910 982	1 913 041

6.5.3 Methodology to estimate biomass carbon stock changes

For the estimation of carbon stock changes of the **biomass carbon pools**, we apply the following **definitions** (see also Section 11.3.1.1.1 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.

“**Wood volume**”, or “**Volume**” is the total above-ground volume of trees. Note that, in Hungary, merchantable volume is not used, and the total above-ground volume is estimated from measured breast-height diameter and total tree height using country-specific volume functions.

With respect to **carbon stock changes in the biomass pools**, only those of trees are estimated using different approaches 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 difference method, Equation 2.5 of Chapter 2, Volume 4 of the IPCC 2006 Guidelines). However, this must be corrected to obtain carbon stock change by excluding the stock of the *newly found* forests. The carbon stock *changes* are separately calculated for L-FL using a specific method (see section 7.3.2), for FL-L under the UNFCCC (the latter being equal to D under the KP, using the stock difference method, see sections 6.5.2 and 6.5.3), as well as for AR under the KP (also using the stock difference method, see sections 11.3.1.1 and 11.3.1.2).

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, appropriate formulas are applied (see below).

In Hungary, the stock difference method is used because, due to the nature of the Hungarian forestry statistics, estimates of total above-ground volume of all forests in the country are available annually, and because this method is deemed more accurate than the gain-loss method. 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. Uncertainties around these statistics 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. (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 consistent with 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

ΔC_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 consistent with Equation 3.2.3 of the GPG for LULUCF, IPCC 2003) has been *adapted* (by excluding BEF from the equation) 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 $^{-1}$).

Note that 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). These functions were derived from field measurement of many felled trees, and directly provide total aboveground volume information which includes the volume of stem, all branches, twigs and bark, i.e. all above-ground parts of the trees. Thus, no (biomass or volume) expansion factors are included in the calculations (i.e., their value is taken to be equal to 1).

Growing stock is estimated during the continuous survey of the forest inventory from various stand measures (such as height, diameter, basal area, and density) depending on species, age, site and stand quality. More accurate methods are usually used for stands of higher volume stocks. Given that, as mentioned above, growth and yield functions are used in years between surveys to update volume stocks, volume and carbon stocks are available for each stand and for each inventory year. (Note that, according to Somogyi, 2008b, the growth of trees accelerated in Hungary recently. Yield tables cannot be regularly updated, however, this growth increase is equivalent to a small underestimation of the updated volume stocks and the removals, thus, the approach is conservative.)

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^3/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, 127.7, 116.7 and 134.3 m^3ha^{-1} for the years of 2008-2014. The mean age of FF is 25.5, 22.2, 24.7, 22.9, 22.8, 22.0 and 23.7 years for the years of 2008-2014.

Concerning wood density, a new set of data of basic wood densities was introduced in 2010. This dataset (Table 6.5.4), which replaced previous data that were oven-dry density values, and which is used across all reporting years, 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). Note that, in order to be consistent with the approach to use total aboveground volumes, the basic wood densities applied were measured from samples taken from all parts of the sample trees, including branches and bark, by correctly excluding the moisture content of wood from the derived density value.

Table 6.5.4. Basic wood density values for the main species and species groups in Hungary (Somogyi, 2008a).

Species or species group	Basic wood density (t/m ³)
Quercus robur	0.57
Quercus pertaea	0.61
Other quercus	0.55
Quercus cerris	0.64
Fagus silvatica	0.59
Carpinus betulus	0.58
Robinia pseudoacacia	0.59
Acer sp.	0.52
Ulmus sp.	0.58
Fraxinus sp.	0.56
Other hard broadleaves	0.5
Hybrid poplars	0.34
Indigenous poplars	0.36
Salix sp.	0.36
Alnus sp.	0.43
Tilia sp.	0.48
Other soft broadleaves	0.48
Pinus silvestris	0.42
Pinus nigra	0.47
Picea abies	0.39
Larix decidua	0.49
Other conifers	0.37

With respect to the below-ground biomass, a general value for the root-to-shoot ratio (R) is applied. Due to lack of proper country-specific data, and in order to be consistent with previous estimates, IPCC default values (Table 4.4 of Chapter 4 of Volume 4 of the IPCC 2006 Guidelines) were considered by expert judgment (Tier 1 methodology). Considering that the majority of the forests in Hungary is young, and that the average volume stocks (calculated on the basis of the area of forest sub-compartments) are 173.0 m³ ha⁻¹ (in 1990) and 190.7 m³ ha⁻¹ (in 2013), 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⁻¹ (Table 4.3 of Chapter 4 of Volume 4 of the IPCC 2006 Guidelines) are used for

broadleaves and coniferous species, respectively. (These values were consistently applied for the entire time series.)

Note that losses of carbon in biomass on land converted to forests are also reported in section 6.5.5 below using the methodology described in section 6.4.4 above.

6.5.4 Forest Land remaining Forest Land (CRF sector 4.A.1)

6.5.4.1 Category description

The main inventory estimates for the FL-FL category can be found in Table 6.5.5. Note that, in order to be consistent with the CRF tables, only the area of forest and other sub-compartments is reported here.

Table 6.5.5. *The 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 ₂ (Gg)	CH ₄ (Gg)	CO (Gg)	N ₂ O (Gg)	NO _x (Gg)
1985	1,748,164	-344	0.68	12.63	0.0277	0.35
1986	1,750,861	-3,271	0.70	12.91	0.0283	0.36
1987	1,753,827	-3,588	0.67	12.34	0.0270	0.35
1988	1,756,259	-3,773	0.65	12.06	0.0264	0.34
1989	1,762,801	-2,475	0.65	12.03	0.0264	0.34
1990	1,768,774	-2,971	0.60	11.16	0.0245	0.31
1991	1,773,942	-2,236	0.58	10.65	0.0233	0.30
1992	1,780,140	-2,794	0.52	9.55	0.0209	0.27
1993	1,785,094	-5,288	0.44	7.94	0.0172	0.22
1994	1,788,184	-5,676	0.44	7.93	0.0172	0.22
1995	1,793,517	-5,439	0.46	8.38	0.0181	0.24
1996	1,797,602	-1,442	0.51	9.16	0.0198	0.26
1997	1,801,572	-1,777	0.50	8.97	0.0193	0.25
1998	1,804,219	-2,737	0.48	8.59	0.0185	0.24
1999	1,809,551	-411	0.32	7.30	0.0177	0.20
2000	1,813,966	490	0.50	11.44	0.0278	0.32
2001	1,817,339	-1,027	0.43	9.89	0.0240	0.28
2002	1,821,574	-167	0.43	9.73	0.0236	0.27
2003	1,822,625	-2,460	0.40	9.18	0.0223	0.26
2004	1,823,592	-1,452	0.29	6.64	0.0161	0.19
2005	1,832,045	-3,646	0.67	15.18	0.0369	0.43
2006	1,841,327	-1,383	0.28	6.46	0.0157	0.18
2007	1,851,638	-1,490	0.58	13.25	0.0322	0.37
2008	1,864,537	-2,862	0.27	6.07	0.0147	0.17
2009	1,876,822	-1,994	0.25	5.75	0.0140	0.16
2010	1,884,103	-1,922	0.28	6.46	0.0156	0.18
2011	1,893,057	-1,805	0.63	14.96	0.0350	0.42
2012	1,903,603	-2,719	0.54	12.20	0.0296	0.34
2013	1,909,771	-2,013	0.38	8.87	0.0211	0.25
2014	1,913,041	-3,254	0.46	10.75	0.0256	0.30

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 resulted in substantial changes in emissions and removals in both the FL-FL and the L-FL categories, however, their sum did not change much.

Table 6.5.6 summarizes methodological information for the Forest Land remaining Forest Land category.

Table 6.5.6. Methodological summary for the Forest Land remaining Forest Land category.
(CS=country specific; D: default; EJ: expert judgment; IE: included elsewhere; AD: activity data; EF: emission/removal factor)

Category	Type of information	Carbon stock changes					Table(5) I, II, V
		AG B	BG B	DW	LI	SOIL	
FL-FL	E/R	CS	D/EJ	NE (demonstrated that not a source)	NE (demonstrated that not a source)	Mineral: NE (demonstrated that not a source); Organic: AD: CS; EF: D	Fertilization: IE Drainage and re-wetting: NO Biomass burning (slash burning + wildfires): AD: CS; EF: D
	Uncertainty	Results of the Tier 2 (Monte Carlo) analysis under FM is applicable		N/A			Results of the Tier 2 (Monte Carlo, where applicable) analysis under FM is applicable

6.5.4.2 CO₂ emissions and removals

The methodology to estimate emissions and removals in the forestry sector is based on that of the IPCC 2006 Guidelines. Whenever it was possible, country specific data was used (Tier 2), and IPCC default values (Tier 1) and expert judgment 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.

6.5.4.2.1 Biomass

Carbon stock changes of the biomass pool in the FL-FL category are calculated from those of the entire Forest Land, D and L-FL sub-categories. The methodology applied for the various sub-categories is as described in section 6.4 above. The input data from these categories, together with the formulas that are used to derive the FL-FL estimates are included in Table 6.5.7 below. 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 for the areas that are found in the inventory year are not estimated based on a dedicated survey in the newly found forests, rather, using an area specific mean net removal value (just like an “implied emission factor”) of the entire FL-FL category (calculated as the ratio of the total net removals and total area of forest subcompartments), multiplied by the total area of found forests.

Table 6.5.7 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 from the respective cells. NE means net emissions, and IEF means “implied emission factor”. Symbol Δ is used to denote changes estimated as either differences between the value of a land use class at two time points, or using another methodology. All other notations are as in Table 6.5.3. (The table is for demonstration only and may include rounding errors; for precise numbers, and for data by geographical locations, see the respective CRF tables.)

Inventory year	ΔC of BIOMASS under the UNFCCC, GgCO ₂													
	FL		new FF (identified in the inventory year)		D, new		FL		L-FL			L-FL net	FL-FL	
	gross Δ	IEF	stock	IEF	Δ	IEF	net Δ = NR	IEF	gains	IEF	losses	Δ	NR	IEF
	from DB	NR/area (Gg CO ₂ /ha)	from DB	stock /area (Gg CO ₂ /ha)	from DB	Δ /area (Gg CO ₂ /ha)	gross ΔFL - new FF stock - D	NR/area (Gg CO ₂ /ha)	from DB	gains /area (Gg CO ₂ /ha)	from DB, only for information in this table	gains+ losses, only for information in this table	net ΔFL - L-FL gains (includes NR of all FF)	NR/area (Gg CO ₂ /ha)
2008	-4 992	-0.002623	876	0.1573	27	0.0922	-4 143	-0.002177	-1 220	-0.150064	4	-1 216	-2 924	-0.001568
2009	-4 139	-0.002163	980	0.1510	58	0.1289	-3 217	-0.001682	-1 161	-0.137902	5	-1 157	-2 055	-0.001095
2010	-3 603	-0.001875	479	0.1527	28	0.1336	-3 152	-0.001640	-1 168	-0.131676	3	-1 165	-1 983	-0.001053
2011	-3 566	-0.001850	644	0.1524	46	0.1654	-2 968	-0.001540	-1 101	-0.121265	5	-1 097	-1 867	-0.000986
2012	-4 578	-0.002368	871	0.1579	132	0.1682	-3 838	-0.001985	-1 057	-0.113019	5	-1 053	-2 781	-0.001461
2013	-3 692	-0.001905	630	0.1441	62	0.1156	-3 124	-0.001612	-1 050	-0.103534	2	-1 048	-2 074	-0.001086
2014	-4 632	-0.002386	341	0.1659	85	0.1404	-4 375	-0.002254	-1 059	-0.099261	2	-1 057	-3 316	-0.001733

The resulting carbon stock changes in FL-FL, in combination with those in L-FL (see below) demonstrate that the biomass of the forests in Hungary has been a sink for the last three decades. This is 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 (Figure 6.5.4). 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 components of the true variability, which are related to the varying true increment of the stands, cannot be captured by our estimation system because it is continuous but based on a combination of measured and model-based (yield table-based) estimates. However, the inter-annual variability of the FL-FL carbon stock change estimates is not an artifact, and reflects 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). 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.

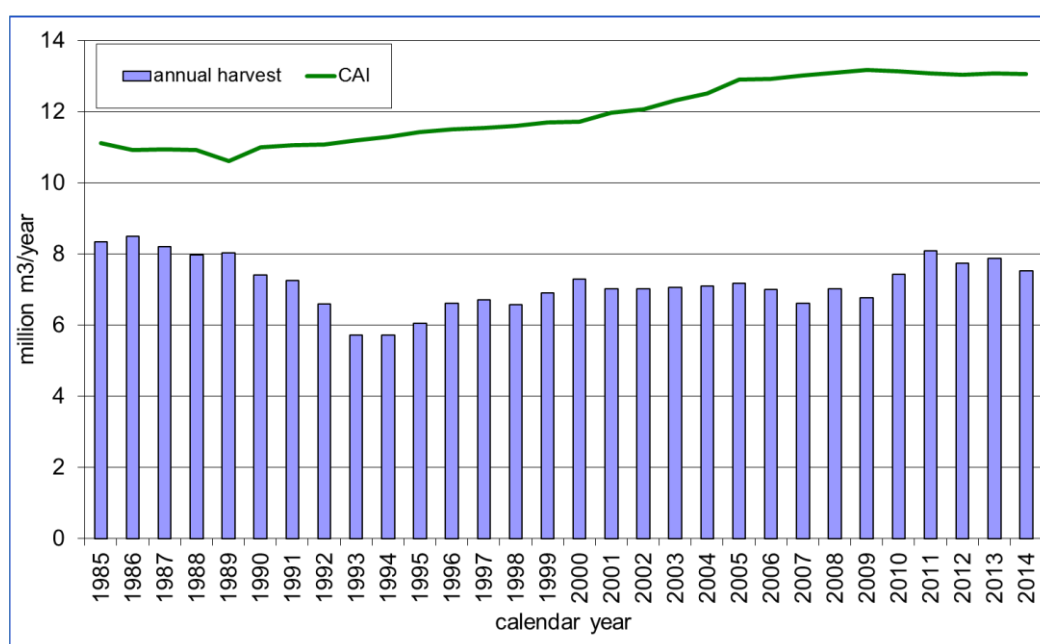


Figure 6.5.4 Annual harvest and current annual increment (CAI) in Hungary in the last three decades.
Data source: National Forest Database.

6.5.4.2.2 Dead organic matter

In Hungary, data has not been collected in a representative sample of stands on deadwood, litter or soil. However, based on some data that we have, it seems justified to state that these pools continue to sequester carbon, rather than to lose carbon, in the medium-term, and that they are not a source.

To demonstrate that the DOM pool is not a source, we present the results that are also published in the European ICP-Forest, Forest Focus and Life+ programs on forest health. These results are based on a small but anyway systematic sampling, and show a varying and slowly increasing tendency of net accumulation of the number of standing dead trees until ca. 2005, and, based on a more limited sample collected since 2006, a quasi-stable (not decreasing) trend later (Figure 6.5.5).

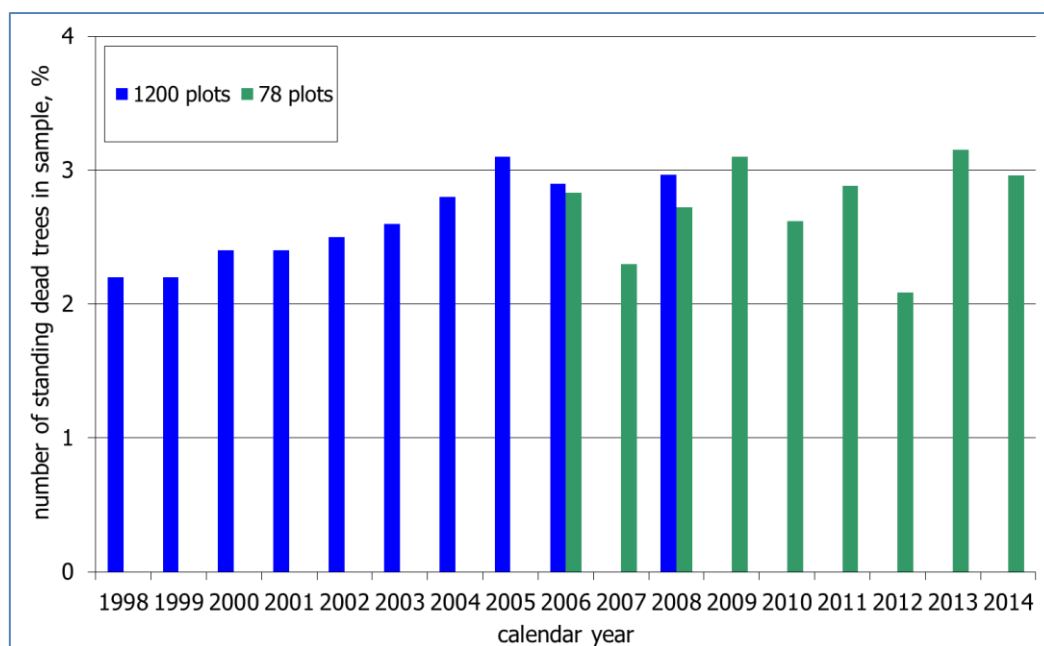


Figure 6.5.5. The amount of standing dead trees in the Hungarian forests (number of trees in the sample, %). Data source: IPC-Forest, Forest Focus, Life+ and FMOS (Forest Monitoring and Observation System) program, and Somogyi and Zamolodchikov, 2007.

The slow but steady increase of the amount of standing dead trees, and in general that of the dead organic matter including deadwood and litter in the Hungarian forests, is mainly due to two reasons. One is the high level of sustainability of the management of existing forests, which means that less wood has been harvested than what is grown for many years. This effect can easily be seen from Figure 6.5.4, 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. For the last several decades, 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 be managed in an increasingly natural way, which includes leaving more deadwood in the forest after harvests than before, that gaps be created and maintained, and that species mixture be enhanced. As a result of the implementation of these requirements, we can assume the accumulation of both deadwood and litter in the Hungarian forests.

Another reason of the increase of the amount of deadwood 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 of dead organic matter pools have not saturated yet.

Finally, no major disturbances or other processes have occurred that could have resulted in substantial emissions from the dead organic matter. 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 this pool is not a source, and that its carbon stock changes are zero.

6.5.4.2.3 Soils

As the amount of dead organic matter increases, it provides input into the soils which ensures that, even if slowly, the carbon stocks of the soils increase. Although there are some events in some forests that lead to emissions (e.g., natural disturbances, harvests etc.), there is a carbon sink in large areas. We are currently not able to estimate the net effect of these processes, carbon stock changes are not

reported quantitatively, but we can conclude based on reasoning (see details in Chapter 11) that, overall, mineral soils can be considered to be not a source.

With respect to organic soils, we conducted a dedicated project in 2013 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 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 6.5.6). These are all previously drained areas. There is practically no rewetting in Hungary. The emissions from the current organic soils, which were typically drained several decades ago, were earlier calculated by multiplying this area by the default emission factor of $0.68 \text{ tCO}_2\text{ha}^{-1}$. The formula is still applied (i.e., it is the same as Equation 2.26 of the IPCC 2006 GL), however, we apply a more recently published default emission factor, which is the IPCC default EF given in Table 2.1 of the Wetlands Supplement for Drained Forest land, temperate zone. This value, i.e., $2.6 \text{ tCO}_2\text{ha}^{-1}$, is higher than the previous default, and we recalculated (in 2015) our emission estimates using this value for the entire time-series in order to be conservative.

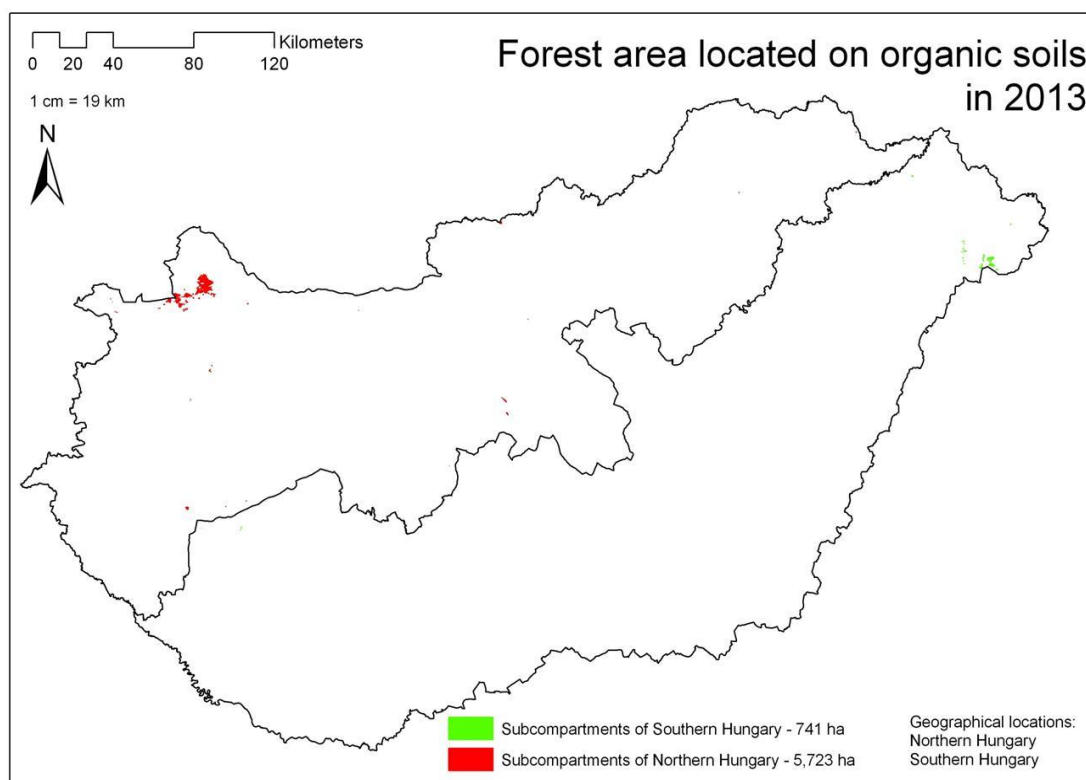


Figure 6.5.6. The distribution of forest stands on organic soil in Hungary (Illes et al., 2013).

6.5.4.2.4 Harvested Wood Products

Changes in the carbon stocks in the harvested wood products (HWP) pool were not reported until 2015. Based on the methodological guidance of the IPCC 2006 GL and the IPCC 2013 KP Supplement, proper data has been collected that is now used to develop estimates for this pool, too. The following data sources were used for the estimation: international databases: UNECE/FAO TIMBER database, 1964-2010, as of January 2012, and the Joint Forest Sector Questionnaire (JFSQ) by ITTO, 2011-13; domestic forestry databases: Halász Aladár, Erdőgazdaságunk, faiparunk és faellátásunk helyzete és fejlődése 1920-1958-ig; Közgazdasági és jogi könyvkiadó, Budapest, 1960.,

333 p.; Halász Aladár: Faellátásunk helyzete és fejlődése; Mezőgazdasági Könyvkiadó Vállalat Budapest, 1966., 322 p.; Halász Aladár: A magyar erdészet 70 éve számokban 1920-1990; FM Erdőrendezési Szolgálat Budapest, 1994., 204 p., OSAP (Országos Statisztikai Adatgyűjtési Program, or National Statistical Data Collection Program, by the National Food Chain Safety Office) and the National Statistical Office (KSH).

Data are available since 1900 for the production categories as well as by domestic removals, import and export, however, considering data accuracy, only data since 1964 have been used. Some data as examples are shown in Table 6.5.8. Exports and imports were treated according to Equations 2.8.1 (for industrial roundwood) and 2.8.2 (for wood pulp) of the IPCC KP Supplement. The amounts of volume that are accounted for as input to the HWP pool exclude firewood as its carbon stock is accounted for using the instantaneous oxidation method.

Annual volumes of wood products were converted to carbon using the default conversion factors from Table 2.8.1 of the IPCC KP Supplement. To estimate net carbon stock changes of the HWP pool, the Tier 2 first order decay calculation method was used, i.e., Equation 12.1 from the 2006 IPCC Guidelines, together with default half life time values as required by Equation 2.8.5 of the KP Supplement, i.e., two years for paper, 25 years for wood panels and 35 years for sawn wood. Instantaneous oxidation assumed for wood in solid waste disposal sites. The estimates included exports.

The methodology used was first published by Király and Kottek (2014).

Table 6.5.8. Wood volume, in selected inventory years, by wood product and production categories used in the calculation of the carbon stock changes of the HWP pool.

Wood product category	Type of quantity	Unit	Calendar year							
			1990	2008	2009	2010	2011	2012	2013	2014
Industrial roundwood	Removals	1000 m3	3 518	2 822	2 365	2 746	3 018	2 987	3 169	3 119
	Import	1000 m3	958	261	195	262	250	208	207	224
	Export	1000 m3	1 159	725	691	875	881	858	975	871
Wood pulp	Production	1000 m.t.	46	0	0	0	0	0	0	0
	Import	1000 m.t.	152	107	91	88	109	94	106	131
	Export	1000 m.t.	3	0	0	0	4	6	2	24
Coniferous sawnwood	Production	1000 m3	331.00	88.76	87.88	13.02	121.60	89.76	33.07	36.39
Non-Coniferous sawnwood	Production	1000 m3	767.00	118.30	87.45	77.49	99.85	153.37	75.53	84.47
Veneer sheets	Production	1000 m3	13.80	34.17	26.76	28.10	95.36	46.28	36.82	63.29
Plywood	Production	1000 m3	14.00	19.14	16.71	5.40	38.46	42.77	26.02	61.39
Particle board (including OSB)	Production	1000 m3	317.00	605.85	257.31	487.22	243.33	226.07	133.13	349.43
Hardboard	Production	1000 m3	0.00	119.62	112.49	151.58	167.40	160.05	176.63	167.46
MDF (medium density fibreboard)	Production	1000 m3	0.00	0.00	0.00	0.00	0.00	4.29	0.48	0.00
Fibreboard, compressed	Production	1000 m3	49.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other board	Production	1000 m3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paper and paperboard	Production	1000 m.t.	443.00	424.00	435.00	640.00	696.00	641.00	675.00	765.00

Note that, in Hungary, the estimated carbon stock changes are relatively small due to the fact that the annual amounts of carbon entering this pool (non-firewood wood products from harvests) and exiting it (products ending their life cycle) are about the same in subsequent years.

See also section 11.5.2.5 for other details.

6.5.4.2.5 Non-CO₂ emissions

Estimated non-CO₂ emissions include those from burning of slash on-site and, for more than a decade, those from wildfires. Non-CO₂ 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 CO₂ emissions from these sources are accounted for in the biomass pool, because we apply the stock-change method. Non-CO₂ emissions include the carbon of CO and CH₄, however, these gases are nevertheless reported because of their high global warming potential, because the double counting of the carbon is negligible, and also in order to comply with the IPCC 2006 GL.

6.5.4.2.6 Non-CO₂ emissions from burning of slash

The estimation of the amount of emissions is done according to section 6.4.3.4. with the following modification:

$$M_b = V_b * D$$

where

V_b = volume burnt, m³ (only includes biomass, reported in Table 6.5.9), and

D = wood density, kg biomass m⁻³ (values used here are the same as those used to estimate carbon stock changes in biomass, see Table 6.5.4 above); and

$$V_b = V_H * C_f$$

where

V_H = total harvest, m³ of wood removed from forest (taken from harvest statistics), and

C_f = combustion factor, dimensionless, for which we use average country-specific values by species (*Rumpf, 2013*). The application of this data became possible based on additional capacity to improve accuracy. Although the new estimates are also based on expert solicitation, they are considered more accurate than the expert judgment applied before, and reflect recent changes in legislature on burning in forests.

Table 6.5.9. *The amount of harvested volume, slash burnt and forest fires based on all available data.*

Reporting year	Harvested volume (m3)	Slash burned on site (t)	Number of wildfires in forest	Area burnt in forest and agricultural fires EFFIS (ha)	Area burnt in forest fires (ha)	Wood volume burnt in forest fires (m3)
1985	8 345 562	100 870	NE	NE	NE	NE
1986	8 500 991	103 199	NE	NE	NE	NE
1987	8 193 145	98 527	NE	NE	NE	NE
1988	7 960 397	96 427	NE	NE	NE	NE
1989	8 031 779	96 233	NE	NE	NE	NE
1990	7 415 162	89 266	NE	NE	NE	NE
1991	7 255 202	84 968	NE	NE	NE	NE
1992	6 588 569	75 921	NE	NE	NE	NE
1993	5 723 745	62 374	NE	NE	NE	NE
1994	5 717 468	62 061	NE	NE	NE	NE
1995	6 049 151	65 696	NE	NE	NE	NE
1996	6 603 733	71 855	NE	NE	NE	NE
1997	6 713 101	69 882	NE	NE	NE	NE
1998	6 578 931	66 683	NE	NE	NE	NE
1999	6 900 612	66 821	229	756	756	3 000
2000	7 287 456	68 753	811	1 595	1 595	80 000
2001	7 010 979	65 225	419	na	1 223	57 000
2002	7 013 167	63 728	382	1 227	1 226	57 000
2003	7 053 960	62 381	375	845	1 054	49 000
2004	7 094 753	61 081	104	247	354	2 000
2005	7 167 426	60 729	150	3 531	3 530	170 000
2006	7 005 190	58 937	97	625	625	3 000
2007	6 609 099	54 446	603	4 636	2 057	160 660
2008	7 024 025	55 132	502	2 404	402	2 730
2009	6 773 537	50 658	608	6 463	845	7 000
2010	7 424 046	57 920	109	878	239	5 324
2011	8 080 206	65 363	2 021	8 055	1 189	149 651
2012	7 731 605	63 038	2 657	14 115	4 303	120 918
2013	7 874 792	64 518	761	1 955	407	36 457
2014	7 517 408	62 146	1 042	4 454	756	79 768

6.5.4.2.7 Non-CO2 emissions from wildfires

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 many percent of the growing stock of each forest sub-compartment were 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 standing volume.

Due to lack of appropriate data, the amount of wood volume 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.

The estimation of the amount of emissions is done according to section 6.4.3.4 with the modification applied for slash burned above. The amount of V_b , i.e., the amount of volume burnt in the areas affected is reported in Table 6.5.9 above (i.e., $C_f = 1$).

6.5.5 Land converted to Forest land (CRF sector 4.A.2)

6.5.5.1.1 Category description

In Hungary, mainly former croplands are afforested. Converting grasslands to forests occurs less frequently (in about 15% of all conversions), whereas converting other areas to forests is marginal, therefore, we predominantly report carbon stock changes from converting croplands and grasslands to forest land.

Not considering soils, land converted to forest land includes areas that do not contain much carbon in either of the carbon pools before they are afforested, but is subject of the effect of intensive photosynthesis after the afforestation. An exception to this is cropland where perennial biomass is present before the afforestation. Concerning soils, cropland usually has less carbon than forest land, but grassland can have more. Thus, converting land to forest land generally increases the amount of carbon in each pool, although at different rates, due to tree growth after the afforestation.

Figure 6.5.7 reports estimated emissions and removals for the biomass pools, whereas Table 6.5.10 summarizes methodological information. See also Section 11 for other details.

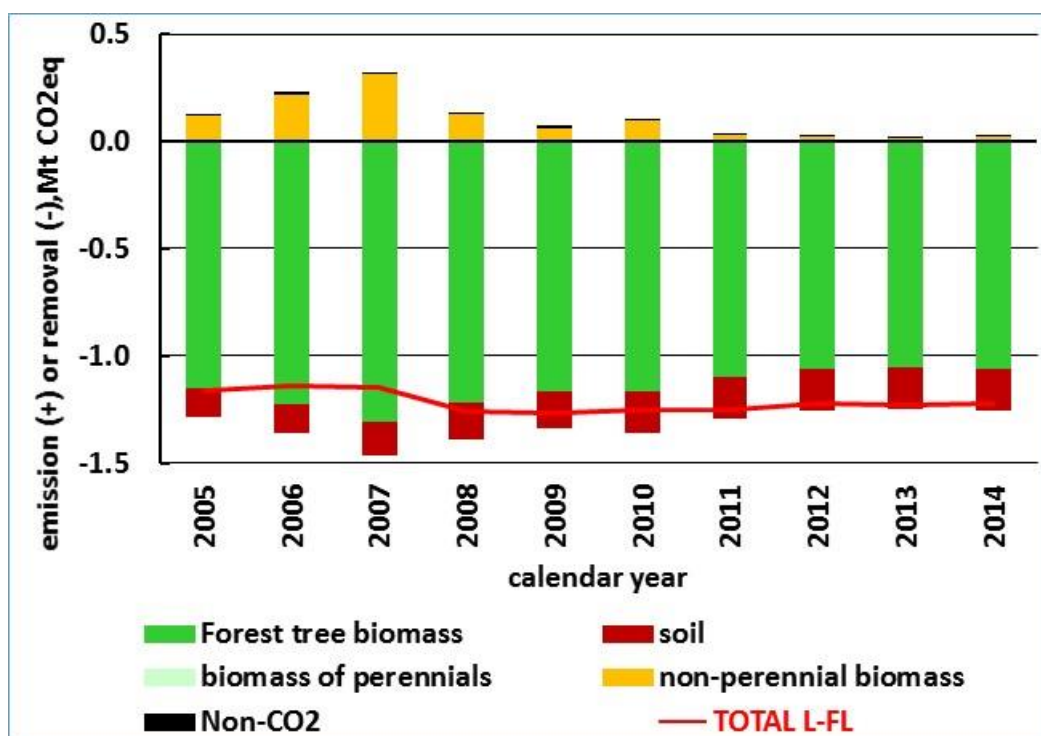


Figure 6.5.7. The sources of emissions and removals in the biomass pools in the L-FL category.

Table 6.5.10. Methodological summary for Land converted to Forest Land. (CS=country specific; D: default; EJ: expert judgment; IE: included elsewhere; AD: activity data; EF: emission/removal factor)

Category	Type of information	Carbon stock changes					Table(5) I, II, V
		AGB	BGB	DW	LI	SOIL	
L-FL	E/R	Post-conversion: CS Pre-conversion: CS	D/EJ D	Not estimated (demonstrated that not a source)	Not estimated (demonstrated that not a source)	Mineral: AD: CS; EF: CS; Organic: not occurring	Fertilization: IE Drainage and re-wetting: NO Controlled burning: NO Wildfires: CS/D
	Uncertainty	Results of the Tier 2 (Monte Carlo) analysis under AR are applicable			N/A		

Category	Type of information	Carbon stock changes					Table(5) I, II, V
		AGB	BGB	DW	LI	SOIL	
L-FL	E/R	Post-conversion: CS Pre-conversion: CS	D/EJ D	NE (demonstrated that not a source)	NE (demonstrated that not a source)	Mineral: AD: CS; EF: CS; Organic: not occurring	Fertilization: IE Drainage and re-wetting: NO Biomass burning: NO
	Uncertainty	Tier 2 (Monte Carlo)		N/A			

6.5.5.2 CO₂ emissions and removals

6.5.5.2.1 Biomass

CO₂ emissions and removals from the biomass pool are estimated from carbon stock changes due to gains in the trees appearing and losses of biomass carbon before the conversion. Whereas a country-specific method is applied for the estimation of gains, Equation 16 of the IPCC 2006 GL are used to estimate losses (see section 6.4.4). For both procedures, the estimation of the conversion area is necessary.

Area of conversion

The area is taken from the “initial planting of afforestations” statistics of the NFCSO Forestry Directorate 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, and Conifers. For the period 2008-2014 the data is taken from the AR database. Data for 1990-2007 was taken from a historical dataset of the Forest Authority that is primarily used to have a subsidy-supporting roll. The area of L-FL cannot be identified on sub-compartment-level in this period. Therefore, for the entire period, modeling was used to develop the growing stock, increment and removal data based on total annual conversion area and age-mean volume function (see below).

Table 6.5.11 below demonstrates the evolution of total area of the category over time. The table shows the area *entering* the category as new afforestation in the second column (under year 1). This area is then rolled over to 19 additional inventory years (in the subsequent columns), after which the area is moved to the FL-FL category.

Table 6.5.11. The total area of successfully converted land for all species by year of conversion (blue cells), and total of all converted land in the category. Incoming areas are reported in the first year of conversion, and areas reported in the column “20 years after conversion” are transferred to the FL-FL category the next year.

Inventory year	Area of successfully converted land (i.e. area actually covered by trees, ha)																				Total in inventory year (ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1985	7274	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7 274
1986	7293	7274	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14 566
1987	7679	7293	7274	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22 245
1988	8254	7679	7293	7274	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30 499
1989	7088	8254	7679	7293	7274	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37 587
1990	6318	7088	8254	7679	7293	7274	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43 906
1991	6162	6318	7088	8254	7679	7293	7274	0	0	0	0	0	0	0	0	0	0	0	0	0	50 068
1992	6556	6162	6318	7088	8254	7679	7293	7274	0	0	0	0	0	0	0	0	0	0	0	0	56 624
1993	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	0	0	0	0	0	0	0	0	0	0	59 586
1994	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	0	0	0	0	0	0	0	0	0	62 226
1995	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	0	0	0	0	0	0	0	0	66 065
1996	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	0	0	0	0	0	0	0	72 136
1997	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	0	0	0	0	0	0	79 777
1998	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	0	0	0	0	0	87 312
1999	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	0	0	0	0	95 309
2000	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	0	0	0	104 301
2001	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	0	0	116 367
2002	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	0	129 989
2003	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	0	141 024
2004	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	7274	147 980
2005	7033	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	7293	147 739
2006	12849	7033	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	7679	153 295
2007	17403	12849	7033	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	8254	163 019
2008	7220	17403	12849	7033	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	7088	161 985
2009	3518	7220	17403	12849	7033	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	6318	158 415
2010	6261	3518	7220	17403	12849	7033	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	6162	158 358
2011	1647	6261	3518	7220	17403	12849	7033	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	6556	153 843
2012	1164	1647	6261	3518	7220	17403	12849	7033	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	2962	148 450
2013	697	1164	1647	6261	3518	7220	17403	12849	7033	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	2640	146 186
2014	1422	697	1164	1647	6261	3518	7220	17403	12849	7033	6956	11035	13622	12066	8992	7996	7535	7641	6071	3839	144 968

A conversion of land to forest, i.e., an afforestation activity, is deemed to have begun when soil preparation has been started. Typically, the first (“initial”) planting of the propagation material on the area happens in a short time after soil preparation is done. Beating up may be carried out depending on the success rate of the initial planting.

Post-conversion biomass

Carbon stock changes in the biomass pool of the newly established trees are estimated using an empirical model of growing stock over age on a unit area of afforestation. In order to estimate the volume data, we have developed species-specific simplified models for the young forests using a sample of young stands of varying age (known based on the year of the afforestation) for which volume was known. This volume was available either from direct assessment or from yield tables (in this last case, height was measured). The models were derived by a set of regression analyses between *age* and *volume* separately for the above 7 target stand-types (Figure 6.5.8 below is an example of a regression obtained for *Quercus* sp.). (It was necessary to use age as predictor, instead of mean height, because, for young individual stands in the category, whereas age is available for each stand, no accurate height estimates are usually available that would enable the use of standard yield tables.) We used 3rd degree polynomial regressions 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. (Note that these curves represent rather constant growing conditions, and it is only worth checking the validity of these curves about once a decade.)

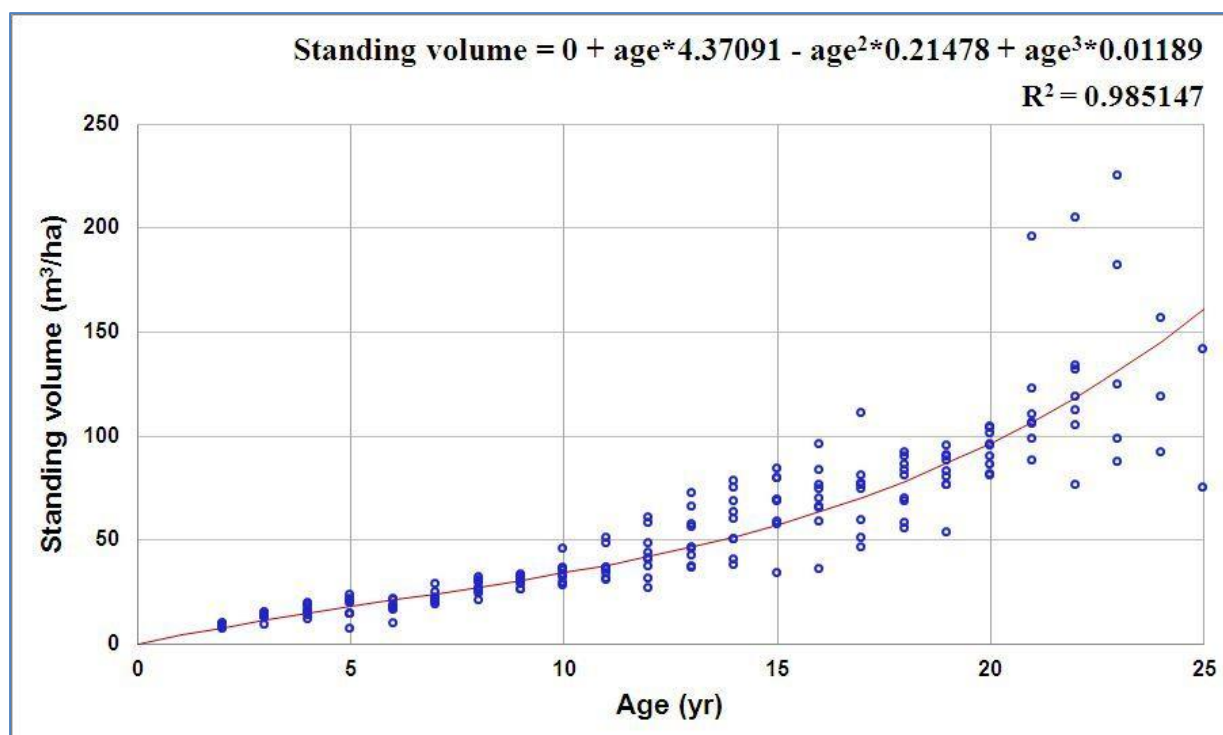


Figure 6.5.8. An example of a regression between age and stand volume. For this fitting, data of *Quercus* sp. ('T') afforestation was used. Note that, although the regression curve was developed using stands somewhat older than 20 years in order to increase the robustness of the regression curve, volume data are only used between ages 1 and 20 years.

Volume stock *change* from a specific year of age to the next one is equal to the *difference* between the volume stocks of the respective consecutive ages as estimated from the regression curves. These differences for the various age classes and species are multiplied by the area of the same classes. The resulting changes reflect the effects of artificial and self-thinnings, and are 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 (either for L-FL or FL-FL) when stands are moved from the L-FL category to the FL-FL category.

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.

Pre-conversion biomass

Emissions arising from removing biomass carbon during the conversion to forest are estimated using data from a recent study that estimated the amount of carbon lost by removing all above-ground biomass due to conversion *for a unit area*. This loss was measured to be 4.7 tC/ha in case of orchards and 9.39 tC/ha in case of vineyards (of average age of 15 and 15.9 years, respectively, which are half of the length of the rotation period of these perennials, Juhos and Tőkei, 2013), and 4.7 and 2.94 tC ha⁻¹ of default CL and GL biomass, respectively (see the respective sections on Cropland and Grassland for more details). The amount of *total loss* of carbon is estimated by multiplying the above values with the size of the area actually converted. (In practice, carbon stock changes from biomass of perennials on CL-FL are estimated by first estimating all carbon stock changes from cropland with perennials to all other categories, the methodology of which is reported in section 6.6.2.1.1, and then multiplying it with the proportion of the area of perennial CL-FL to the total area of perennial CL converted to all

other land use category. For forest land, this proportion varies between 12 and 19%, and is 16% in 2014.)

Note that, according to the default method (Equation 2.12), 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.

6.5.5.2.2 Dead organic matter

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 can only increase after the conversion. That neither the litter nor the deadwood pool contains carbon stocks on cropland and grassland before the conversion is a general experience, which is corroborated by the fact that, for crop sanitary and other reasons, biomass (dead or alive) is removed during harvests, and there is usually not enough time on abandoned croplands for the woody biomass to develop substantial dead organic matter before the land is converted. Removals due to such natural vegetation processes before afforestation are not accounted, either. Also, Somogyi et al. (2013) measured zero carbon stocks on pre-conversion land in their study. We think that our current sampling (and data) is not intensive enough to make it possible to develop estimates from emissions/removals from deadwood and litter on a statistical basis. Nevertheless, the conversions of non-forest land to forest land result, in all probability, in net removals in the DOM & litter pools, however, reporting zero emissions in these pools is considered by an acceptable approach for L-FL until we develop a more advanced estimation.

6.5.5.2.3 Soil

The estimation of carbon stock changes in soils is done according to section 6.4.1.

The results of the estimation are corroborated by recent estimates according to which converting land from cropland to forest does not entail any net emissions from soil (see Somogyi, 2005, Somogyi-Horváth, 2006a, Somogyi-Horváth, 2006b, and Somogyi et al., 2013), and that converting grassland to forest may lead to some emissions (see Horvath, 2006). 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 (see above), overall, no major emissions from soils are expected due to conversion of land to forest land (Figure 6.5.9).

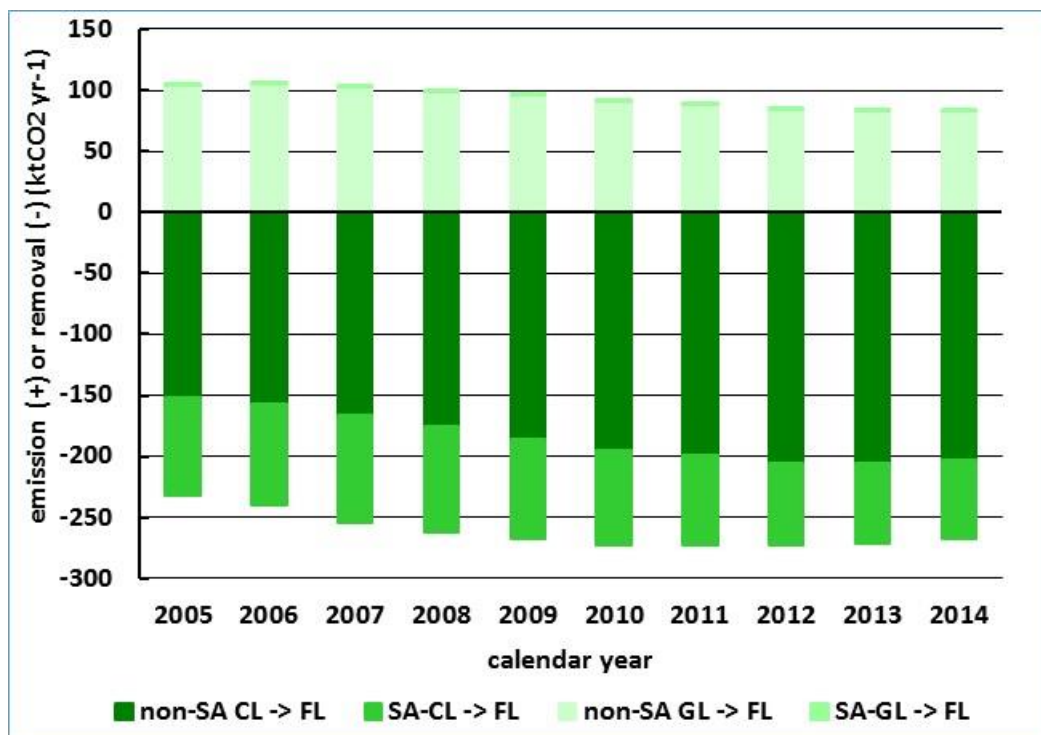


Figure 6.5.9. Emissions and removals from converting land to forest land (non-SA: non set-aside; SA: set-aside).

Concerning organic soils, there are no afforestations on such soils, therefore, no emissions occur from this source.

6.5.5.3 Non-CO₂ emissions

6.5.5.3.1 Emissions from wildfires

In Hungary, very few forest fires occur in the Land converted to Forest Land category. Following the former recommendation of the inventory review, non-CO₂-emissions are separately reported for L-FL and FL-FL (see above).

6.5.5.3.2 Emissions from mineral soils as a result of loss of soil carbon through change in land use or management

The estimation of N₂O emissions from soils associated with loss of carbon is done according to section 6.4.2, using the appropriate carbon loss data for the sub-category. Note that, consistent with what is reported for soils above, emissions only occur when grasslands are converted to forests.

6.5.6 Forest Land converted to other land uses (CRF sector 4.B.2.1, 4.C.2.1, 4.E.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 the specific permission. All areas of conversions are surveyed, and emissions are estimated using the land conversion database of the Forest Authorities (see at 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.

6.5.6.1 CO₂ emissions and removals

Table 6.5.12 reports CO₂ emissions and removals estimated for the biomass, deadwood, litter and soil pools, whereas Table 6.5.13 reports methodological information for this sub-category.

Table 6.5.12 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 are as for Tables 6.5.3 and 6.5.6. (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, GgCO ₂				
	biomass	minreal soils	organic soils	litter	dead-wood
2008	27	31	IE	9	3
2009	58	33	IE	14	4
2010	28	35	IE	7	2
2011	46	34	IE	9	2
2012	132	34	IE	25	7
2013	62	35	IE	17	5
2014	85	35	IE	19	6

Table 6.5.13. Methodological summary. (CS=country specific; D: default; EJ: expert judgment; IE: included elsewhere; AD: activity data; EF: emission/removal factor)

Category	Type of information	Carbon stock changes					Table(5) I, II, V
		AGB	BG B	DW	LI	SOIL	
FL-L	E/R	Post-conversion: 0 Pre-conversion: CS	0 CS	CS	CS	D	Drainage: NO Biomass burning: NO
	Uncertainty						

6.5.6.1.1 Biomass

For biomass, the methodology described in section 6.4.4 is applied. For all conversions of FL to CL, GL, WL, SE and OL, it is assumed that the biomass carbon stock after the conversion is equal to zero, so all carbon in the biomass of the deforested land, estimated as described in section 6.5.3, is completely emitted as CO₂.

6.5.6.1.2 Dead organic matter

Emissions from deadwood and litter are estimated by multiplying the area of annual deforestations by area-specific values. In these calculations, just like with biomass, we assume that, in the year of the deforestation, all deadwood and litter are completely removed from the area, i.e. carbon in these pools are emitted in the year of the deforestation.

The area-specific value of the amount of deadwood and litter comes from the Hungarian forest health monitoring system, called Forest Protection Monitoring and Observation System (in Hungarian: EMMRE). The system includes plots in a 4×4km systematic grid, and sampling in this program is done using concentric permanent sample plots. The 16×16km sub-grid of this program is part of the European level forest health monitoring Network (IPC Forest, Forest Focus, Life+ programs & FutMon Project). Since the average amounts of deadwood in the sampled years do not show a decreasing trend (see Figure 6.5.5), we believe that the data available are suitable for estimating of the emissions from deadwood for the entire time series.

In estimating total carbon stock changes from the estimated volume, we used the methodology of stock change as detailed above and applied the assumption that the average wood density of the deadwood is the same as for the woody biomass.

Considering litter, we now rely upon a case study, done by Heil, Kovács and Szabó (2012), which provided an estimate of the mean litter content (excluding coarse litter between about 1 cm and 10 cm) of the Hungarian forests. In this study it was found that the average amount of carbon in litter is 8.78 t/ha, which means that, in general, the mass of carbon stored in the litter pool amounts to some 1.5% of the whole carbon stock of Hungarian forests. (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.)

We note 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 (and often conservatively) assumed that neither deadwood nor litter are produced any more after the conversion, thus, no removals are accounted for in these pools.

6.5.6.1.3 Soil

The estimation of carbon stock changes in soils was done according to section 6.4.1.

For each piece of land converted, the same amounts of annual 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 be added up to get the aggregated emissions for the entire FL-L category.

The areas identified, and the resulting CO₂ emissions are included in Table 6.5.14.

Table 6.5.14. The area, as well as CO₂ 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 (ha)		CO ₂ emissions (Gg)	Area (ha)		CO ₂ emissions (Gg)	Area (ha)		CO ₂ emissions (Gg)	Area (ha)		CO ₂ emissions (Gg)
	all	subcomp-artments		all	subcomp-artments		all	subcomp-artments		all	subcomp-artments	
1985	94.8	94.8	3.683	210.5	210.5	7.423	20.9	20.9	-0.1	326.1	326.1	11.030
1986	94.8	94.8	3.683	210.5	210.5	7.423	20.9	20.9	-0.2	326.1	326.1	10.954
1987	94.8	94.8	3.683	210.5	210.5	7.423	20.9	20.9	-0.2	326.1	326.1	10.876
1988	94.8	94.8	3.683	210.5	210.5	7.423	20.9	20.9	-0.3	326.1	326.1	10.799
1989	94.8	94.8	3.683	210.5	210.5	7.423	20.9	20.9	-0.4	326.1	326.1	10.723
1990	180.0	180.0	3.848	392.6	392.6	7.745	40.3	40.3	-0.5	612.9	612.9	11.068
1991	453.6	59.9	4.546	1265.6	167.0	9.605	97.8	12.9	-0.9	1817.0	239.8	13.273
1992	511.8	44.4	5.356	827.3	71.8	10.693	107.9	9.4	-1.3	1447.1	125.6	14.795
1993	12.7	12.7	5.197	233.1	233.1	10.733	82.7	82.7	-1.5	328.6	328.6	14.425
1994	28.4	28.4	5.068	162.5	162.5	10.648	27.3	27.3	-1.5	218.2	218.2	14.179
1995	53.2	53.2	4.987	244.1	244.1	10.707	60.5	60.5	-1.7	357.8	357.8	13.993
1996	140.4	78.7	5.075	335.4	188.1	10.928	140.9	79.0	-2.1	616.7	345.9	13.873
1997	192.1	192.1	5.265	239.6	239.6	10.979	90.3	90.3	-2.4	522.0	522.0	13.868
1998	88.9	88.9	5.251	271.4	271.4	11.086	41.7	41.7	-2.5	402.0	402.0	13.857
1999	98.1	26.8	5.255	1016.9	277.9	12.508	331.9	90.7	-3.5	1446.9	395.4	14.272
2000	111.8	67.8	5.285	981.6	594.9	13.868	93.1	56.4	-3.8	1186.6	719.1	15.384
2001	152.8	61.4	5.393	893.0	358.6	15.071	251.2	100.9	-4.5	1297.0	520.9	15.952
2002	317.0	108.9	5.812	1279.7	439.5	16.957	259.6	89.2	-5.3	1856.4	637.5	17.470
2003	54.3	25.7	5.731	1104.7	523.4	18.534	93.1	44.1	-5.6	1252.1	593.3	18.691
2004	109.0	74.2	5.753	1102.7	750.5	20.107	175.0	119.1	-6.1	1386.7	943.8	19.753
2005	148.7	71.2	5.850	654.4	313.2	20.890	55.7	26.7	-6.2	858.8	411.1	20.539
2006	115.8	44.4	5.884	1156.6	443.4	22.558	54.2	20.8	-6.3	1326.7	508.6	22.153
2007	90.7	16.4	5.871	1061.1	192.5	24.058	201.7	36.6	-6.8	1353.5	245.5	23.103
2008	379.6	96.8	6.399	634.7	161.9	24.806	137.5	35.1	-7.2	1151.9	293.8	23.991
2009	183.8	55.5	6.558	970.3	293.0	26.146	335.9	101.5	-8.1	1490.0	450.0	24.570
2010	670.4	59.4	7.460	1154.8	102.3	27.490	526.1	46.6	-9.6	2351.3	208.3	25.339
2011	388.5	66.8	7.302	1074.6	184.9	27.153	140.5	24.2	-9.7	1603.5	275.9	24.710
2012	247.6	113.1	6.767	614.1	280.4	26.777	851.6	388.9	-12.0	1713.2	782.4	21.542
2013	270.2	115.4	7.243	702.4	299.9	27.604	273.5	116.8	-12.6	1246.1	532.1	22.255
2014	382.6	153.4	7.188	877.6	351.8	27.318	241.2	96.7	-13.2	1501.3	601.9	21.263

6.5.6.2 Non-CO₂ emissions

6.5.6.2.1 Emissions from wildfires

The estimation of non-CO₂ emissions from fires 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, the probability that wildfires affect these areas is negligible. 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 6.4.3. Activity data is available for both the area and the volume of forest land converted to other land use.

6.5.6.2.2 Emissions from mineral soils as a result of loss of soil carbon through change in land use or management

The estimation of N₂O emissions from soils associated with loss of carbon is done according to section 6.4.2.

6.5.7 Category-specific uncertainties and time-series consistency

We conducted an uncertainty analysis in 2012 for the last time. The main objective of that uncertainty analysis, complying with that of the IPCC Guidelines, was 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. The uncertainty analysis focused on the uncertainty of carbon stock change estimates of the biomass of forests for the categories under the Kyoto Protocol, therefore, the detailed results can be found in Chapter 11 (Section 11.3.1.5). As the methods of quantitative estimation are similar to respective categories under the UNFCCC, and because KP and UNFCCC categories significantly overlap, we regard the results reported there relevant for the uncertainties of emissions and removals under the UNFCCC, and only some additional information is reported here.

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 in the respective sections above (and/or were approximated by assumptions), however, it is highly probable that their exclusion only results in conservative estimation, i.e. overestimation of net emissions, and underestimation of net removals.

The reported estimated emissions and removals are generally considered 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. Where no country-specific values are available, IPCC default values are used. Whenever more accurate methods could be identified, these were applied (see section 6.1.4 on recalculations above).

It is probable that total forest area is somewhat underestimated, which is shown by the fact that the forest inventory has identified new forest areas (“found forests”) each year for the last two decades or so. As long as forests in Hungary are a sink, this underestimation of the forest area can only lead to the underestimation of removals. Nevertheless, the detection and monitoring of forest area has been continuously improving, and will continue to improve.

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 volume stock changes are underestimated. This assessment is also supported by preliminary statistical results of a sample-based inventory which indicate higher volume stocks and higher annual volume increment 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 up to 250,000 m³ annually. This amount is additional to, but small relative to, the annual official figure of annual harvests of around 7-8 million m³. Although this means that actual wood harvests are somewhat underestimated, so is volume stock increment but to a larger extent, thus, the, net volume stock changes, and thus net removals, are most probably underestimated.

We have continuously been improving not only our stand statistics, but also our country-specific emission factors. As reported in the previous NIRs, the accuracy was improved earlier, among others, by introducing new, more realistic, country-specific basic wood density values, slash fraction, soil C/N values and the biomass of orchards and vineyards that have been removed during conversions of cropland to forest land and grassland.

Accuracy cannot always be quantified partly because the error distributions are unknown due to lack of measured data, and partly because calculation errors or 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 as described in the next section.

For carbon stock changes in biomass, the system of calculations allows for the use of a simple sensitivity analysis. This is especially true if only the major sources of CO₂ emissions and removals are considered, which represent the bulk of all emissions and removals. The reason for this is that the equation used for the calculation is simple: only volume stock changes, wood density, root-to-shoot ratio, and carbon fraction factors are involved.

With respect to net *annual* CO₂ emissions (or removals), actual values may deviate from estimated values as the stock volume inventory for the whole country is not able to capture all inter-annual variability of timber growth and harvests, which can be high due to the variability of meteorological conditions. Note that the inter-annual variability of the estimated net removals in the Forest Land sector is due to a number of reasons, including the continuously, although slowly, changing structure of the forests by species, site fertility and age, and the variability of annual harvests and mortality. All these effects have rather different delayed effects, and these effects may be rather small relative to the total volume stocks, but can result in larger variability when combined.

It can be concluded that, with regard to carbon stock change estimation, errors are rather limited in our estimation, and it is expected that current estimates rather well reflect emissions and removals associated with forest land.

With regard to non-CO₂ emissions, the estimation is accurate and precise as far as practicable for the years for which we have data on wildfires and controlled burning, as well as for forests on organic soils. Data collection considerably improved in the last few years.

Finally, both methods and data are applied consistently throughout the entire reporting period. This results in a consistent time series of both the area and the GHG information. Please refer to Section 11.3.1.5 for further details.

6.5.8 Category-specific QA/QC and verification

The calculations to obtain emission and removal estimates 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. Forests have been continuously monitored since that year, and the responsible authorities have been applying computer-based information technology for data management 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 to ensure the quality of work resulted in the increasing accuracy of the Database in recent years.

Since 2011, the GHG inventory has been completed by the Forestry Directorate of the National Food Chain Safety Office (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 of the calculations involved in the GHG inventory and the correct application of IPCC assumptions and methodologies have been performed at the national level by the Hungarian Forest Research Institute of the National Agricultural Innovation and Research Center for years. The separation of the two roles (i.e., the preparation and the QA of the GHG inventory) has 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 in Section 6.5.4.2.1, and also previous NIRs of Hungary). All information used for the development of the GHG information is archived by the inventory agency. Thus, the correctness of the estimation methodology is in principle *verifiable*.

6.5.9 Category-specific recalculations

Following the many recalculations last year (see our previous submission), no recalculations were made this year due to category-specific reasons.

6.5.10 Category-specific planned improvements

We will continue to develop our data collection on forests and on the Forest Monitoring and Observation Network to develop more advanced estimates for carbon stock changes.

6.6 Cropland (CRF sector 4.B)

6.6.1 Description of category

Although the area of croplands decreased in the last four decades (roughly 800,000 hectares were abandoned or converted to another category of land use), croplands with their 56% proportion of the total area of the country still represent the main land use category in Hungary (see Figure 6.3.1 above). All the plough-lands with annual crops, orchards and vineyards (i.e., perennial woody crops) and kitchen gardens are all classified as cropland. Set-aside croplands are also reported in this category (Figure 6.6.1.) The distribution of the removals by sub-categories is reported in Figure 6.6.2.

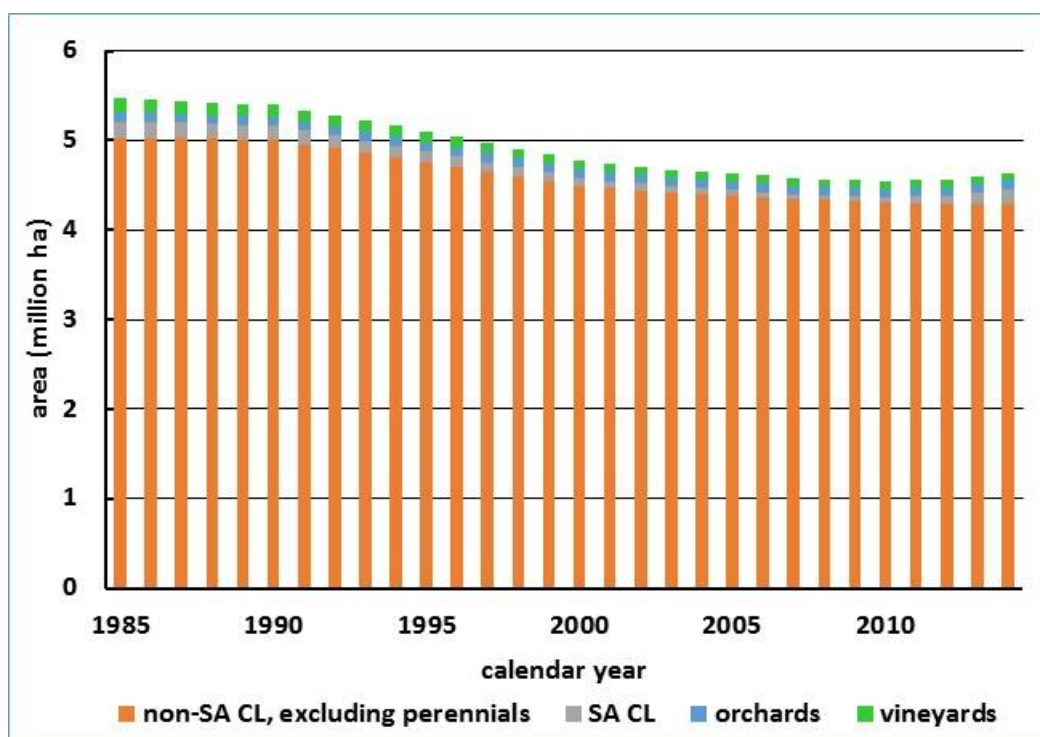


Figure 6.6.1. The distribution of Cropland area 1985-2014.

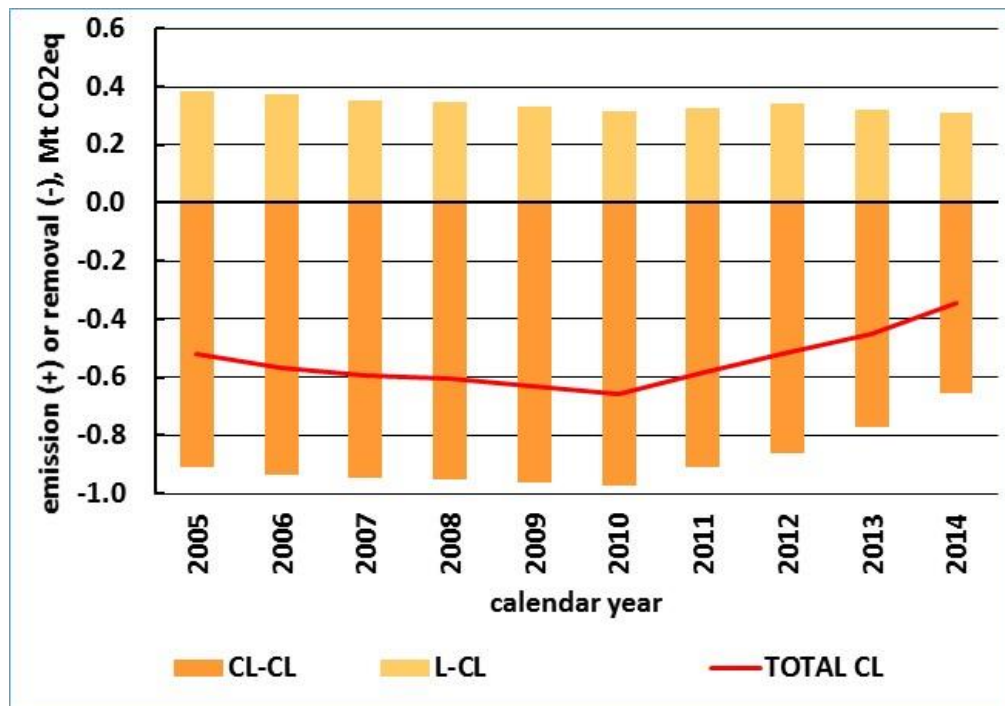


Figure 6.6.2. The distribution of removals in Cropland 2005-2014.

6.6.2 Cropland remaining Cropland

Figure 6.6.3 reports emissions and removals, whereas Table 6.6.1 reports methodological information for this sub-category. Figure 6.6.4 is reported to demonstrate that most removals in the Cropland category (including the Cropland remaining Cropland category) arise due to changes in land use either between sub-categories, or (in case of the Cropland remaining Cropland category) within a sub-category, due to changes from non set-aside to set-aside land and back.

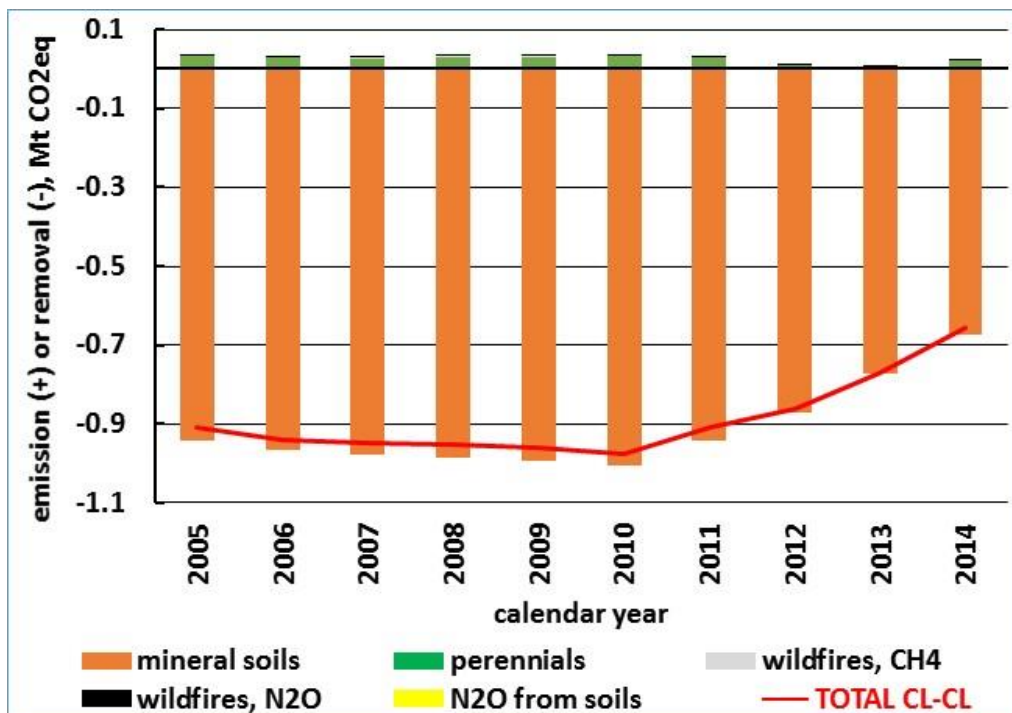


Figure 6.6.3. The distribution of emissions and removals in CL-CL 2005-2014.

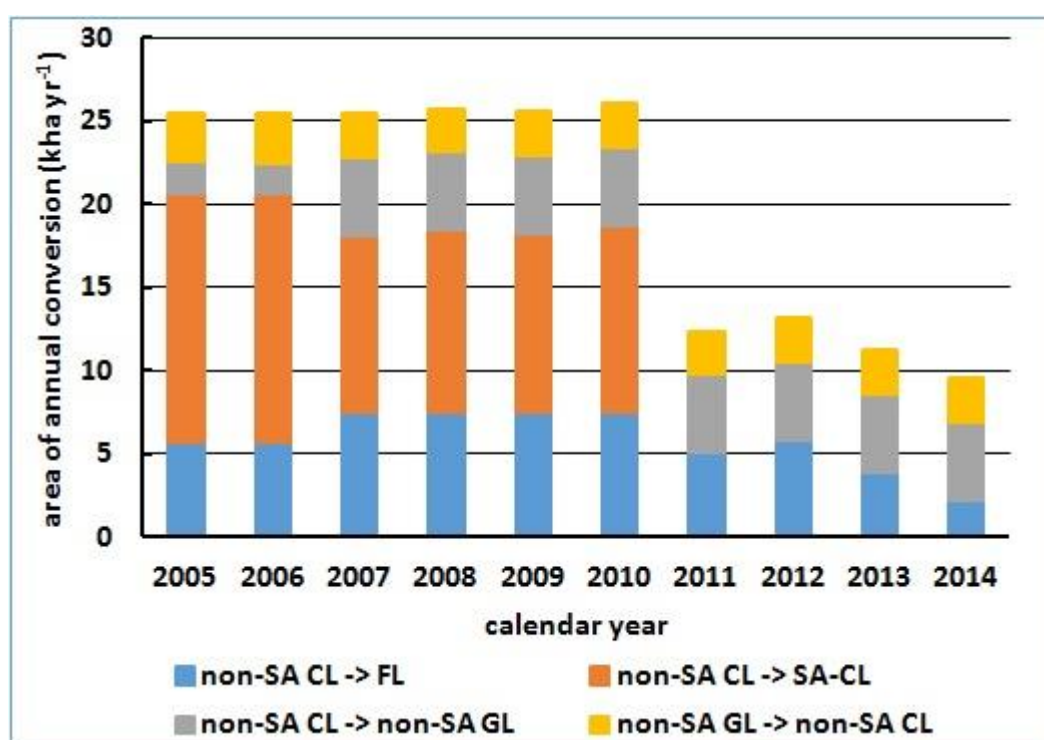


Figure 6.6.4. The trend of annual area of the most important land use change categories, all of which involve croplands, with significant soil carbon stock changes.

Table 6.6.1. Methodological summary for CL-CL (CS=country specific; D: default; AD: activity data; EF: emission/removal factor).

Carbon stock changes						Table (4)III	Table (4)V
BIOMASS		DOM		SOIL			
annual	perennial	DW	LI	mineral	organic		
Tier 1: 0	AD: CS; EF: CS and D	Tier 1: 0		AD: CS; EF: CS/D	NO	Direct N2O emissions from N mineralization: D	Wildfires: AD: CS; EF: D Biomass burning: NO

6.6.2.1 Biomass

Consistent with the IPCC 2006 GL, carbon stock changes in biomass are only estimated for perennial woody crops (the biomass of annual crops is assumed to be in equilibrium). In Hungary, perennial biomass is found in orchards and vineyards. This chapter thus reports on emissions and removals from biomass in areas that remained orchards or vineyards in the inventory year.

Carbon stock change of biomass (ΔC_{Biom}) was estimated applying Equation 2.15 of the IPCC 2006 GL:

$$\Delta C_{\text{Biom}} = \Delta C_{\text{G}} + \Delta C_{\text{Conversion}} - \Delta C_{\text{loss}}$$

where

ΔC_{Biom} = annual change in carbon stocks of biomass, tonnes C yr⁻¹

ΔC_G = annual increase in carbon stocks due to biomass growth, tonnes C yr⁻¹

ΔC_L = annual decrease in carbon stocks due to biomass loss, tonnes C yr⁻¹

$\Delta C_{\text{Conversion}}$ = annual carbon loss due to converting perennials to other land use, tonnes C yr⁻¹.

The estimation is done separately for orchards and vineyards separately for growth and losses, and for losses due to conversions where perennials are converted to annual croplands or other land use.

6.6.2.1.1 Growth and loss

Carbon stock changes due to growth and loss were estimated using Equation 2.7 of the IPCC 2006 GL:

$$\Delta C_{\text{Biom}} = \Delta C_G - \Delta C_L$$

Orchards and vineyards are assumed to be grown in rotations of 30 and 31.8 years, respectively. For the entire period, ΔC_G was estimated using Equation 2.9 of the IPCC 2006 GL:

$$\Delta C_G = A_{\text{perennials}} * G_{\text{TOTAL}} * CF$$

where

$A_{\text{perennials}}$ = area of orchards and vineyards, respectively (taken from the statistics of the HCSO) in the inventory year, ha (all areas included that were perennials at the beginning of the inventory year),

G_{TOTAL} = county-specific net biomass accumulation rate (0.313 and 0.626 t biomass ha⁻¹ yr⁻¹ for orchards and vineyards, respectively), and

CF = carbon fraction (the default value of 0.5 tC t biomass⁻¹ is used).

G_{TOTAL} was estimated in the detailed study of Juhos and Tőkei (2012). As it was not possible to measure below-ground biomass, G_{TOTAL} only includes above-ground biomass (which is the application of the default assumption, according to which there is no change in below-ground biomass of perennial trees in agricultural systems).

The annual decrease in carbon stocks from biomass loss due to regenerating perennials was estimated using Equation 2.16 of the IPCC 2006 GL:

$$\Delta C_L = A_{\text{regenerated_perennials}} * B_{\text{Before}} * CF$$

where

$A_{\text{regenerated_perennials}}$ = the area of regenerated orchard or vineyard in the inventory year =
= ($A_{\text{perennials}} - A_{\text{conv}}$) / RPL, ha

A_{conv} = area of orchards and vineyards that are converted to other land use categories in the inventory year (see below), ha

RPL = length of rotation period, 30 years (orchards) and 31.8 years (vineyards), and

B_{Before} = biomass of the regenerated orchard or vineyard at the end of the rotation period, t biomass, and is equal to G_{TOTAL} (tC ha⁻¹ yr⁻¹) * RPL (years). (Since all biomass is considered lost during the regeneration, the “fraction of biomass lost in disturbance” term, or f_d , in the original equation is taken

to be equal to 1.)

Note that the above methodology implies that removals due to slight increases of the area of perennials (this has only happened in a few years and on small areas) are all accounted for in the Cropland remaining Cropland category (i.e., the assumption is applied that all increases of the area of perennials are due to conversions from annual cropland).

6.6.2.1.2 Conversions

Total emissions from biomass from converting orchards and vineyards are estimated applying the methodology described in section 6.4.4 (i.e., Equation 2.16 of the IPCC 2006 GL) with

$B_{\text{After}} = 0$, and

B_{Before} and CF as above.

A_{conv} was estimated using an estimated proportion of converted perennials, P_P , that remained in the Cropland category:

$$A_{\text{conv}} = A_{\text{perennials}} * P_P.$$

P_P for Cropland was estimated from the land statistics database (see section 6.3.2 for details).

Note that the above methodology to estimate conversion areas is somewhat different from what was applied earlier due to the fact that areas removed are now calculated from actual reduction, if any, of the total areas and thus the estimation of emissions from these areas are now fully consistent with that of removals due to growth.

6.6.2.2 Dead organic matter

The Tier 1 method is applied. This method assumes that the dead wood and litter stocks are not present in Cropland or are at equilibrium as in agroforestry systems and orchards. Thus, the carbon stock changes are not reported for these pools.

6.6.2.3 Mineral soils

The method and emission factors used are those described in section 6.4.1. For CL-CL, what may cause changes of the mineral soil carbon stocks are the following: changes in management, changes in input, and converting non-set aside to set-aside and back. Using county-specific SOC_{REF} and default F_{LU} , F_{MG} and F_{I} values, the effect of all these changes and conversions is included in the calculations.

6.6.2.4 Non-CO₂ emissions

The amount of non-CO₂ emissions is estimated according to section 6.4.2 (for N₂O emissions from soils) and 6.4.3 (for emissions from wildfires).

For the mass of available fuel (M_B) in the wildfire calculation, no proper country-specific values have been derived yet, therefore, a default value of 10 t d.m. ha⁻¹ was assumed. This is a value from Table 2.4 of the IPCC 2006 GL for maize which is quite a representative crop in Hungary, and which can be considered as a conservative value as wheat and other crops of less biomass are also abundant.

6.6.3 Land converted to Cropland

Figure 6.6.5 reports emissions and removals, whereas Table 6.6.2 reports methodological information for this sub-category. Note that non-CO₂ emissions from wildfires, if any, are reported as IE in the Cropland remaining Cropland category. Emissions from burning is NO.

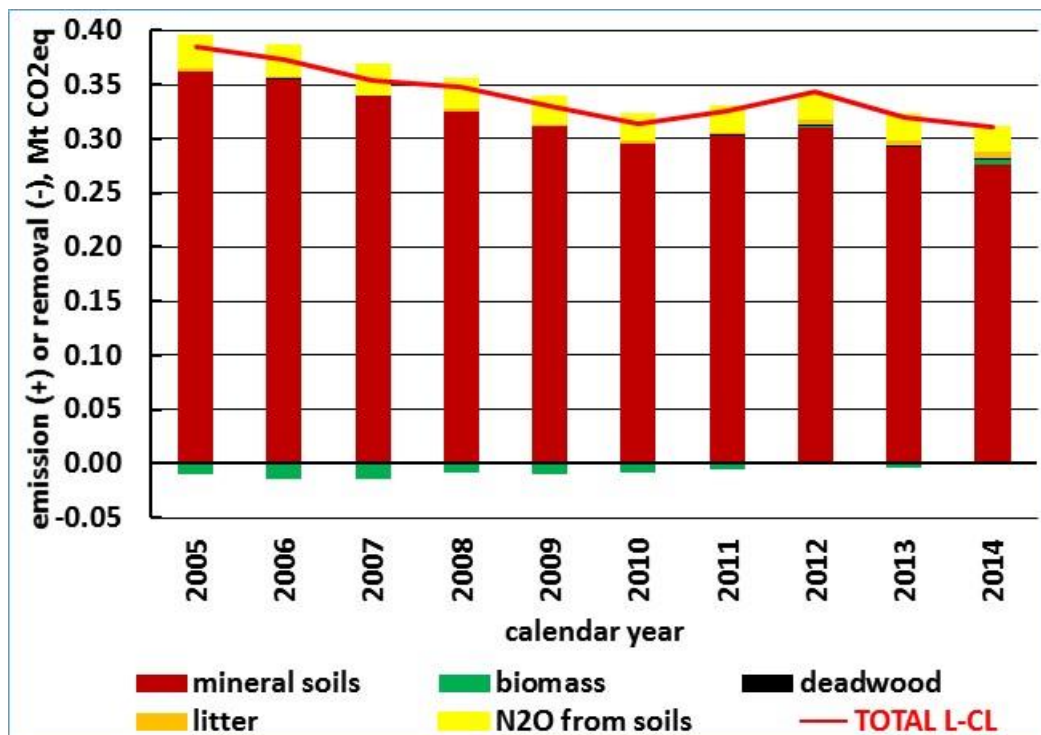


Figure 6.6.5. The distribution of emissions and removals in L-CL 2005-2014.

Table 6.6.2. Methodological summary for L-CL. (CS=country specific; D: default; IE: included elsewhere; AD: activity data; EF: emission/removal factor)

"FROM" category	BIOMASS	DOM		SOIL		Table (4)III	Table (4)V
		DW	LI	mineral	organic		
FL	AD: CS; EF: CS	AD: CS; EF: CS		AD: CS; EF: CS/D	NO	Direct N2O emissions from N mineralization (where applicable): D	slash burning: IE (FL-FL)
GL	AD: CS; EF: D	Tier 1: 0		AD: CS; EF: CS/D	NO		IE (CL-CL)
WL	NO	NO		NO	NO		IE (CL-CL)
SE	Tier 1: 0	Tier 1: 0		AD: CS; EF: CS/D	NO		IE (CL-CL)
OL	NO	NO		NO	NO		IE (CL-CL)

6.6.3.1 Forest Land converted to Cropland

For the methodology to estimate carbon stock changes in the biomass, DOM and soil pools, see Sections 6.5.6.1.1, 6.5.6.1.2 and 6.5.6.1.3, respectively. Note that the total emissions from these pools were split between FL-CL and other conversions by the area of these conversions. The share of FL-CL to all FL-L varies between about 4 and 37% and was 25.5% in 2014.

6.6.3.2 Grassland converted to Cropland

6.6.3.2.1 Biomass

Equations 2.15 of the IPCC 2006 GL were applied as follows:

$$\Delta C_B = \Delta C_G + \Delta C_{\text{CONVERSION}} - \Delta C_L$$

where:

ΔC_B = biomass carbon stock change due to land use conversion, tC year⁻¹

ΔC_G = annual increase in carbon stocks in biomass due to growth on the 'converted to' land, tonnes C yr⁻¹

ΔC_L = annual decrease in biomass carbon stocks due to losses, tonnes C yr⁻¹

$\Delta C_{\text{CONVERSION}}$ = initial change in carbon stocks in biomass on the 'converted to' land, tonnes C yr⁻¹, estimated using Equation 2.16 of the IPCC 2006 GL as described in section 6.4.4.

For A_{Conv} , data from the annual land use change matrix was used. B_{before} was estimated from the proportion of Grassland area of cold dry and warm dry climate types ($P_{\text{CD}} = 0.41$, $P_{\text{WD}} = 0.59$) and respective specific default Grassland biomass (in order that all biomass is accounted for, the following total above- and below-ground biomass values were taken from Table 6.4 of the IPCC 2006 GL: $B_{\text{CD}} = 6.5$ t biomass ha⁻¹ and $B_{\text{WD}} = 6.1$ t biomass ha⁻¹, respectively). The resulting biomass is: $B_{\text{before}} = P_{\text{CD}} * B_{\text{CD}} + P_{\text{WD}} * B_{\text{WD}} = 6.26$ t biomass ha⁻¹. In accordance with the Tier 1 assumption, B_{after} in the equation is 0, and the carbon fraction is the default value of 0.47 tC t biomass⁻¹ (page 6.29 of the IPCC 2006 GL). For ΔC_G , the value of 4.7 tC ha⁻¹ was used, whereas ΔC_L was assumed to be equal to 0.

6.6.3.2.2 Mineral soils

The method and emission factors used are those described in section 6.4.1.

6.6.3.3 Wetlands converted to Cropland

This land-use change is not occurring in Hungary.

6.6.3.4 Settlements converted to Cropland

For the rather small conversion areas in this category, only carbon stock changes in mineral soils are estimated. The method and emission factors used are those described in section 6.4.1.

6.6.3.5 Other Land converted to Cropland

This land-use change is not occurring in Hungary.

6.6.4 Uncertainties and time-series consistency

An uncertainty analysis of the emission and removal estimates for the Cropland category was reported in the previous NIR. This analysis was made using a Tier 1 approach. As there were recalculations for the entire LULUCF sector, the uncertainty analysis should be updated, however, we focused our capacities on the improvement of the land transition matrix, some other activity data, some emission

factors and some methodological issues, and the updating of the uncertainty analysis was not possible.

Part of our efforts to improve the emission and removal estimates was dedicated to further improve the time series consistency. However, whereas this inventory is more consistent than before, further improvements are possible.

6.6.5 Category-specific QA/QC and verification

This year, emissions/removals were estimated by the National Food Chain Safety Office, whereas the QA/QC was done by an external expert. This division of tasks made it possible to separate the work related to emission estimation and the QA/QC procedures.

The LULUCF QC measures are based on the QC procedures as described by Chapter 5 of the IPCC 2006 Guidelines.

The main checks that were carried out are as follows:

Activity data:

- Methodological issues of the collection of the land-use / land-cover data.
- The differences between the different land-use datasets.
- Consistency of the activity data. In the case of inconsistency (methodological change in the data collection) the dataset are adjusted in consultation with the data provider.
- Data inputs for transcription errors.
- The units of activity data in the calculation sheets throughout the emission calculation.
- The consistency of the total area of Hungary in the land-use change matrices and the CRF tables.
- The comparison of activity data with data from other sources, if possible.

Methodology:

- The applied methodologies and emission factors against the IPCC 2006 GL.
- The correctness of the equations and factors in the calculation sheets.
- The consistency of the applied methodology throughout the entire time series.

Emissions and removals:

- Reported emissions for transcription errors between the calculation sheets and the CRF tables.
- Recalculation differences and reasons for recalculations.

6.6.6 Category-specific recalculations

Last year, a number of recalculations were made (relative to the estimates for the previous years), see Section 6.1.4 of our NIR of 2015. This year, we made one sector-specific recalculation, i.e., we corrected the formulas for the L-CL subcategory for years 1985-, and used the corrected formula afterwards, to estimate N₂O emissions from soils due to N-mineralization in mineral soils as a result of loss of soil carbon through change in land use or management. The recalculation substantially increased these emissions relative to the ones submitted earlier, but these emissions remain relatively small and only marginally affect total emissions.

6.6.7 Category-specific planned improvements

As mentioned in our previous submission, planned improvements include Tier 1 (and possibly Tier 2) uncertainty estimation.

6.7 Grassland (CRF sector 4.C)

6.7.1 Description of category

In 1985, the livestock of grazing animals included 2 million cattle, 1 million geese and 3 million sheep. The decade beginning 1980 both saw the highest number of grazing livestock in the country and was the period of the most intensive management of the Hungarian grasslands with respect to fertilizer doses and irrigation. The number of grazing animals and the intensity of grassland management started to decrease after about the mid-1980's and reached its bottom in the middle of the 1990's. All this also affected the area of grassland which considerably decreased after 1985, but started to increase again beginning 2011, and amounted to about 8.4 percent of the official area of Hungary in 2014 (Figure 6.7.1). Of the emissions and removals due to changes to and from grasslands, those that are accounted for in the Grassland category are reported in Figure 6.7.2.

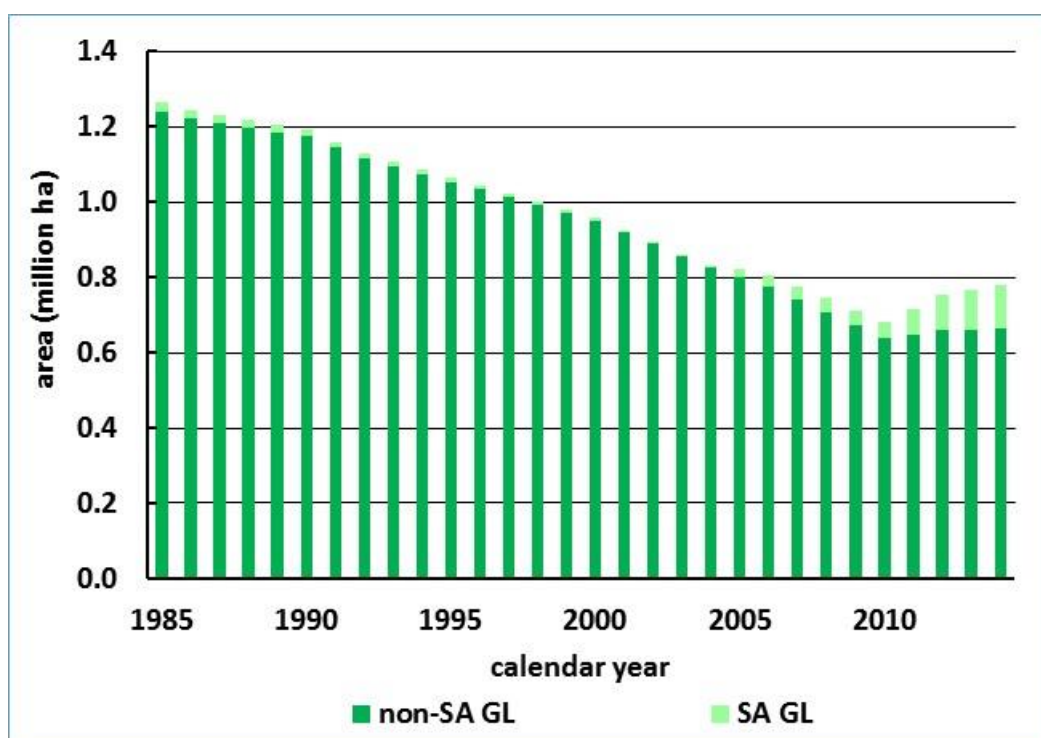


Figure 6.7.1. The area and distribution of the Grassland category 1985-2014.

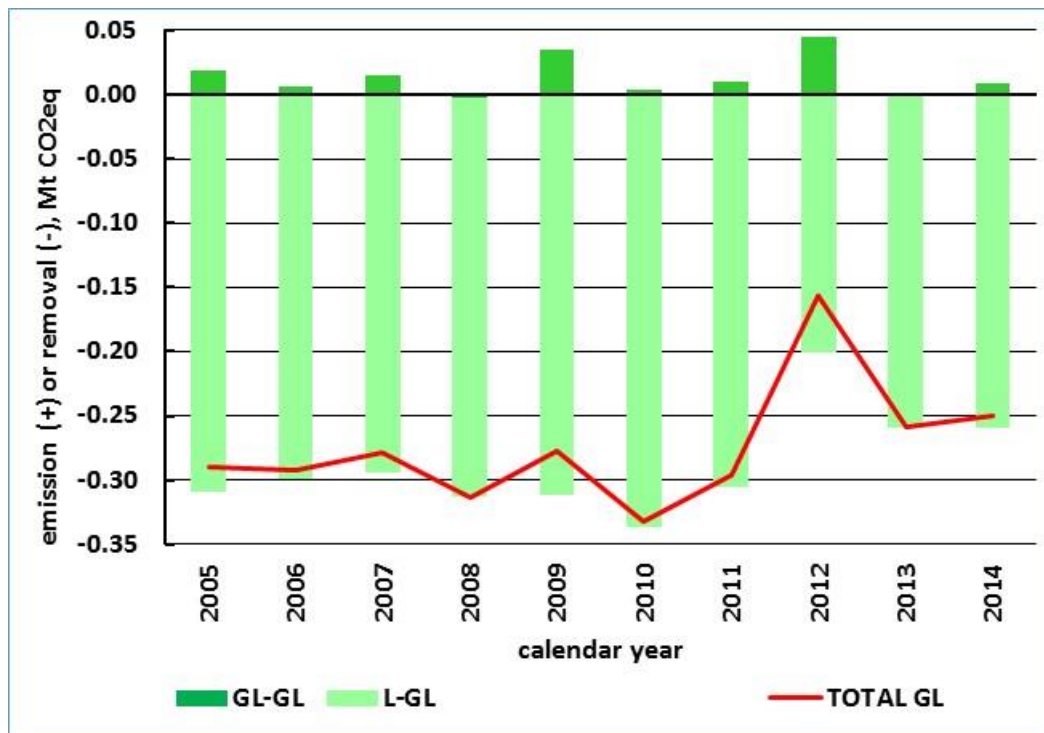


Figure 6.7.2. Emissions and removals in the Grassland category 2005-2014.

6.7.2 Grassland remaining Grassland

Figure 6.7.3 reports emissions and removals, whereas Table 6.7.1 reports methodological information for this sub-category.

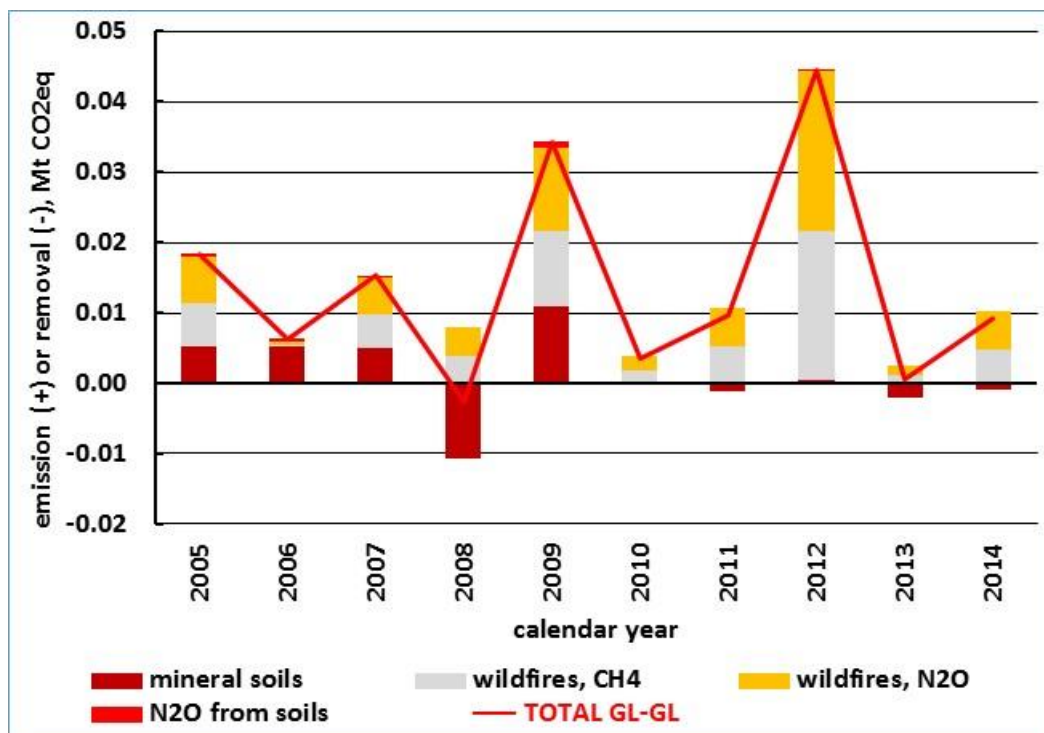


Figure 6.7.3. Emissions and removals in the GL-GL category 2005-2014.

Table 6.7.1. Methodological summary for GL-GL (CS=country specific; D: default; AD: activity data; EF: emission/removal factor).

Carbon stock changes						Table (4)III	Table (4)V
BIOMASS		DOM		SOIL			
annual	perennial	DW	LI	mineral	organic		
Tier 1: 0	Tier 1: 0	Tier 1: 0	Tier 1: 0	AD: CS; EF: CS/D	NO	Direct N2O emissions from N mineralization: D	Wildfires: AD: CS EF: D Biomass burning: NO

6.7.2.1 Biomass

Grasslands are meadows and pastures which are grazed or harvested annually and where tree cover is non-existent or very low. Due also to its relatively small area and dynamics, the biomass of grassland remaining grassland is not a key category. Therefore, we adapt the Tier 1 method of the IPCC 2006 GL which assumes no change in biomass. In line with this, 'NO' is reported for the biomass of this category. Note that, due to the increase of set-aside grassland, a rather slow increase in woody biomass might have been occurring, thus, applying the Tier 1 method might slightly underestimate carbon removals.

6.7.2.2 Dead organic matter

As the dead organic matter pool and its carbon stock changes are relatively small, the Tier 1 method is applied which assumes that the dead wood and litter stocks are at equilibrium, and the carbon stock changes for these pools are not estimated.

6.7.2.3 Soils

As reported above, grassland management has been decreasing for about three decades now. Some direct local results have already been published concerning CO₂-emission from grasslands (Nagy et al. 2007, Zsembeli et al. 2006). However, in lack of country-wide monitoring results the Tier 2 IPCC method is applied.

The method and emission factors used are those described in section 6.4.1. Data demonstrate that high activity clay mineral soils are dominant, similar to the case of croplands. (These include salt affected soils that are very characteristic to Hungary and that are partly utilized as grasslands, mainly depending on the extent of salinization.)

Concerning management, sufficient statistics are lacking for the period 1985-2002. As an approximation, the management, hence the quality of grasslands were determined for this period based on the number of grazing animals and the level of management costs for each soil type and climate region, taking into consideration the spatial distribution of the number of livestock by species. The spatial distribution of quality, utilization and load of grasslands were estimated and overlaid on the genetic soil maps and climatic zone maps mentioned in section 6.4.1. Based on this, the following two broad categories are used to characterize the management of the Hungarian grasslands: nominally managed (non-degraded) grasslands (with no input), which includes pastures, rangelands and other unmanaged grasslands, and improved grasslands with medium input. The area of the latter can be calculated from HCSO data based on the area of grasslands treated with chemical fertilizers (Table 6.7.2) and that of irrigated grasslands which are available for some years since 2003. The proportion

of 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, and the rest is taken as nominally managed.

Table 6.7.2. *The area of grasslands treated with chemical fertilizer (source: HCSO).*

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	11441
2012	11494
2013	12387
2014	11675

As the data show the management of grasslands was reduced due to the introduction of Agro-environmental Management Program in 2002-2003, and was limited to slightly intensive planted grasslands. This program resulted in the natural succession of pastures that is characterized by the propagation of weeds and soil degradation. The management of grasslands is limited to their grazing and cutting.

All the above information formed a sufficiently good bases for the expert judgment that was necessary to develop the required proportions (Table 6.7.3).

Table 6.7.3. *The distribution of grasslands in Hungary by management and input in 2014.*

Management	Input	Proportion of total grassland area (%)
non-degraded	-	98.6
improved	medium	1.40

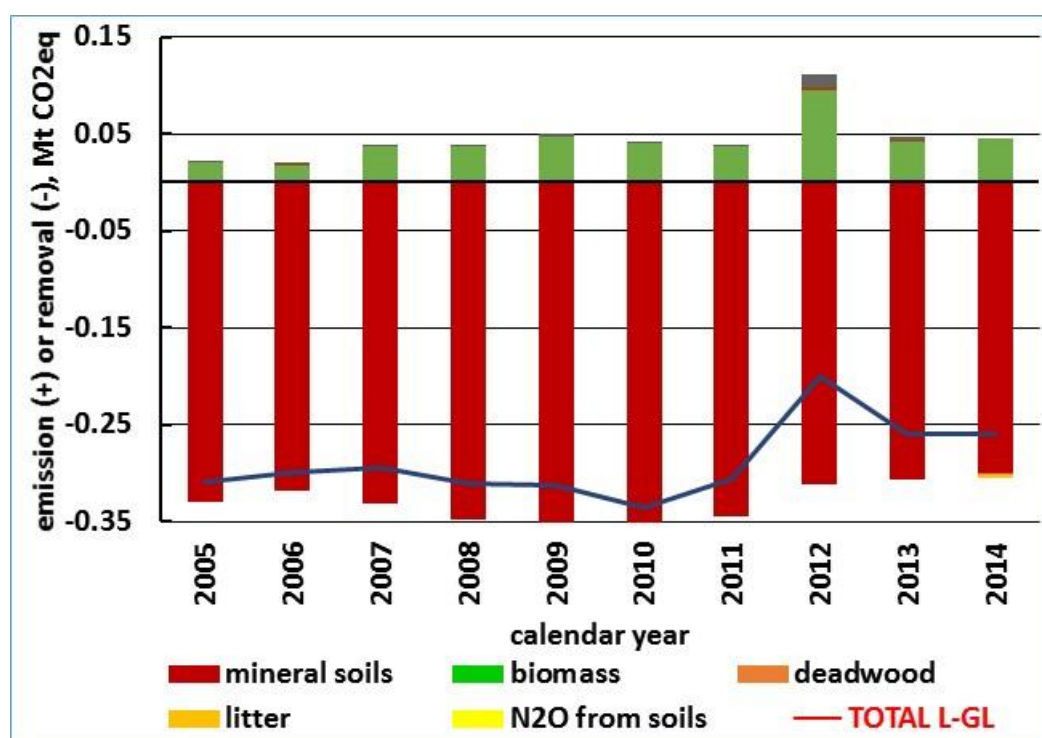
For the above climate, soil, management and input categories, the applied reference soil organic carbon stocks were the same as those reported in Table 6.4.2 above. The land-use factor (F_{LU}) is 1.0 for all grasslands, whereas the selected management factors (F_{MG}) are reported in Table 6.7.4 and the level of input (F_I) was assumed to be 1.0 for both the nominally managed grasslands and the improved grassland (IPCC 2006).

Table 6.7.4. Management factors (F_{MG}) for Grassland

Management regime	F_{MG}
Nominally managed (non-degraded)	1.00
Improved	1.14

6.7.3 Land converted to Grassland

Figure 6.7.2 reports emissions and removals, whereas Table 6.7.5 reports methodological information for this sub-category.

**Figure 6.7.4.** Emissions and removals in the L-GL category 2006-2014.**Table 6.7.5.** Methodological summary for L-GL. (CS=country specific; D: default; IE: included elsewhere; AD: activity data; EF: emission/removal factor)

"FROM" category	BIOMASS	DOM		SOIL		Table (4)III	Table (4)V
		DW	LI	mineral	organic		
FL	AD: CS; EF: CS	AD: CS; EF: CS		AD: CS; EF: CS/D	NO	Direct N2O emissions from N mineralization: D	Wildfires: IE (GL-GL)
CL	AD: CS; EF: D	Tier 1: 0		AD: CS; EF: CS/D	NO		
WL	NO	NO		NO	NO		
SE	Tier 1: 0	Tier 1: 0		AD: CS; EF: CS/D	NO		
OL	NO	NO		NO	NO		

6.7.3.1 Forest Land converted to Grassland

For the methodology to estimate carbon stock changes in the biomass, DOM and soil pools, see Sections 6.5.6.1.1 and 6.4.4, 6.5.6.1.2 and 6.5.6.1.3, respectively. The total emissions from these pools estimated using this methodology was split between FL-GL and other conversions by the area of these conversions. The share of FL-GL to all FL-L varies between about 4 and 50% and was 16% in 2014.

6.7.3.2 Cropland converted to Grassland

6.7.3.3 Biomass

Carbon stock changes in biomass in this category are the sum of those from converting Cropland with annual crops to Grassland and those from converting Cropland with perennials to Grassland.

For annual crops, the methodology of estimating carbon stock changes is the same as reported in sections 6.4.4 and 6.6.3.2.1, and symbols applied there are used here, too.

For A_{Conv} , data from the annual land use change matrix was used.

B_{before} for annual croplands, the default 10 t biomass/ha, was taken from text to Table 5.9 of the IPCC 2006 GL, whereas B_{after} was estimated from the proportion of Cropland area of cold dry and warm dry climate types ($P_{CD} = 0.41$, $P_{WD} = 0.59$) and respective specific default Grassland biomass (total above- and below-ground biomass, Table 6.4 of the IPCC 2006 GL: $B_{CD} = 6.5$ t biomass ha^{-1} and $B_{WD} = 6.1$ t biomass ha^{-1} , respectively): $B_{after} = P_{CD} * B_{CD} + P_{WD} * B_{WD}$. In accordance with the Tier 1 assumption, B_{after} in the equation is 0, and the carbon fraction is the default value of 0.47 tC t biomass $^{-1}$.

For ΔC_G , the same biomass value of 6.26 tC ha^{-1} , together with the default carbon fraction of 0.47 tC t biomass $^{-1}$ was used as for the pre-conversion biomass of B_{before} in the CL-GL category, whereas ΔC_L was assumed to be equal to 0.

When converting Cropland with perennials to Grassland, the methodology of estimating carbon stock changes is consistent with the one reported in section 6.6.2.1.1. P_P for Grassland was also estimated from the CORINE land cover change database (see Table 6.7.6 and section 6.2 for details).

Table 6.7.6. The distribution of the area of cropland-grassland conversions 1985-2014.

Year	Area (ha)			
	Annual cropland converted to grassland	Vineyard converted to Grassland	Orchard converted to Grassland	Total CL-GL
1985	4938	80	320	5338
1986	4420	532	386	5338
1987	0	0	0	0
1988	0	0	0	0
1989	0	0	0	0
1990	0	0	0	0
1991	15684	329	0	16013
1992	15690	323	0	16013
1993	5713	994	0	6707

1994	5699	1008	0	6707
1995	5721	986	0	6707
1996	5727	980	0	6707
1997	5737	970	0	6707
1998	5728	979	0	6707
1999	5747	960	0	6707
2000	6020	687	0	6707
2001	1132	715	0	1847
2002	1615	169	64	1847
2003	1600	180	68	1847
2004	1603	177	67	1847
2005	1575	198	75	1847
2006	1607	175	66	1847
2007	4476	165	62	4703
2008	4449	185	69	4703
2009	4453	182	68	4703
2010	4442	190	72	4703
2011	4391	108	204	4703
2012	4641	63	0	4703
2013	4663	0	40	4703
2014	4564	140	0	4703

6.7.3.3.1 Mineral soils

The method and emission factors used are those described in section 6.4.1.

6.7.3.4 Wetlands converted to Grassland

This land-use change is not occurring in Hungary.

6.7.3.4.1 Settlements converted to Grassland

The land cover change databases indicate rather small areas of Settlement converted to Grassland (ranging 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). These areas are predominantly biological re-cultivation of abandoned surface mines. In general, the biological re-cultivation results in an increase in the carbon stocks. For the sake of consistency and completeness, carbon stock changes in mineral soils are estimated using the method and emission factors that are reported in section 6.4.1.

6.7.3.5 Other Land converted to Grassland

This land-use change is not occurring in Hungary.

6.7.4 Uncertainties and time-series consistency

An uncertainty analysis of the emission and removal estimates for the Grassland category was reported in a previous NIR. The analysis was made using a Tier 1 approach. As there have been recalculations for the entire LULUCF sector since then, the uncertainty analysis should be updated. However, we focused our capacities in the last two years on the improvement of the land transition matrix, some other activity data, some emission factors and some methodological issues, and thus the updating of the uncertainty analysis was not possible.

Part of our efforts to improve the emission and removal estimates was dedicated to further improve the time series consistency. However, whereas this inventory is more consistent than before, further improvements are possible.

6.7.5 Category-specific QA/QC and verification

See section 6.6.5.

6.7.6 Category-specific recalculations

Last year, a number of recalculations were made (relative to the estimates for the last year) that were listed in section 6.1.4 of last year's NIR. This year, sector-specific recalculations were made to correct mistakes in the formulas to estimate emissions from the biomass pool. The corrections resulted in small changes in the emission estimates.

6.7.7 Category-specific planned improvements

As mentioned above, planned improvements include Tier 1 (and possibly Tier 2) uncertainty estimation.

6.8 Wetland (CRF sector 4.D)

6.8.1 Description of category

Wetlands account for only 2.8 per cent of the total area of Hungary (Figure 6.3.1) and include inland marshes, peat bogs, and natural and artificial water courses and water bodies. Wetlands are *ex lege* protected in Hungary that is among the signatories of the Ramsar Convention. The preservation and the sustainable use of Wetlands became standard practice decades ago. In 2016, altogether 29 wetland areas (with a total area of 256,948 ha) were included the Ramsar List of Wetlands of International Importance and managed accordingly (<http://www.ramsar.org/sites/default/files/documents/library/sitelist.pdf>).

The methodology of identifying Wetlands (see section 6.3) does not allow for the separation of managed and unmanaged Wetlands (the latter having a rather small share), but the area of Wetlands could be split into remaining and 'converted to' sub-categories. As wetlands are mainly precipitation dominated, their extent to a certain degree depends on the seasonal and annual variability in precipitation, and due to the nature of land use and land use change statistics, this variability could not be entirely reflected in the annual land-use change matrices.

Emissions from wetlands are not significant in Hungary because both the managed and total Wetland area have been small and quite constant for decades, therefore, the Tier 1 method is applied for the estimation of the emissions. In order to ensure completeness, emissions from both land conversions to water bodies (as conversions to 'flooded land') and peat extraction are reported. The Hungarian Mining Authority (HMA) provided data on the establishment of new peat extraction sites and on the amount of peat extracted annually. 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. No new extraction sites have been established since 2006.

6.8.2 Wetland remaining Wetland

Table 6.8.1 reports methodological information for this sub-category.

Table 6.8.1. Methodology summary for Wetland remaining Wetland (CS=country specific; D: default; AD: activity data; EF: emission/removal factor; NO: not occurring).

Carbon stock changes		CO2 emissions, on-site	N2O emissions, on-site	CO2 emissions, off-site	Table (4)I, II, III	Table (4)V
BIOMASS	DOM	SOIL				
AD: CS; EF: D	Tier 1: 0	AD: CS; EF: D	AD: CS; EF: CS/D	AD: CS; EF: D	Direct N2O emissions from N inputs to managed soils: NO; Emissions from peat extraction: D; Direct N2O emissions from N mineralization: D;	Wildfires: NO Biomass burning: NO

6.8.2.1 Carbon stock changes as well as CO₂ emissions (on-site and off-site)

According to Equations 7.3. and 7.4 of the IPCC 2006 GL, one source of CO₂ emissions (for all production phases) from peatlands is emissions from peatland extraction (both on-site and off-site) and

from biomass clearing:

$$\text{CO}_2\text{-C}_{\text{WW peat on-site}} = [(A_{\text{peatRich}} * \text{EF}_{\text{CO}_2 \text{ peatRich}}) + (A_{\text{peatPoor}} * \text{EF}_{\text{CO}_2 \text{ peatPoor}})] / 1000 + \Delta\text{C}_{\text{WW peat B}}$$

where

$\text{CO}_2\text{-C}_{\text{WW peat on-site}}$ = on-site $\text{CO}_2\text{-C}$ emissions from peat deposits, Gg C yr^{-1}

A_{peatRich} = area of nutrient-rich peat soils managed for peat extraction, ha

A_{peatPoor} = area of nutrient-poor peat soils managed for peat extraction, ha

$\text{EF}_{\text{CO}_2 \text{ peatRich}}$ = CO_2 emission factors for nutrient-rich peat soils managed for peat extraction or abandoned after peat extraction, $\text{tonnes C ha}^{-1} \text{ yr}^{-1}$

$\text{EF}_{\text{CO}_2 \text{ peatPoor}}$ = CO_2 emission factors for nutrient-poor peat soils managed for peat extraction or abandoned after peat extraction, $\text{tonnes C ha}^{-1} \text{ yr}^{-1}$

$\Delta\text{C}_{\text{WW peat B}}$ = $\text{CO}_2\text{-C}$ emissions from change in carbon stocks in biomass due to vegetation clearing, Gg C yr^{-1} .

Data for A_{peatRich} and A_{peatPoor} was obtained from the HMA for the period 1995-2014 (Table 6.8.2). For the years 1985 to 1994 data on area conversions are not available, therefore, proxy data, i.e., data of 1995 was used for the estimation. For the emission factors, IPCC default values, i.e., 1.1 and 0.2 $\text{tonnes C ha}^{-1} \text{ yr}^{-1}$, from Table 7.4 of Volume 4 of the IPCC 2006 GL, were used for nutrient-rich and nutrient-poor peats, respectively.

Table 6.8.2. 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	802.15
1999	205.15	211.97
2000	88.67	28.13
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
2013	NO	NO
2014	NO	NO

Carbon stock change in biomass due to vegetation clearing was estimated using Equation 2.16 (see

Section 6.4.4). In Hungary, the typical biomass of peat bogs, i.e., B_{before} in this equation, is grass as demonstrated in different studies (e.g., Hubayné, 2005 and Dömsödy, 2006). Therefore, B_{before} was estimated from the proportion and average specific biomass for cold dry and warm dry climate types: $B_{\text{before}} = P_{\text{CD}} * B_{\text{CD}} + P_{\text{wD}} * B_{\text{wD}}$ ($P_{\text{CD}} = 0.41$, $P_{\text{wD}} = 0.59$, $B_{\text{CD}} = 6.5 \text{ t biomass ha}^{-1}$ and $B_{\text{wD}} = 6.1 \text{ t biomass ha}^{-1}$, respectively; see more details in Section 6.7.3.3). B_{after} in the equation is 0, and the carbon fraction is the IPCC default value of $0.47 \text{ tC t biomass}^{-1}$.

Off-site emissions from managed peatlands were estimated using Equation 7.5 (by modifying it, i.e., deleting the division by 1000, to correct for appropriate dimensions):

$$\text{CO}_2\text{-C}_{\text{WW peat off-site}} = W_{\text{t}_{\text{dry_peat}}} * C_{\text{fraction}_{\text{wt_peat}}}$$

where

$\text{CO}_2\text{-C}_{\text{WW peat off-site}}$ = off-site $\text{CO}_2\text{-C}$ emissions from peat removed for horticultural use, tC yr^{-1}

$W_{\text{t}_{\text{dry_peat}}}$ = air-dry weight of extracted peat, tonnes yr^{-1}

$C_{\text{fraction}_{\text{wt_peat}}}$ = carbon fraction of air-dry peat by weight, tonnes C (tonnes of air-dry peat) $^{-1}$.

$W_{\text{t}_{\text{dry_peat}}}$ was estimated from the annual statistics of the amount of peat extracted (provided by the HMA, Table 6.8.3) and the density of the peat, also provided by the HMA by extraction site. The density values showed rather large variation and, in order not to underestimate emissions, the largest density value (i.e., $0.8 \text{ tonnes biomass m}^{-3}$) was used. For $C_{\text{fraction}_{\text{wt_peat}}}$, the area-weighted value of $0.42 \text{ tonnes C (tonnes of air-dry peat)}^{-1}$ is used, which was calculated based on the area of nutrient rich and nutrient poor sites and respective data from Table 7.5 of the IPCC 2006 GL.

Table 6.8.3. Amount of peat extracted (tonnes)

Year	Amount of peat extracted	
	Estimated by HMA, m^3	Converted to biomass, tonnes
1985	464 000	371 200
1986	797 000	637 600
1987	860 000	688 000
1988	795 000	636 000
1989	704 000	563 200
1990	637 000	509 600
1991	395 000	316 000
1992	263 000	210 400
1993	464 000	371 200
1994	275 000	220 000
1995	321 000	256 800
1996	202 000	161 600
1997	346 000	276 800
1998	240 000	192 000
1999	313 000	250 400
2000	330 000	264 000
2001	355 000	284 000
2002	341 000	272 800
2003	247 000	197 600
2004	273 000	218 400
2005	294 000	235 200

2006	297 000	237 600
2007	226 000	180 800
2008	188 000	150 400
2009	323 000	258 400
2010	169 500	135 600
2011	268 700	214 960
2012	185 700	148 560
2013	285 200	228 160
2014	166 000	132 800

6.8.2.2 N₂O emissions

The IPCC 2006 GL provides a Tier 1 methodology to estimate N₂O emissions due to peat extraction. These emissions were only estimated for nutrient rich sites using Equation 7.7:

$$N_2O_{WW \text{ peatExtraction}} = (A_{\text{peatRich}} * EF_{N_2O \text{ peatRich}}) * 44/28 * 10^{-6}$$

where

$N_2O_{WW \text{ peatExtraction}}$ = N₂O emissions due to peat extraction, Gg N₂O yr⁻¹

A_{peatRich} = area of nutrient rich peat extraction sites, ha (see above)

$EF_{N_2O-N \text{ peatRich}}$ = emission factor for drained nutrient-rich wetlands, kg N₂O–N ha⁻¹yr⁻¹ for which the IPCC default value of 1.8 kg N₂O–N ha⁻¹yr⁻¹ from Table 7.6 was used (the multiplier 10⁻⁶ is necessary in the equation to obtain the result in units of Gg N₂O yr⁻¹).

6.8.2.3 Land converted to Wetland

Table 6.8.4 reports methodological information for this sub-category.

Table 6.8.4. Methodology summary for Land converted to Wetland (CS=country specific; D: default; AD: activity data; EF: emission/removal factor; NO: not occurring).

Subcategory	"FROM" category	BIOMASS	DOM		SOIL		Table (4)I, III	Table (4)V
			DW	LI	mineral	organic		
E/R, land converted to peatland	not estimated (insignificant amounts; if any, included in E/R in land converted to flooded land)							
E/R, land converted to flooded land	FL	NO	NO	NO	NO	NO	Direct N2O emissions from N inputs to managed soils: NO; Direct N2O emissions from N mineralization/immobilization: NO	Wildfires: NO; Biomass burning NO
	CL	NO	NO	NO	NO	NO		
	GL	AD: CS; EF: D	Tier 1: 0		AD: CS; EF: CS/D	NO		
	SE	Tier 1: 0	Tier 1: 0		AD: CS; EF: CS/D	NO		
	OL	NO	NO		NO	NO		

6.8.2.4 Grassland converted to Wetland

The general methodology of identifying the area of Land converted to Wetlands is described in section

6.3.1.

6.8.2.5 Biomass

Equation 7.10 of the IPCC 2006 GL was applied as follows:

$$\Delta C_{LWfloodLB} = A_{Conversion} * (B_{after} - B_{before}) * CF$$

where:

$\Delta C_{LWfloodLB}$ = biomass carbon stock change due to land-use conversion to Wetland, tC year⁻¹

$A_{Conversion}$ = annual area of land converted to Wetland, ha year⁻¹

B_{after} = carbon stocks of biomass after the conversion to Wetland, tonnes C ha⁻¹

B_{before} = carbon stocks in biomass before the conversion to Wetland, tonnes C ha⁻¹

CF = carbon fraction, tC (t biomass)⁻¹.

To estimate the amount of biomass cleared in the year of conversion, the annual area of Grassland converted to Wetlands is needs to be used, which is reported in Table 6.8.5.

Table 6.8.5. Annual area of Grassland converted to Wetland (ha)

Year	Areas of Grassland converted to Wetland (ha)
1985	298
BY	298
1986	298
1987	298
1988	298
1989	298
1990	298
1991	300
1992	299
1993	597
1994	597
1995	597
1996	597
1997	597
1998	597
1999	599
2000	598
2001	487
2002	488
2003	487

2004	484
2005	491
2006	487
2007	117
2008	117
2009	117
2010	117
2011	117
2012	117
2013	487
2014	0

B_{after} is zero, and B_{before} was estimated the same way as described for wetland prepared for peat extraction above. For more details see “Grassland converted to Cropland” in Chapter 6.6.3.2.

6.8.2.6 Settlements converted to Wetland

There area of Settlements converted to Wetlands is very small. The CLC codes which were classified into this category are reported in Table 6.3.2. This land-use change category mainly contains the area of sandpits and gravel pits, extraction and construction area which are not covered by soil and biomass. Therefore, emissions from these land-use change conversions are most probably zero.

6.8.3 Uncertainties and time-series consistency

An uncertainty analysis of the emission and removal estimates for the Wetland category was reported in a previous NIR. This analysis was made using a Tier 1 approach. As there were recalculations for the entire LULUCF sector in 2015, the uncertainty analysis should be updated, however, we focused our capacities on the improvement of the land transition matrix, some other activity data, some emission factors and some methodological issues, and the updating of the uncertainty analysis has not been possible yet.

Part of our efforts to improve the emission and removal estimates was dedicated to further improve the time series consistency. However, whereas this inventory is more consistent than before, further improvements are possible.

6.8.4 Category-specific QA/QC and verification

See section 6.6.5.

6.8.5 Category-specific recalculations

This year, a number of category-specific recalculations were made (relative to the estimates for the last year). These are due to new input data in area of peat extration and in the amount of extrated peat biomass.

6.8.6 Category-specific planned improvements

As with other categories, we are planning to conduct a Tier 1 (and possibly Tier 2) uncertainty estimation for this sector, too.

6.9 Settlements (CRF sector 4.E)

6.9.1 Description of category

Settlements account for 6.3 per cent of the area of Hungary, and only for a tiny fraction of emissions of the sector.

6.9.2 Settlements remaining Settlements

As this category is not a key category, the Tier 1 assumption of no change in carbon stocks in all pools is applied.

6.9.3 Land converted to Settlements

Table 6.9.1 reports methodological information for this sub-category.

Table 6.9.1. Methodology summary for Land converted to Settlements (CS=country specific; D: default; AD: activity data; EF: emission/removal factor; NO: not occurring).

"FROM" category	BIOMASS	DOM		SOIL		Table (4)I, III	Table (4)V
		DW	LI	mineral	organic		
FL	AD: CS; EF: CS	AD: CS; EF: CS		AD: CS; EF: CS/D	NO	Direct N ₂ O emissions from N inputs to managed soils: NO; Direct N ₂ O emissions from N mineralization: D	Wildfires: NO; Biomass burning: NO
CL	AD: CS; EF: D	Tier 1: 0		AD: CS; EF: CS/D	NO		
GL	AD: CS; EF: D	Tier 1: 0		AD: CS; EF: CS/D	NO		
WL	Tier 1: 0	Tier 1: 0		AD: CS; EF: CS/D	NO		
OL	NO	NO		NO	NO		

6.9.3.1 Forest land converted to Settlements

For the methodology to estimate carbon stock changes in the biomass, DOM and soil pools, see Sections 6.5.6.1.1, 6.5.6.1.2 and 6.5.6.1.3, respectively. The total emissions from these pools estimated using this methodology was split between FL-SE and other conversions by the area of these conversions. The share of FL-SE to all FL-L varies between about 36 and 88%, and it was 58% in 2014.

6.9.3.2 Cropland converted to Settlements

6.9.3.2.1 Biomass

Carbon stock changes in biomass in this category are the sum of those from converting Cropland with annual crops to Settlement and those from converting Cropland with perennials to Settlement.

For annual crops, the methodology of estimating carbon stock changes is the same as reported in Sections 6.4.4 and 6.6.3.2.1, and symbols applied there are used here, too.

For A_{Conv} , data from the annual land use change matrix was used.

B_{before} for annual croplands, the default 10 t biomass/ha, was taken from text to Table 5.9 of the IPCC 2006 GL. For Croplands, B_{before} was estimated from the proportion of Cropland area of cold dry and warm dry climate types ($P_{\text{CD}} = 0.41$, $P_{\text{WD}} = 0.59$) and respective specific default Cropland biomass (total above- and below-ground biomass, Table 6.4 of the IPCC 2006 GL: $B_{\text{CD}} = 6.5$ t biomass ha^{-1} and $B_{\text{WD}} = 6.1$ t biomass ha^{-1} , respectively); $B_{\text{after}} = P_{\text{CD}} * B_{\text{CD}} + P_{\text{WD}} * B_{\text{WD}}$. In accordance with the Tier 1 assumption, B_{after} in the equation is 0, and the carbon fraction is the default value of 0.47 tC t biomass $^{-1}$. ΔC_L was assumed to be equal to 0.

When converting Cropland with perennials to Settlements, the methodology of estimating carbon stock changes is the same as reported in section 6.6.2.1.1. P_P for Settlements was also estimated from the CORINE land cover change database (see Table 6.9.2 and section 6.2 for details).

Table 6.9.2. *The distribution of the area of cropland annually converted to Settlements.*

Year	Area (ha)			
	Annual cropland converted to Settlements	Vineyard converted to Settlements	Orchard converted to Settlements	Total CL-SE
1985	789	10	40	838
1986	724	67	48	838
1987	789	25	25	838
1988	797	26	16	838
1989	818	15	5	838
1990	825	14	0	838
1991	797	41	0	838
1992	798	40	0	838
1993	858	80	0	938
1994	857	81	0	938
1995	859	79	0	938
1996	859	79	0	938
1997	860	78	0	938
1998	859	78	0	938
1999	861	77	0	938
2000	734	203	0	938
2001	1753	212	0	1965
2002	1896	50	19	1965
2003	1892	53	20	1965
2004	1893	52	20	1965

2005	1884	59	22	1965
2006	1894	52	19	1965
2007	1179	49	18	1246
2008	1171	55	21	1246
2009	1172	54	20	1246
2010	1169	56	21	1246
2011	1154	32	60	1246
2012	1227	19	0	1246
2013	1234	0	12	1246
2014	1205	41	0	1246

6.9.3.2.2 Mineral soils

The method and emission factors used are those described in section 6.4.1.

6.9.3.3 Grassland converted to Settlements

6.9.3.3.1 Biomass

For converting Grassland to Settlement, the methodology of estimating carbon stock changes is the same as reported in section 6.6.3.2.1 (see also Table 6.9.3), the only exception being that ΔC_G (and ΔC_L) were assumed to be equal to 0.

Table 6.9.3. *The annual area of Grassland converted to Settlements (ha)*

Year	Area of Grassland converted to Settlements
1985	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	285
2008	285
2009	285
2010	285
2011	285
2012	285
2013	285
2014	285

6.9.3.3.2 Mineral soils

The method and emission factors used are those described in section 6.4.1.

6.9.3.4 Wetland converted to Settlements

6.9.3.4.1 Biomass

Wetlands converted to Settlements are typically inland marshes (rarely peat bogs) the biomass of which is typically grass (Dömsödi, 2006) and water bodies with no biomass. Therefore, the emissions from biomass were estimated using the methodology that is applied to the Grassland converted to Settlement, see Section 6.9.3.3.1) which, for water bodies, may somewhat overestimate the amount of biomass lost.

6.9.3.4.2 Organic soils

For these conversions, Equation 2.26 was used to estimate the annual carbon loss:

$$L_{\text{organic from water-bodies}} = A_{\text{entire category}} * P_{\text{water-bodies}} * EF_{\text{water-bodies}}$$

and

$$L_{\text{organic from marshes-bogs}} = A_{\text{entire category}} * P_{\text{marshes-bogs}} * EF_{\text{marshes-bogs}}$$

where

L_{organic} = annual carbon loss from organic soils of water bodies and marshes-bogs, respectively, from converting Wetland to Settlements, tCyr^{-1}

$A_{\text{entire category}}$ = area of the entire category of Wetland converted to Settlements, ha

$P_{\text{water-bodies}}$ = proportion of the area of water bodies relative to $A_{\text{entire category}}$, %

$P_{\text{marshes-bogs}}$ = proportion of the area of marshes-bogs, relative to $A_{\text{entire category}}$, %

$EF_{\text{water-bodies}}$ = emission factor for water bodies, $\text{tCha}^{-1}\text{yr}^{-1}$

$EF_{\text{marshes-bogs}}$ = emission factor for marshes and bogs, $\text{tCha}^{-1}\text{yr}^{-1}$

The P values were identified according to section 6.3.1, whereas for the emission factors the default IPCC (2006) values of 0.25 (cold temperate) and 2.5 (warm temperate) $\text{tCha}^{-1}\text{yr}^{-1}$ (Table 6.3) and 10.0 $\text{tCha}^{-1}\text{yr}^{-1}$ (Table 5.6) were used, respectively.

6.9.4 Uncertainties and time-series consistency

An uncertainty analysis of the emission and removal estimates for the Settlements category was reported in a previous NIR. This analysis was made using a Tier 1 approach. As there were recalculations for the entire LULUCF sector last year, the uncertainty analysis should be updated, however, we focused our capacities on the improvement of the land transition matrix, some other activity data, some emission factors and some methodological issues, and the updating of the uncertainty analysis has not been possible yet.

Part of our efforts to improve the emission and removal estimates was dedicated to further improve the time series consistency. However, whereas this inventory is more consistent than before, further improvements are possible,

6.9.5 Category-specific QA/QC and verification

See section 6.6.5.

6.9.6 Category-specific recalculations

Last year, a number of recalculations were made (relative to the estimates developed in the preceding year). This year, no recalculations were made.

6.9.7 Category-specific planned improvements

As mentioned above, planned improvements include Tier 1 (and possibly Tier 2) uncertainty estimation.

6.10 Other Land (CRF sector 4.F)

The Other Land category includes the sparsely vegetated areas, which account for only 0.03 percent of the total area of the country (see Figure 6.3.1). The area in the Other Land category is unmanaged (excludes unmanaged grasslands) with very little conversions from and to Other land.

6.11 Uncertainty and time-series consistency

As mentioned above for the various sub-sectors, uncertainty estimation for the Forest Land category was earlier calculated using the Monte Carlo simulation, whereas uncertainties for the other LULUCF sub-sectors were earlier calculated using the Tier 1 method. As a summary of the results, the 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 estimates of CO₂ removals in the 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. However, the Land converted to Grassland category has the highest overall uncertainty ($\pm 188\%$) among all land-use and land use change categories. The impact of non-CO₂ emissions on LULUCF uncertainty is negligible because they account for only 1.5% of the total net removals.

While it is believed that the above estimates are more or less relevant for the submission this year, our intention is to repeat the uncertainty analysis sometimes in the future, and maybe apply a Tier 2 (Monte Carlo) method for the entire sector, in addition to a Tier 1 estimation.

6.12 Sector specific QA/QC and verification

See section 6.6.5.

6.13 Sector specific recalculation

As indicated above (section 6.1.4, and in the respective section for each land use category), a number of recalculations took place in 2015. No category-specific recalculations were made this year.

6.14 Sector specific planned improvements

One of the main plans is to conduct an uncertainty analysis sometimes in the future.

7. Waste (CRF sector 5)

Recent key developments:

- In contrast with other sectors, emissions from the waste sector are by 16% higher now than in the base year;
- However, the growth in emissions had stopped in the last decade, and a reduction of 10% could be observed between 2005 and 2014;
- Amount of disposed municipal waste decreased by 43% between 2005 and 2014;
- 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:

- 5A: The Hungarian municipal waste composition statistics usually does not contain a separate category for wood. For this submission, it was assumed that within the municipal waste category about half of the "bulky waste" (EWC 200307) is similar to wood waste and was as such included into the IPCC waste model. The amount of industrial waste has been updated for 2013.
- 5B: As the EU trial review pointed out, some double counting occurred in the previous submission as regards biogas leakage. In this submission, leakage from only 'other' biogas production is taken into account in the category 5B Biological Treatment of Solid Waste. Landfill biogas has been removed, and leakage from sludge digestion has been reallocated to 5D.
- 5C: Amount of incinerated clinical waste has been updated for 2012-13.
- 5D: Following a recommendation from the EU review, MCF=0 is used now (instead of MCF=0.1) for river and lake discharge as Hungarian rivers and lakes cannot be considered as oxygen-deficient aquatic environment.

7.1 Overview of sector

This section discusses the emissions from solid waste disposal (CH₄), biological treatment of solid waste including composting and anaerobic digestion at biogas facilities (CH₄, N₂O), waste incineration (CO₂, CH₄, and N₂O), and domestic and industrial wastewater treatment (CH₄ and N₂O). One peculiarity of the sector is that most part of the carbon-dioxide emissions is generated from biological (biogenic) sources and this CO₂ 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 waste sector with 4283.8 Gg CO₂ equivalent represented 7% of total national GHG emissions in 2014. In the base year, total GHG emissions from the waste sector amounted to 3682.3 Gg CO₂ equivalent which accounted for 3% of total national GHG emissions. The largest category was solid waste disposal on land, representing 78% in 2014, followed by wastewater treatment and discharge (14%), incineration of waste (5%), and biological treatment of solid waste (3%). In contrast with other sectors, emissions from the waste sector are by 16% higher now than in the base year. However, the growth in emissions had stopped in the last decade, and a reduction of 10% could be observed between 2005 and 2014. 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 e.g. landfilled municipal waste decreased by 43%), 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 7.1.1.

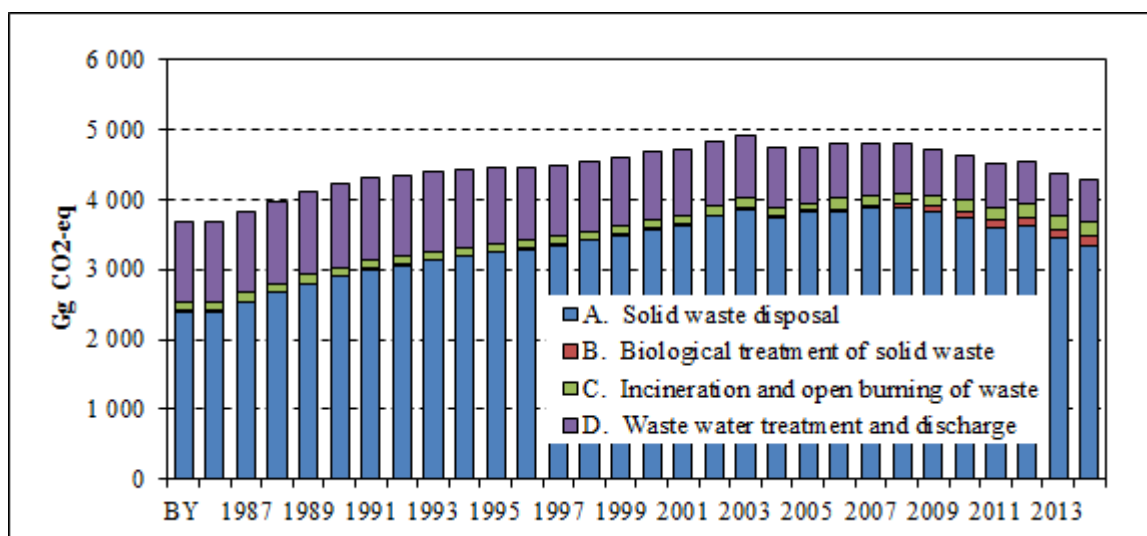


Figure 7.1.1 Trend of emissions of the different categories in waste sector

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 3712 Gg in 2014. Out of this, 1159 Gg (31%) was recovered by recycling and composting, 373 Gg (10%) was incinerated for energy purposes, and 2181 Gg (59%) went to landfills. (In previous years 30-228 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 7.1.1 summarizes recent changes in generation and treatment of municipal waste for the period 2004-2014. The following beneficial trends could be observed:

- Increase of waste generation stopped around 2006, and started to decrease quite significantly afterwards (-21% between 2006 and 2014);
- Share of landfilling decreased from 84% to 59% between 2004 and 2014. However, in comparison with the Western-European situation, the share of waste disposal is still relatively high;
- Importance of both recycling and composting increased; currently they represent 25% and 6%, respectively.

Table 7.1.1 Generation and treatment of municipal solid waste (2004-2014)

[kt]	2004	2005	2006	2008	2009	2010	2011	2012	2013	2014
Waste generated	4592	4646	4711	4553	4312	4033	3809	3988	3738	3712
Landfill	3857	3859	3792	3341	3212	2838	2563	2609	2415	2181
Incineration	155	303	389	393	406	406	408	364	336	373
Recycling	501	403	432	607	576	641	654	832	799	923
Composting	39	41	58	85	90	148	184	183	188	236
Other	40	40	40	126	29	—	—	—	—	—

7.2 Solid waste disposal in landfills (CRF sector 5A)

Emitted gas: CH₄

Key source category: Level, Trend 1

7.2.1 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 CO₂ generated in landfills is of biogenic origin and is thus excluded from the inventory. Under the conditions prevailing in landfills, CO₂ generated from wastes containing carbon of fossil origin is insignificant and direct incineration does not occur in landfills. Illegally disposed wastes are not considered here, partly as they 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 CO₂ emission has to be included in this category.

7.2.2 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 with the “waste by composition” option. The FOD method produces a time-dependent emission profile which reflects the true pattern of the degradation process.

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 7.2.1 had been used. This figure was taken from a university textbook sponsored by the Ministry of Education and Culture.

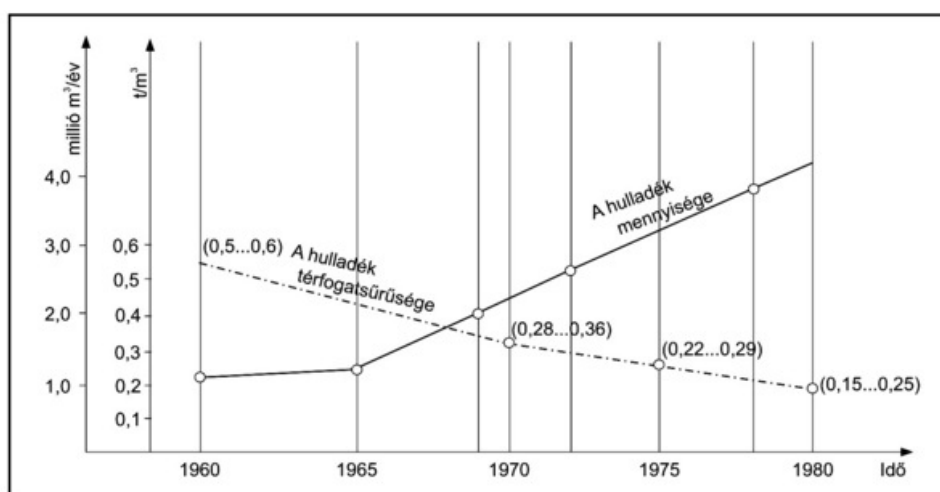


Figure 7.2.1 The loosening trend of municipal solid waste in Budapest. The solid line denotes the amount of waste while the dotted line shows the decrease of volume-density. Source: (<http://www.hik.hu/tankonyvtar/site/books/b108/>).

Before 2001, the amount of removed solid waste was reported in volume units (m³), therefore these data had to be converted to mass unit using the gravimetric density (t/m³) as an important physical characteristic of the waste. Between 1975 and 2000, the value of this parameter decreased from 0.3 t/m³ to 0.2 t/m³ 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. 7.2.1. To summarize the above, the following densities can be used for conversion from volume to waste units:

Table 7.2.1 Waste densities suitable for conversion

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

(As the statistical office publishes data in mass units from 1990, practically there was no need for the compiler institute to do this conversion for the recent years.)

For the period 1950-1975, the following assumptions were made. The first data found in statistical publication was from 1975, i.e. 6,241 thousand m³. This value was converted using a density of 0.3 t/m³ 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 a few years ago 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 m³ 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 m³. 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 t/m³ in 1986 to 0.24 t/m³ 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
- 2004- 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 above categories represent an additional 2-8 per cent. Our data source for these waste categories was the Waste Management Information System for the period 2005-2014. For the earlier years, extrapolation was carried out using two types of proxy data:

- 1990-2004: primer energy use with the assumption that energy efficiency measures might go hand in hand with improved material usage in industry (e.g. (who is wasting energy might be wasting materials too)).
- 1960-1990: volume index of GDP was used as proxy. For the preceding 10 years (1950-1959) the amount was kept constant.

Since the previous submission, we have added also construction and demolition waste. (The total amount from the waste information system reported as EWC waste group 17 Construction and demolition wastes including excavated soil from contaminated sites was taken into account.) Quite considerable amount of C&D waste was landfilled in the last decade, i.e. 2-4 thousand kilotonnes which is comparable to the amount of municipal wastes. After 2010, however, the amount of landfilled C&D waste decreased substantially. The time series was constructed as follows:

- 2004-2013 data as published by the statistical office was directly used;
- 1990-2004: volume indices of value added in the construction sector were used as proxy;
- 1960-1990: similarly to industrial waste, the volume indices of GDP were used as proxy. For the preceding 10 years (1950-1959) the amount was kept constant.

In earlier 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. Let me quote a study “Landfills in Hungary” under a research framework “Organising for EU Enlargement: A Challenge for the Member States and the Candidate States”

State-of-the-art: the Hungarian landfills

In Hungary the typical form of managing waste is disposal: 85 per cent of collected waste is disposed of into landfills. According to a PHARE project designed to assess all landfills in the country, there were 2700 operational landfills, out of these only 728 were registered landfills serving all the municipalities in Hungary in 2002 (European Commission, 2001). Only 6 are so far in line with the *acquis* and a further 67 seem to be aligned to a large extent. In particular, a great number of low capacity local landfills do not conform to the *acquis* and there are a large number of illegal ones. Measures are being implemented to close down all the illegal or non-EU compliant landfills. The objective laid down in the National Waste Management Plan is to establish regional collection and management systems with a maximum of 100-120 landfills. At the end of 2004, the regional collection and management systems planned in the framework of ISPA programme cover one-third of the country. A further objective is that the abovementioned cover-rate should reach 100 per cent by 2009.]

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).

Naturally, changes did not occur from one day to another. Still, the development was quite rapid. Hungary started a modernization program relating disposal sites: the number of SWDSs decreased from about 2700 to 701 in 2000, then to 340 in 2005, to 213 in 2008, and to 69 in 2011. Currently (2012), 72 disposal sites are in operation.

Parallel to the closure of obsolete sites, the general level of management of the remaining disposal sites must have been improved.

Some domestic statistics indicate that only about 4% of municipal waste was still disposed uncontrolled in the early 2000's, therefore we decided to use MCF=1 for all years after 2000 which might be a little conservative estimate for the transition years.

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, based on the IPCC Guidelines, the use of the oxidation value of 0.1 is justified for covered, well managed SWDS to estimate both diffusion through the cap and escape by cracks/fissures.

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 7.2.2 *The ratio of managed vs. well-managed landfills*

	D1	D5
2004	45%	55%
2005	42%	58%
2006	35%	65%
2007	38%	62%
2008	44%	56%
2009	30%	70%
2010	17%	83%
2011	23%	77%
2012	7%	93%
2013	1%	99%
2014	3%	97%

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.

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. For this submission, we have added wood to MSW composition categories with a contribution of about 2.5%. (Basically, we have considered the following EWC categories as wood: 200138 wood, and half of 200307 “bulky waste”).

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 50% fraction of methane in developed gas was kept, and so was the 6 month of delay time.

Table 7.2.3 Used DOC content and methane generation rate constant of different MSW components

	DOC IPCC 2006	DOC Used values	Methane generation rate constant (k)
Paper	0.4	0.4	0.04
Textiles	0.24	0.24	0.04
Food	0.15	0.16	0.06
Wood	0.43	0.43	0.02
Sewage sludge	0.05	0.05	0.06
Hygienic waste	0.24	0.24	0.05
Construction and demolition	0.04	0.04	0.05
Industrial waste	0.01-0.43	0.11-0.03	0.05
DOCF	0.5	0.5	

The amount of recovered CH₄ 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 7.2.4 Summary of activity data and the resulting emissions

	MSW kt	C&D kt	IW kt	Food	Paper	Wood	Textile	Nappies	Recovery Gg CH ₄	Emission Gg CH ₄
1950	1224	1004	99	30%	22%	8%	5%	0%	0,0	0,0
1975	1872	2288	225	31%	20%	4%	6%	0%	0,0	46,3
BY	4018	3061	300	32%	20%	3%	7%	0%	0,0	96,0
1990	3963	2739	301	32%	20%	3%	7%	0%	0,0	115,9
1991	3340	2326	288	37%	18%	3%	3%	0%	0,0	120,1
1992	3506	2216	263	38%	19%	3%	4%	0%	0,0	122,5
1993	3400	2163	269	33%	17%	3%	7%	0%	0,0	125,3
1994	3571	2304	262	32%	18%	3%	5%	0%	0,0	127,3
1995	3481	1963	272	34%	17%	3%	4%	0%	0,0	129,7
1996	3693	2073	279	31%	19%	3%	3%	0%	0,0	131,4
1997	3928	2220	273	27%	19%	3%	6%	4%	0,0	133,6
1998	3936	2484	270	30%	18%	3%	6%	3%	0,0	136,5
1999	4024	2630	268	29%	20%	3%	5%	3%	0,0	139,6
2000	3736	2754	263	39%	14%	3%	4%	1%	0,0	142,9
2001	3696	2930	269	39%	16%	3%	3%	2%	0,0	145,3
2002	3841	3305	269	29%	16%	3%	3%	2%	0,0	150,1
2003	3968	3500	275	28%	16%	3%	3%	3%	0,0	154,2
2004	3857	3689	275	29%	15%	3%	3%	2%	0,0	149,6
2005	3859	3051	290	28%	15%	2%	3%	2%	0,0	152,4
2006	3792	2984	334	24%	15%	2%	3%	3%	0,9	153,0
2007	3429	2293	294	23%	11%	3%	4%	3%	1,7	154,7
2008	3341	2650	293	23%	13%	3%	4%	3%	1,7	155,7
2009	3212	1897	356	22%	12%	2%	4%	4%	2,4	153,2
2010	2838	1233	300	22%	14%	2%	5%	5%	3,9	149,3
2011	2563	2076	469	23%	13%	2%	5%	5%	9,2	144,1
2012	2608	758	535	22%	13%	2%	5%	5%	3,8	145,4
2013	2415	709	510	25%	14%	1%	5%	5%	9,3	137,5
2014	2181	156	308	27%	15%	1%	3%	6%	11,4	134,0

Trend	-46%	-95%	3%	-15%	-22%	-53%	-49%	40%
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7.2.3 Uncertainties and time-series consistency

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

Quantity of disposed municipal solid wastes	>±10%
Degradable organic carbon	±20%
Fraction of Degradable Organic Carbon Decomposed	±20%
CH ₄ correction factor (=1)	-10 %, +0 %
CH ₄ content of landfill gases (0.5)	±5%
CH ₄ recovery	one order of magnitude
Half-life	±25%

The time series can be regarded as consistent.

(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).

7.2.4 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.

7.2.5 Recalculation

In this submission, following a recommendation of a European review team, wood waste with high degradable organic carbon content is considered as a separate category within MSW. In addition, amount of disposed industrial waste has been updated for 2013. Compared to the previous submission, new emission estimates are higher both for the base year (+1.7% or +40.6 kt in CO₂-eq) and for 2013 (+2.7% or 90.1 kt in CO₂-eq).

7.2.6 Planned improvements

It is planned to continue data collection on flaring.

7.3 Biological treatment of solid waste (CRF sector 5B)

Emitted gases: CH₄, N₂O

Key source: none

As composting is showing a growing tendency recently, GHG emissions were calculated and reported for this category also in the previous submission using the IPCC 2006 methodology. For this submission, the following changes have been made:

- Methane emission during anaerobic digestion at biogas facilities has been calculated the same way as in the previous submission, but only for biogas production reported as “other biogases from anaerobic fermentation” to the IEA. This means that landfill gas has been excluded from the calculations and possible leakages during sewage sludge gas production are taken into account under category 5D.

7.3.1 Methodological issues

The Tier 1 method from 2006 Guidelines was used with default emission factors.

Table 7.3.1 Activity data and emissions from biological treatment of solid waste

	Composting			Biogas facilities	
	MSW (kt)	Sludge (kt)	CH ₄ (kt)	N ₂ O (kt)	Biogas (TJ)
CH ₄ (kt)					
1985		20	0.20	0.01	
1986		20	0.20	0.01	
1987		20	0.20	0.01	
1988		20	0.20	0.01	
1989		20	0.20	0.01	
1990		20	0.20	0.01	
1991		20	0.20	0.01	
1992		20	0.20	0.01	
1993		20	0.20	0.01	
1994		20	0.20	0.01	
1995		28	0.28	0.02	
1996	18	29	0.36	0.02	
1997	19	26	0.34	0.02	
1998	18	23	0.30	0.02	
1999	18	32	0.39	0.02	
2000	17	30	0.37	0.02	6
2001	17	27	0.34	0.02	4
2002	47	37	0.56	0.03	4
2003	47	56	0.75	0.04	62
2004	39	24	0.40	0.02	107
2005	41	53	0.69	0.04	102
2006	58	43	0.66	0.04	129
2007	64	51	0.77	0.05	250
2008	85	62	0.96	0.06	490
2009	90	90	1.26	0.08	734
2010	148	82	1.41	0.08	898
2011	183	81	1.55	0.09	1336
2012	183	90	1.63	0.10	1105
2013	187	93	1.68	0.10	2042
2014	236	93	1.88	0.11	2018

The amount of composted municipal waste was received from the Hungarian Central Statistical Office. In 2014, 236.09 Gg waste was composted which represented 6% of all generated MSW.

As regards the amount of composted sludge, the time series of was constructed using the following data sources:

- Data published by the statistical office;
- Composting related information from the Waste Management Information System (the same database that is used for SWDS);
- Data from the Wastewater Information System (the same database that is used for emission calculations for wastewater treatment);
- For the period 1985-1993 we used a constant value corresponding to the amount reported for 1994.

In 2013 93.26 kt sludge was composted. The same amount was assumed for 2014 too.

As generally the calculations were carried out on dry weight basis, and the corresponding emission factors from Table 4.1 in the 2006 IPCC Guidelines were applied, some of the original data had to be converted to dry weight. Sludge data in the Waste Management Information System are categorized on the basis of their dry matter content which allowed this conversion. For composted municipal waste, 60% moisture content was assumed.

Our starting point for estimating methane emission from anaerobic digestion at biogas facilities was produced biogas from the energy statistics. The energy values (TJ) were then converted to mass of methane (kt) using the default calorific value of biogas, i.e. 50.4 TJ/Gg. Emissions of CH₄ due to unintentional leakages at biogas facilities were then assumed to be 5% as suggested by the 2006 IPCC Guidelines.

7.3.2 Uncertainties and time-series consistency

No category specific information is available.

7.3.3 Source-specific QA/QC and verification

The used data from Eurostat was compared with data from the Hungarian Central Statistical Office.

7.3.4 Recalculations

Landfill gas and sewage sludge gas production has been omitted from this category. This has not affected the base year emissions as biogas utilization began around 2000. Compared to previous submission, the new emission estimates for 2013 are lower by 24.3% or 30.6 kt in CO₂-eq.

7.3.5 Planned improvements

None.

7.4 Incineration of waste (CRF sector 5C)

Emitted gases: CO₂, CH₄, N₂O

Key source: none

7.4.1 Source category description

This subsector covers only emissions from thermal waste treatment without energy recovery (D10). Emissions from waste incineration for energy purposes (R1) are allocated to the energy sector.

During waste incineration, mainly CO₂ is emitted out of which only the fossil part contributes to the total emissions. (Biogenic CO₂ emissions were calculated as well but these were included only as memo items). Methane emissions are insignificant and N₂O generation is also minimal.

Table 7.4.1 Activity data and emissions from waste incineration

	Liquid	Clinical	Hazardous	Ind.sludge	Ind.solid	CO ₂	CH ₄	N ₂ O
	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]	[kt]
1985	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1986	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1987	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1988	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1989	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1990	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1991	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1992	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1993	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1994	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1995	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1996	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1997	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1998	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
1999	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
2000	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
2001	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
2002	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
2003	22.9	10.3	23.5	0.0	2.9	120.87	0.011	0.004
2004	22.9	10.3	23.5	0.0	2.9	119.77	0.011	0.004
2005	20.8	9.4	13.9	0.4	2.4	95.75	0.008	0.003
2006	44.1	6.9	16.5	0.1	2.1	164.76	0.008	0.003
2007	33.1	3.8	23.1	0.1	4.5	143.25	0.009	0.003
2008	31.1	5.5	23.8	0.3	4.4	140.47	0.010	0.004
2009	27.8	3.8	26.4	4.0	7.9	135.22	0.011	0.006
2010	38.7	7.6	26.1	5.3	8.0	167.76	0.013	0.007
2011	40.8	7.0	32.5	5.3	6.8	181.48	0.014	0.007
2012	42.5	3.7	33.8	6.1	7.1	186.95	0.013	0.008
2013	42.2	2.3	36.9	6.1	6.1	192.48	0.014	0.008
2014	43.4	2.3	38.0	5.1	8.0	198.14	0.015	0.008

(Only fossil CO₂ is included in the above table.)

7.4.2 Methodological issues

For estimating CO₂ emissions, the Tier 2 method was applied as country-specific data on waste amount, composition and management practices was used. The very 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 of which most was liquid.

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). Table 7.4.2 summarizes the used non-CO₂ emission factors for the different waste types.

Table 7.4.2 *The used non-CO₂ emission factors n*

	CH₄	N₂O
	[kg/kt]	[kg/kt]
SOLID INDUSTRIAL WASTE	300	100
CLINICAL	300	100
HAZARDOUS	300	100
LIQUID	0.56	9.8
INDUSTRIAL SLUDGE	9.7	450
SEWAGE SLUDGE	9.7	900

7.4.3 Uncertainties and time-series consistency

Consistency of the time series needs to be investigated, as constant values are used for the years before 2004.

7.4.4 QA/QC information

Data taken from the Hungarian Waste Management Information System for the calculations are compared with the relevant data published by the domestic statistical office and by Eurostat. As most part of waste incineration occurs with energy recovery, even if the resulting emissions are accounted for in the energy sector it is worth mentioning here that the IEA and ETS data were cross-checked, and also the biggest incinerator plant is contacted once in a while for verification purposes.

7.4.5 Recalculations

Amount of incinerated clinical waste has been updated for years 2012 and 2013 on the basis of the latest information contained in the Hungarian waste information system. The effect of the recalculation was minor in 2013: the new estimates are lower by 2.3% or -4.5 kt.

7.4.6 Source-specific planned improvements

None.

7.5 Wastewater treatment and discharge (CRF sector 5D)

Emitted gas: CH₄, N₂O

Key source: CH₄: Level, N₂O: Level

7.5.1 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 N₂O emissions from human sewage are also part of the inventory.

7.5.2 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. 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 BOD₅ = 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.

Total organics produced by industrial facilities is partly taken into account with the default correction factor I (=1.25) corresponding to additional industrial BOD discharged into sewers thus accounted for in the domestic category. The activity data in the industrial wastewater category were the total output of wastewater [1000m³/year], the emitted total organic wastewater [kg COD/year] and in some cases the organic load (kg BOD/day) 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.

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 2005-2013. The following conclusions could be drawn:

- Recently, 140 to 240 million cubic meter wastewater from industrial facilities was discharged into rivers and seas. On average, 60% of this amount had either no treatment or only mechanical treatment beforehand (trend decreasing);
- The average COD content of the above, only partially treated wastewater was as low as 0.05 kg/m³.

- On average, about 30 million m³ 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/m³ in 2008-2011.
- Domestic and commercial wastewater treatment plants, (that also treat industrial wastewater), discharge yearly 440 to 580 million m³ 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 65% in 2005, and to 96-98% in 2010-2014;
- In line with the above development, the average BOD₅ content of the discharged wastewater decreased from 0.15 kg/m³ in 2005 to 0.02 kg/m³ in 2013.
- Activity data for the industrial wastewater category were partly taken from the Wastewater Information System database. For earlier years, before 2008, activity data were extrapolated using proxy data, i.e. volume of water supplied to other than household consumers published by the statistical office. (see http://www.ksh.hu/docs/eng/xstadat/xstadat_annual/i_uw004.html) For the period 1985-1990, constant values are used

Table 7.5.1 Municipal wastewater discharge and treatment (1990–) [1000 m³]

Year	Total volume of waste water		Volume of waste water discharged to public sewerage or transported directly to public waste water treatment plant and treated			
	discharged to public sewerage	discharged to public sewerage and conducted	only with mechanical	also with biological	also with advanced	total
1990	877,187	779,373	475,968	280,426	22,979	779,373
1991	826,978	739,433	450,224	267,869	21,340	739,433
1992	787,879	713,278	449,544	244,066	19,667	713,278
1993	709,786	644,838	389,484	236,192	19,162	644,838
1994	652,960	593,778	344,383	235,859	13,536	593,778
1995	639,697	583,444	325,451	244,992	13,001	583,444
1996	608,372	520,984	265,888	239,665	15,431	520,984
1997	570,615	488,782	231,634	245,386	11,762	488,782
1998	549,843	487,769	222,593	232,777	32,400	487,769
1999	588,460	523,269	224,673	261,597	36,998	523,269
2000	530,484	479,192	168,910	252,978	57,304	479,192
2001	519,549	480,214	197,629	222,229	60,355	480,214
2002	525,179	491,667	185,064	214,865	91,738	491,667
2003	525,082	486,501	142,451	182,455	163,383	488,288
2004	557,456	534,260	165,074	193,404	177,357	535,835
2005	588,064	558,245	174,815	188,779	196,784	560,378
2006	567,303	532,938	152,939	249,641	133,379	535,959
2007	533,889	508,082	128,143	217,654	165,186	510,983
2008	542,106	516,796	135,845	204,820	179,123	519,787
2009	529,022	505,069	123,512	201,941	182,073	507,525
2010	556,338	551,207	17,607	280,760	255,008	553,375
2011	467,594	464,170	8,930	219,184	237,848	465,963
2012	435,692	429,355	831	106,293	324,523	431,647
2013	497,930	482,997	759	108,799	375,327	484,885
2014	500,882	481,057	552	109,651	372,580	482,783

Source: Hungarian Central Statistical Office:

http://www.ksh.hu/docs/eng/xstadat/xstadat_annual/i_uw005.html

Last year we had the possibility to look also into detailed reports of wastewater facilities of different industrial plants. Special emphasis was given to industries with high COD output, e.g. food and beverage, paper and pulp, chemical industry etc. By analyzing organic load data before treatment we were able to introduce the following country-specific data on industrial wastewater as summarized in Table 7.5.2 below:

Table 7.5.2 *The used data for industrial wastewater*

	BOD
	[kg/m3]
Pulp and paper	2
Starch	1.14
Sugar	3.4
Pharmaceutical	1.5
Beer	1.5
Meat	1
Dairy products	1.5
Vegetable oils	0.85
Wine	5.27
Fruits	2.9
Chemical industry	0.25
Coke production*	5
Oil refinery*	1

**refers to COD*

As for industrial wastewater generally COD values are used, the above BOD values were converted using a conversion factor of 2.4. Please note, as we expect more data from individual facilities, the above data might be subject of changes.

Emission factors

For the calculation of the emission factor (EF), default maximum CH₄ producing capacities of 0.25 kg CH₄/kg COD and 0.6 kg CH₄/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 38% now it's around 75%. 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 all 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 0.05 (for secondary treatment) and to 0.0 (tertiary treatment) were applied up to 2004, thus to allow some emissions in case of incidental overload, and more importantly, to reflect modernization in the sector. (In the previous submission, the default

MCF value of 0.1 was applied for direct discharge into rivers and lakes. This was abolished following a recommendation of a European review team, since it can be assumed that flowing rivers (such as the Danube) are not oxygen-deficient.)

- Based on the energy statistics, sewage sludge gas utilization started in 2001 in Hungary. As unintentional leakage might occur during anaerobic digestion of sewage sludge, some CH₄ emission are added to this category. The same methodology was used as for the category 5B Biological treatment of solid waste, i.e. 5% leakage was assumed.

All the above considerations, used parameters and the resulting emissions are summarized in Table 7.5.3

Table 7.5.3 Domestic and industrial wastewater treatment (1985-2014)

	Domestic				Industrial		Biogas	
	TOW kt BOD	primary	secondary	advanced	CH ₄ [Gg]	TOW kt COD	CH ₄ [Gg]	production [TJ]
1985	254.3	55%	28%	0%	29.2	216.6	5.4	
BY	253.7	55%	29%	0%	29.8	216.6	5.4	
1986	253.8	55%	29%	0%	29.8	216.6	5.4	
1987	252.9	55%	30%	0%	30.4	216.6	5.4	
1988	252.2	55%	30%	0%	31.0	216.6	5.4	
1989	251.6	55%	31%	0%	31.5	216.6	5.4	
1990	250.8	54%	32%	3%	32.1	216.6	5.4	
1991	251.1	54%	32%	3%	31.8	204.6	5.1	
1992	251.4	57%	31%	2%	31.3	192.7	4.8	
1993	251.5	55%	33%	3%	31.0	180.7	4.5	
1994	251.4	53%	36%	2%	30.7	168.8	4.2	
1995	251.4	51%	38%	2%	30.4	156.8	3.9	
1996	251.8	44%	39%	3%	30.0	120.9	2.7	
1997	252.1	41%	43%	2%	29.6	117.5	2.4	
1998	252.3	40%	42%	6%	29.1	112.6	2.0	
1999	252.4	38%	44%	6%	28.7	109.2	1.6	
2000	252.4	32%	48%	11%	28.3	112.3	1.4	
2001	253.3	38%	43%	12%	27.5	106.1	1.3	86
2002	254.0	35%	41%	17%	26.3	107.8	1.3	132
2003	254.9	27%	35%	31%	24.8	108.0	1.3	135
2004	256.0	30%	35%	32%	23.6	105.0	1.3	173
2005	257.1	30%	32%	33%	20.6	97.7	1.2	193
2006	257.9	27%	44%	24%	19.5	93.1	1.2	337
2007	258.9	24%	41%	31%	18.3	90.5	1.1	365
2008	259.0	25%	38%	33%	17.3	84.9	1.1	337
2009	259.2	23%	38%	34%	16.4	85.5	1.1	441
2010	258.9	3%	50%	46%	15.5	85.5	1.1	419
2011	258.4	2%	47%	51%	14.9	92.5	1.2	742
2012	257.8	0%	24%	74%	14.8	84.4	1.1	917
2013	257.7	0%	22%	75%	14.4	86.1	1.1	702
2014	257.9	0%	22%	74%	14.0	86.1	1.1	587

As regards emissions from sludge treatment, our approach is as follows. It is assumed that whenever anaerobic digestion of sludge takes place, the generated methane (reported as sludge gas in the energy statistics) is recovered and used for energy purposes. The amount of methane recovered for energy is reported in CRF Table 5D but this amount was not subtracted from the total emissions as no additional methane emission from sludge digestion was taken into account in the above calculations.

It has to be emphasized that emissions from sludge treatment (besides leakage at biogas facilities) are taken into account in other emission categories:

- Landfilled sewage sludge is accounted for in the 5A Solid waste disposal in landfills category;
- Composted sewage sludge is taken into account in the 5B Biological treatment of solid waste category;

Nitrous oxide emissions from effluents were calculated applying the default method, i.e. Equation 6.8 from the 2006 IPCC Guidelines with all the default parameters. However negligible, we have also added nitrous oxide emissions from advanced centralized wastewater treatment plants using the method described in Box 6.1 in the 2006 IPCC Guidelines. Our results are summarized in Table 7.5.4

Table 7.5.4 Protein consumption and all the resulting N₂O emissions

	Protein	N₂O effluent	N₂O plants
	[g/day]	[Gg]	[Gg]
1985	106.1	114.93	
BY	107.3	115.75	
1986	106.4	114.83	
1987	109.4	117.50	
1988	107.8	115.28	
1989	108.8	115.87	
1990	104.7	110.98	0.00
1991	100.5	106.50	0.00
1992	101.1	107.16	0.00
1993	94.8	100.43	0.00
1994	91.3	96.55	0.00
1995	87.0	91.87	0.00
1996	84.4	89.01	0.00
1997	87.7	92.33	0.00
1998	87.2	91.66	0.00
1999	89.5	93.78	0.00
2000	96.6	100.92	0.00
2001	93.9	97.88	0.00
2002	93.5	97.23	0.00
2003	103.0	106.76	0.01
2004	101.0	104.42	0.01
2005	105.4	108.77	0.01
2006	104.6	107.72	0.01
2007	101.3	104.21	0.01
2008	100.6	103.27	0.01
2009	99.5	102.00	0.01
2010	95.8	98.04	0.01
2011	93.6	95.52	0.01
2012	93.4	94.79	0.02
2013	92.1	93.26	0.02
2014	92.1	92.95	0.02

7.5.3 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 B0	-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 Bo :	-30 % to + 30 %
Uncertainty of N ₂ O emissions	
Emission factor	order of 2
Per capita protein consumption	±10%
Used factors	±20%
Source: according to the recommendations of the Revised Guidelines and 2006 Guidelines, on the basis of expert estimates	

The time series of emissions are most probably consistent.

7.5.4 QA/QC information

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

7.5.5 Recalculation

Generally, in this submission MCF=0 is used for discharged wastewater into open waters either untreated or treated. This new approach is due to a recommendation of a European expert review team. In the previous submission, MCF=1 was assumed for all directly discharged untreated wastewater into rivers. In addition, some (minor) CH₄ emission was calculated also on the basis BOD or COD contents of the discharged wastewater from treatment plants into open waters with an MCF value of 0.1 representative of sea, river, and lake discharge.

The new emission estimates are generally lower. The effect of recalculation was bigger for the base year when more untreated wastewater was discharged into rivers. Methane emission became lower by 13.6% (-138.6 Gg in CO₂-eq) in 1985-87. Changes were more limited for recent years as most domestic wastewater is treated now and the lower emission estimates due to application of MCF=0 value is somewhat compensated by the reallocation of leakage emissions of sewage sludge gas production facilities from category 5B. In 2013, methane emissions decreased only by 0.6% due to recalculations.

Also protein consumption data for the year 2013 was updated which led to minor changes in N₂O emissions in this category (-1.3%).

7.5.6 Planned improvements

More analyses of the industrial wastewater treatment facilities are planned to confirm or modify data in Table 7.5.2 above.

8. Chapter 8: Other (CRF sector 6)

Not in use.

9. Chapter 9: Indirect CO₂ and nitrous oxide emissions

Not applicable in this submission.

10. RECALCULATIONS AND PLANNED IMPROVEMENTS

Since the previous submission, the methodologies provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories have been used in a consistent manner. The switch to the new methodological framework led to recalculations in every sector for the whole time series. The most fundamental changes were implemented for the previous submission. This time, rather the usual refinements have been carried out as even in normal years, i.e. without fundamental changes in the methodological background, recalculations of some data-series of the inventory occur and 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 the autumn of 2015, Hungary voluntarily took part in a trial review of the 2015 submission carried out by EU experts. Some of the recalculations listed below can be regarded as implementation of the (informal) recommendations from this review.

ENERGY

- The latest version of the Annual IEA/Eurostat Questionnaires submitted to Eurostat in November 2015 were used as activity data. All the changes in the energy statistics, especially in the period 2011-13, are reflected in the current inventory;
- Some of the above changes affected some of the automatic reallocations that usually depend on the energy use of the most recent years:
 - Less gasoil has been reallocated from road transport to off-road machinery;
 - More natural gas has been allocated to pipeline transport;
- To be consistent with the approach in the CL RTP inventory, all gasoil used in other industries (1A2g) has been allocated off-road machinery;
- The most up-to-date database received from Eurocontrol has been used for the period 2005-2014. This also had some minor effect on the fuel use (and consequently on the emissions) of the previous years due to the built-in extrapolation procedures.
- Double counting was detected with the category 5C Incineration and Open Burning of Waste therefore the corresponding emissions were removed from 1A4a for the years 2012-2013.

The overall effect of the recalculations was negligible for almost all the years; it reached 0.1% only in 2011 and 2013.

INDUSTRIAL PROCESSES AND PRODUCT USE

- **2A3 Glass** - Recalculation due to inclusion of +10% CO₂ emission covering the potential glass manufacturers not included in EU ETS as recommended by the informal review organized by the EU in November 2015.

	CO ₂ EM in 2A3 Glass in 2015 OCT submission	CO ₂ EM in 2A3 Glass in 2016 submission	<i>Diff</i>	<i>Diff</i>
	Gg CO ₂	Gg CO ₂	%	Gg CO ₂
B.Y.	86.06	94.66	10%	8.61
1990	74.62	82.09	10%	7.46

1995	73.67	81.04	10%	7.37
2000	69.47	76.42	10%	6.95
2005	73.30	80.63	10%	7.33
2006	75.27	82.80	10%	7.53
2007	76.15	83.76	10%	7.61
2008	62.98	69.28	10%	6.30
2009	53.97	59.37	10%	5.40
2010	50.69	55.76	10%	5.07
2011	50.82	55.90	10%	5.08
2012	54.42	59.86	10%	5.44
2013	52.48	57.73	10%	5.25
2014	53.46	58.81	10%	5.35

- **2A4d Waste gas scrubbing** - During the informal review organized by the EU in November 2015, it was noted that an installation is also included where there the waste gas scrubbing technology do not result CO₂ emissions. The data of this installation is now eliminated and time-series are therefore recalculated.

	2015 OCT submission	2016 submission	Diff	Diff
	Gg CO ₂	Gg CO ₂	%	Gg CO ₂
2002	115.54	115.54	0%	0.00
2003	138.69	138.69	0%	0.00
2004	170.81	170.81	0%	0.00
2005	223.93	222.10	-1%	-1.84
2006	217.14	214.35	-1%	-2.79
2007	220.01	217.02	-1%	-2.99
2008	208.37	205.71	-1%	-2.67
2009	194.65	192.62	-1%	-2.04
2010	191.13	189.17	-1%	-1.96
2011	212.63	210.42	-1%	-2.21
2012	207.75	205.33	-1%	-2.42
2013	205.11	203.93	-1%	-1.18
2014		186.83		

- **2C1 Iron and steel** - CH₄ emissions from Natural Gas use in subsector 2C1d-e Sinter is included due to the recommendation received during the informal review organized by the EU in November 2015

	2015 OCT submission	2016 submission	Diff	Diff
	Gg CO ₂ eq	Gg CO ₂ eq	%	Gg CO ₂ eq
B.Y.	4587.17	4587.18	0.0001%	0.005
1990	3160.26	3160.26	0.0001%	0.004
1995	2611.47	2611.48	0.0001%	0.004
2000	1666.10	1666.10	0.0002%	0.003

2005	1546.91	1546.91	0.0003%	0.004
2006	1565.04	1565.04	0.0002%	0.003
2007	1495.26	1495.26	0.0002%	0.003
2008	1474.30	1474.30	0.0002%	0.003
2009	1181.60	1181.60	0.0002%	0.003
2010	1289.29	1289.29	0.0002%	0.003
2011	1331.16	1331.16	0.0002%	0.003
2012	1205.26	1205.27	0.0003%	0.003
2013	728.28	728.28	0.0005%	0.003
2014		907.76		

- **2D1 Lubricant use** - Activity data of the year 2013 has been changed in the case of Lubricants as it was recommended by the informal review organized by the EU in November 2015.

2013		
2015 OCT submission	Gg CO2 eq	0
2016 submission	Gg CO2 eq	9.34

- **2D3 Other** – Indirect CO2 emissions from the sectors reported before 2015 submission have been included again from 2016 MARCH submission.
- **2F1 RACHP** - The sum of emissions did not change, but the division of emissions within the 6 subsectors have slightly been changed as it was recommended by the informal review organized by the EU in November 2015. In MAC subsector solely HFC-134a is now reported and other HFCs are allocated into other subsectors within 2F1.
- **2F3 Fire** - A mistype error has been corrected affecting solely year 2012 and 2013 that caused less than 1 Gg increase of emissions.

		2012	2013
2015 OCT submission	t	0.9971	0.8506
2016 submission	t	1.1554	1.1092
Diff	t	0.1583	0.2586
Diff	Gg CO2 eq	0.5541	0.9050
Diff	%	16%	30%

- **2F4 MDI&Aerosols** - Emissions are not changed but rows “filled into new products” within 2F4 sector have also been filled in within CRF as it was recommended by the informal review organized by the EU in November 2015.

AGRICULTURE

As a result of the 'Trial review of the 2015 greenhouse gas inventory of Hungary under the Effort Sharing Decision' (hereafter trial ESD review, 2015) conducted in October 2015 and the 'Step 1, EU review of the 2016 greenhouse gas inventory of Hungary under the Effort Sharing Decision' (hereafter Step 1, ESD review, 2016) a number of minor changes were implemented in this submission of the agricultural inventory. Additionally, the annual standard QC procedure also resulted in some slight changes. In some cases the required modifications caused additional corrections in other subsectors (e.g. revision of the nitrogen excretion rate for Rabbits affected the direct and indirect emissions from 3.B as well as 3.D).

Revisions of volatile solid excretion rate (VS) for Swine and maximum methane producing capacity (B_o) for Cattle reduced significantly from 3.B. Compared to the CH_4 , revision of factors used to estimate N inputs from crop residues and fraction of removal due to burning as fuel, N input from animal manure and fractions of irrigated and humid regions resulted in a raise in the N_2O emissions from 3.D.

Revisions by sub-categories are as follows:

3.A Enteric Fermentation

In response to an informal recommendation of the Trial ESD review, 2015 the county-specific methane conversion factor (Y_m) for dairy cattle was recalculated based on a related publication (Soliva, 2006) for the whole time series. As in the previous submissions the same methodology was used for non-dairy cattle, these Y_m values were also revised for the 2016 submission.

Revision of methane conversion factors for dairy cattle and non-dairy cattle resulted in a 5.2% increase in the BY emissions which equates to 209.3 kt CO_2 -eq. In 2013 emissions increased by 4.7% (86.2 kt CO_2 -eq).

3.B Manure Management CH_4

- As a result of the Step 1 ESD review, 2016 the volatile solid excretion rate (VS) for Swine was revised. The formerly applied default value of the 2006 IPCC Guidelines for breeding swine ($0.5 \text{ kg head}^{-1} \text{ day}^{-1}$) was replaced with another default from the Guidelines for market swine ($0.3 \text{ kg head}^{-1} \text{ day}^{-1}$) for the whole time series. Revisions of CH_4 emissions from swine resulted in 25% (545.6 kt CO_2 -eq) and 26% (273.5 kt CO_2 -eq) decrease in the total emissions from 3.B in the BY and in 2013, respectively
- As a result of the Step 1 ESD review, 2016 CH_4 emissions from 3.B Manure management from non-dairy cattle was recalculated due to the revised values of maximum methane producing capacity (B_o) for Non-Dairy Cattle. The formerly incorrectly applied value of 0.24 was replaced with 0.17 for the whole time series. The overall effect of recalculations of CH_4 emissions from Non-Dairy Cattle on total emissions from 3.B were decreased by 6.5% (142.1 kt CO_2 -eq) and 5.8% (62.0 kt CO_2 -eq) in the BY and 2013, respectively.
- Methane conversion rate (MCF) for Dairy Cattle liquid manure was recalculated, because the Trial ESD review, 2015 revealed the fractions of natural crust cover was take into account inconsistently in the calculation of CH_4 and N_2O emissions. For the 2016 submission this error was corrected, which resulted in an increase of the MCF for Dairy Cattle liquid manure from 10.7% to 12.2%. This revision resulted in a slight increase in the CH_4 emissions (in 2013 0.6%, 6.2 kt CO_2 -eq).
- Additionally, due to the Trial ESD review, 2015 the MCF for Cattle, Swine and Poultry manure treated in anaerobic digesters was revised, and the formerly applied value of 2% was replaced with the values for liquid slurry due to the lack of enough information to calculate

MCF values according to the equations of the 2006 IPCC Guidelines. This revision resulted in an insignificant increase in the resulted CH₄ emissions.

CH₄ emissions from 3.B Manure Management decreased by 35.5% (686 ktCO₂-eq) and 34.0% (326 kt CO₂-eq) in the BY and in 2013 respectively. The impact of this revisions resulted in a 0.6% decrease in national total emissions in 2013.

3.B Manure Management N₂O

- For category 3.B.4 Direct N₂O emissions due to rabbits were recalculated for the whole time-series. The formerly used nitrogen excretion rate was modified to bring it in line with the 2006 IPCC Guidelines. This revision led to a slight increase in the direct N₂O emissions from 3.B in the full time series (11.3%, 29 kt CO₂-eq in 2013).
- Indirect N₂O emissions from N losses due to volatilization from manure management were revised due to the revision of NH₃ and NO_x emissions from 3.B in the CLRTAP inventory. The recalculation of indirect emissions from 3.B resulted in a 4.8% and 7.0 kt CO₂-eq increase in the indirect N₂O emissions from 3.B in 2013.
- For category 3.B.5 Indirect N₂O emissions due to leaching and run-off for the whole period notation key 'NO' was replaced by 'NE' as these emissions are not reported due to lack of T1 methodology.

The overall increases of N₂O emissions from 3.B was 6.6% (59 kt CO₂-eq) in the BY and 9.0% (36 kt CO₂-eq) in 2013.

The net effect of recalculations in 3.B resulted in a -22.2% (626 kt CO₂-eq) decrease in the BY and 23.5% (394 kt CO₂-eq) decrease on average in the period 1990-2013. The overall effect of recalculations on national total emissions (excluding as well as including LULUCF) is a decrease by 0.6% and 0.5% in the BY and in 2013, respectively.

3.D. Agricultural soils N₂O

3.D.a Agricultural soils/Direct emissions

- Recalculation of emissions from 3.D partly arose from the revisions in 3.B. Change in the nitrogen excretion rate for Rabbit for the full time series caused an increase in the total amount of organic N fertilizers applied to soils (F_{ON}), while the modification of the indirect emissions partially offset the resulted overall increase in F_{ON}. As a result of these revisions emissions from 3.D.a.2.a increased by 9.8% (83.8 kt CO₂-eq) in the BY and 12.3% (51.6 kt CO₂-eq) in 2013.
- As a result of our standard QC procedure CRF category 3.D.a.3 Urine and dung deposited by grazing animals was recalculated, because in the former submission emissions from Buffalo were calculated using the emission factor EF_{3PRP,SO} instead of EF_{3PRP,CPP}. This recalculation led to an insignificant (less than 1kt CO₂-eq) increase in the emissions.
- Recalculations undertaken in the emissions from crop residues and forage/pasture renewal in the 3.D.a.4 sub-sector for the full time series summed up to 113.1 kt CO₂-eq (17.8%) higher emissions in 2013. The change in the BY is 14.5% (84.3 kt CO₂-eq). Recalculations were due to the findings of the Trial EU ESD review, 2015. Parameters to estimate N added to soils for some crops were revised in line with TERT's suggestions. Additionally, the formerly used estimate on fraction of above-ground residues of crop removed annually for burning in power plants was omitted due to insufficient data, thus no removal for burning as fuel was assumed in this submission.
- N₂O emissions from 3.D.a.5 Mineralization was recalculated to ensure the consistency with the reported carbon stock changes in mineral soils in category 4.B.1 Cropland remaining Cropland.

All of these recalculations impacts on the emission estimates for category 3.D.2 Agricultural Soils Indirect emissions.

3.D.b Agricultural soils/Indirect emissions

- Emissions from 3.D.b.1 Atmospheric Deposition was revised for the whole time-series due to change in the N-inputs from organic manure as well as the change in the fraction of N emitted as NO_x and NH_3 ($\text{Frac}_{\text{GASM}}$). The first one is the consequence of the changes delineated regarding to the 3.B and 3.D.a sectors, while changes in the $\text{Frac}_{\text{GASM}}$ is the effect of the recalculated NO_x and NH_3 emissions in the CLRTAP inventory. The changes in the emissions from 3.D.b.1 Indirect emissions from atmospheric deposition are insignificant, and negative in some years and positive in other years. Emissions changed 6.6 kt CO_2 -eq on average in the full time series.
- There have been a significant changes made within the category 3.D.b.2 Nitrogen leaching and run-off because of the revision of irrigated areas and humid regions, where $\text{Frac}_{\text{LEACH-H}}$ is non-zero. This revision was a consequence of findings of the Trial EU ESD Review, 2015 and led to a significant increase in the amount of N that is leached annually, and the subsequent N_2O emissions. The increase in the emissions due to the recalculation was 111 kt CO_2 -eq in the BY and 66 kt CO_2 -eq on average for the whole time series.

The overall changes in the N_2O emissions from 3.D.b due to these revisions range between 47 and 113 kt CO_2 -eq.

Emissions from 3.D increased by 5.9% (281.4 kt CO_2 -eq) and 8.7% (256.1 kt CO_2 -eq) in the BY and in 2013 respectively. Impact of recalculations in 3.D on total national emissions (excluding LULUCF) was an increase by 0.3% in the BY and 0.4% in 2013.

3.G CO_2 emissions from liming for the year 2012 was revised due to the change in the activity data.

The overall impact of recalculations in the Agriculture sector resulted in a 1.1% (135.8 CO_2 -eq) decrease in the BY, -1.9% (125.6 kt CO_2 -eq) decrease on average in the period 1990-2011 and 0.6% (36.7 kt CO_2 -eq) increase on average for the years 2012 and 2013. The impact of recalculations on national total emissions (excluding as well as including LULUCF) was an increase by 0.1% in the BY as well as in 2013. The decrease in the CH_4 emissions from 3.B was partially offset by increases in N_2O emissions from 3.D. Thus, changes are more significant discussing the CH_4 and N_2O emissions separately. CH_4 emissions decreased by 7.9% (476 kt CO_2 -eq) in the BY and 8.5% (239.4 kt CO_2 -eq) in 2013. In contrast, the N_2O emissions increased in similar degree. In the BY and 2013 agricultural N_2O emissions increased by 6.0% (340.4 kt CO_2 -eq) and 8.8% (292.4 kt CO_2 -eq), respectively. CO_2 emissions were recalculated for 2012, resulting in a negligible change in the emissions.

LULUCF

Forest Land

- Losses of carbon in biomass on land converted to Forest Land and on AR land are reported for the first time.
- HWP estimates under the Kyoto Protocol have been revised following a recommendation raised on the 2016 JRC LULUCF Workshop.
- Updated technical correction of the FMRL due to revised HWP estimates.

Cropland:

- Land use and land use change data for years 2006- 2014 were revised using the CLC 2012 dataset.
- The formulas for the L-CL subcategory for years 1985- were corrected, and used the corrected formula afterwards, to estimate N_2O emissions from soils due to N-mineralization in mineral soils.

Grassland:

- Land use and land use change data for years 2006- 2014 were revised using the CLC 2012 dataset.
- Sector-specific recalculations were made to correct mistakes in the formulas to estimate emissions from the biomass pool.

Wetland:

- Land use and land use change data for years 2006- 2014 were revised using the CLC 2012 dataset.
- Category-specific recalculations were made due to new input data in area of peat extration and in the amount of extrated peat biomass.

Settlements:

- Land use and land use change data for years 2006- 2014 were revised using the CLC 2012 dataset.

WASTE

- 5A: The Hungarian municipal waste composition statistics usually does not contain a separate category for wood. For this submission, it was assumed that within the municipal waste category about half of the "bulky waste" (EWC 200307) is similar to wood waste and was as such included into the IPCC waste model. The amount of industrial waste has been updated for 2013.
- 5B: As the EU trial review pointed out, some double counting occurred in the previous submission as regards biogas leakage. In this submission, leakage from only 'other' biogas production is taken into account in the category 5B Biological Treatment of Solid Waste. Landfill biogas has been removed, and leakage from sludge digestion has been reallocated to 5D.
- 5C: Amount of incinerated clinical waste has been updated for 2012-13.
- 5D: Following a recommendation from the EU review, MCF=0 is used now (instead of MCF=0.1) for river and lake discharge as Hungarian rivers and lakes cannot be considered as oxygen-deficient aquatic environment.

The overall effect of the above recalculations in the waste sector was a decrease of 2.6% (-98 Gg CO₂-eq) in the base year and an increase of 1.1% (49.4 Gg) in 2013.

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11. KP-LULUCF

11.1 General information

According to relevant provisions, 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 6). These provisions set principles to govern the treatment of LULUCF activities; require a consistent definition for terms such as “forest”, as well as definitions for activities under Article 3.3 and agreed activities under Article 3.4; and describe 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 given in IPCC (2013).

Hungary started, in 2006, 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) where, among others, Hungary reported the election of an activity under Art. 3.4, i.e., Forest Management (FM) for the first commitment period, and broadly defined both FM and “forest”.

This part of the NIR provides 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 6 of the NIR.*

As Hungary only elected FM under Art. 3.4 for the first commitment period (it is obligatory to report on FM in the second commitment period), and no other activity has been elected for the second commitment period, 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 reported in our both Initial Reports (i.e., 2006 and 2016), Hungary has elected elements and single minimum values for „forest” according to Table 11.1. We note that these elements have not been changed since, and are the same for, the first commitment period.

Table 11.1 Definition of “forest” with prescribed characteristics and the justification of the chosen values.

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
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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. The width of 10m typically 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 managerial 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 are exactly the same as those 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.

With respect to origin, forests in Hungary are:

- planted, when the propagation material (seeds, cuttings or seedlings) is artificially put in the soil;
- semi-natural, when the propagation material comes from the mature, harvested trees of managed forests during an assisted natural regeneration, or when parts of these trees (roots and stumps) serve as sources of the regenerating shoots of a new generation of trees after harvest; and
- natural, when the entire regeneration process, which includes the production of propagation material of any sort, happens due to natural processes.

Based on the above, Hungary defines “**planted forests**” under the provisions of Decision 2.CMP/7 as forest plantations with artificially regenerated, short rotation (<40 years) species and long rotation species of coppice origin. All other forests, whether managed or not (such as forest reserves, see section 11.1.3.3 below) are considered “**natural forests**”.

11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

As stated in both of our Initial Reports, as well as above, Hungary only elected FM under Article 3, paragraph 4 for the first commitment period, and no other activities under Art. 3.4 have been elected for the second commitment period.

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 Chapter 6, all forests can be regarded as “managed”. Beginning 2015¹, all forests in each new inventory year that are identified in the reporting year and are classified as “found forests” (FF) are included under FM.

The total area within the forestry sector under the KP is split among 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 plus FF.

In the remaining parts of this section, first we define each activity, then provide details of the methodology of the estimation of emissions and removals. Note that for the development of carbon stock changes of most pools, most methodological information is discussed in Sections 6.4 and 6.5. Both the definitions and methods of estimation are consistently applied throughout the period 1990-2014.

The evolution of the area of AR, D and FF is demonstrated in Figure 11.1, whereas that of FM is demonstrated in Figure 11.3 below.

¹ This decision is consistent with the suggestion of the ARR of 2013.

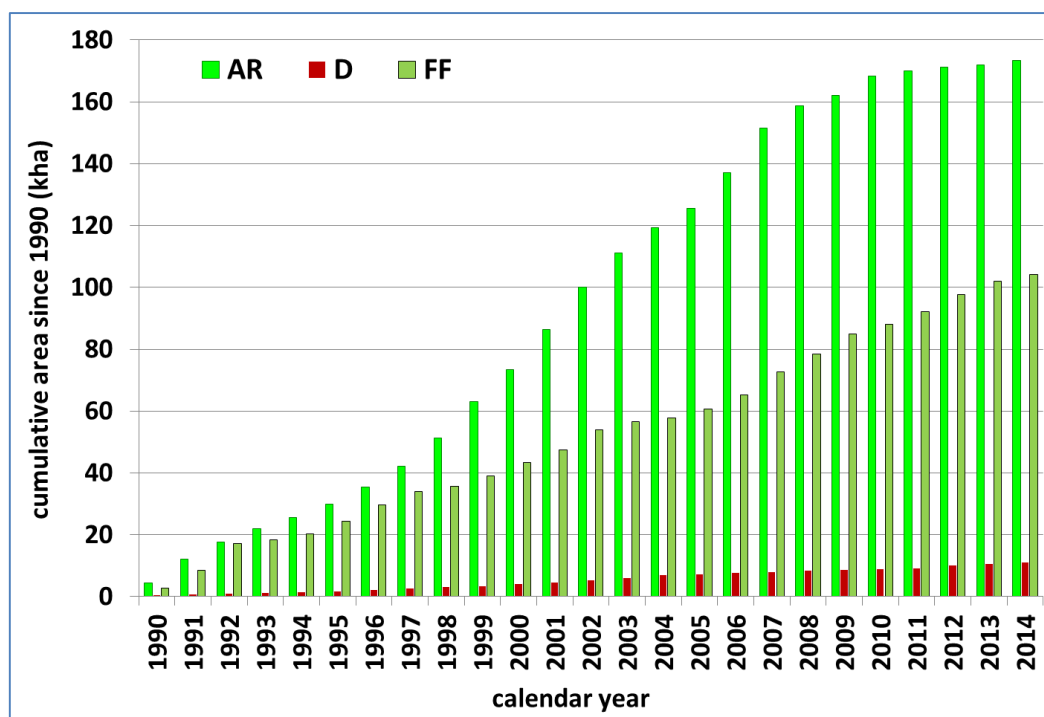


Figure 11.1. The evolution of the cumulative area of AR, D and FF between 1990 and 2013.

11.1.3.1 Definition and identification of “AR since 1990”

In general, AR is an activity with the objective to establish “forest” as 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 through direct human induced activity since 1990. No AR land has been deforested in Hungary so far. As required by relevant provisions, AR can only include forest that can be demonstrated to have originated due to direct human induced activity. Therefore, in some years, the area of this category increases less than the L-FL category which includes increases of forest area due to both human-induced and natural causes.

In Hungary, afforestations are done in three steps. The first step is to do site preparation and, after that, 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 when 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 6). 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. In any event, an area becomes part of AR when the first step is completed.

However, note that we began to identify “AR since 1990” areas by considering the database of the above certificates. It was found during the analysis that some of the certified areas have not yet entered, or could not be identified in, the NFD (i.e. in the 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 proved to be unsuccessful. 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, and for which a proof exists that the afforestation was indeed successful.

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 by an inventory year 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.

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 Hungarian Forest Act, all afforestations become subjects to FM right away as they enter the AR category. Thus, all forests under AR since 1990 are subject to 3.4 FM.

We also note here that the category “AR since 1990” includes the areas of stands that were actually afforested (i.e., the area of forest subcompartments), but not adjacent roads or other areas that are not covered by trees, see section 11.2.2 below.

Finally, we note again 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 the fact that not all increases are due to direct human induced activities, and that we find forests (i.e., FF) each year as explained later.

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 thus 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. (Note that all possible emissions are accounted for on D land in the year of the deforestation, therefore, no emissions can be expected on any of the land that was deforested before 2008, and no removals are accounted for, either, on this land in order to be conservative. Therefore, we believe that the ignorance of the location of land deforested before 2008 presents no risk at all of underestimation of emissions.)

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 as reported in the CRF tables; see also Figure 11.2.

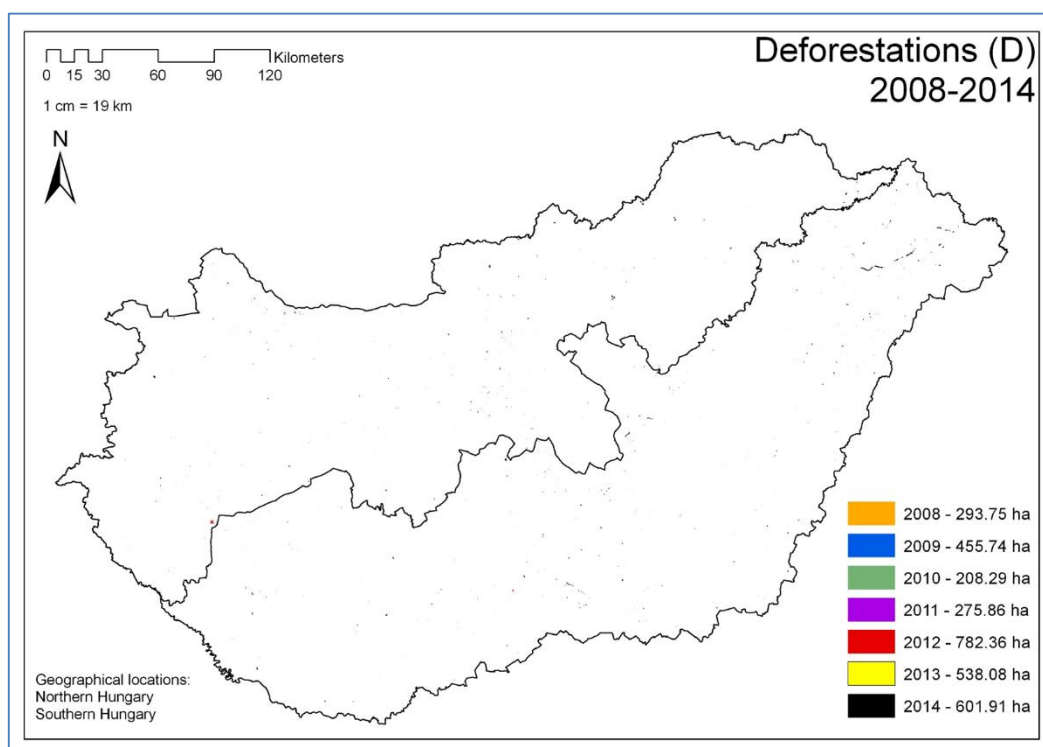


Figure 11.2. The spatial distribution of deforested land 2008-2014.

It is noted here that, just like with AR, D areas only include the area of stands, which in the case of deforestation are those with tree cover that have been actually 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 below.

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). 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.” The most recent 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 and 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.)

“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 all forests are managed rather intensively, although the 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 subcompartment (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 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 of the high rate of wood utilization, 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⁻², 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 whatsoever. 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.

Activities that are carried out in all Hungarian forests also include preparing forest management plans, surveying and inspecting stands regularly.

Because one or several of the above activities are carried out in each known stand each year, all forests in Hungary are regarded as “*managed since 1990*”.

The above also means that Hungary applies a *broad definition* of “Forest Management” under Art. 3.4 of the KP.

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 and adding FF areas in subsequent years. It thus excludes D areas, but includes all land that, with the exception of AR, increased forest area (see also Chapter 6.2). FF are young, and are thus in their intensive growing phase. Note that as very little information was available on the origin of these forests, it was deemed to be impossible to demonstrate “direct human induced activity” in their establishment, therefore, we excluded these forests from FM in the first commitment period. However, as it seems improbable that these forests are unmanaged, and to comply with the requirements of ARR 2013, we now include all FF in our FM estimates.

Finally, it is also noted that we report the area of FM, just like for AR and D, as the total area of subcompartments 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 all forests (“FL” in the report under the UNFCCC) minus the total of the “AR since 1990” minus “D since 1990” plus 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 below.

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

The information below is supplementary to that reported in Section 6.2

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 that is applied for the purposes of reporting under the KP 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.
- Areas under D activity are identified since 1 Jan 2008 on a per stand basis each year, and the area of these stands is summed up.
- Both before and in years 2008-2014, 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 increased by the area of FF.

As noted above, this procedure ensures the consistency of land identification under all KP activities, as well as FL under the UNFCCC. We 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 6.2 above.)

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.

Note that, as discussed in Chapter 6.2 above, 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, for FM, AR and D, 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 note that, in order to be conservative, emissions from soils are estimated for the total area of the FL-L category, i.e., the total of the area of stands plus the area not covered by trees.

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 (CRF Table NIR 2. LAND TRANSITION MATRIX) of the KP CRF with the total area of forests under the various activities. (Anyway, 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 time series data of the total area all forests, along with that of the land that is strictly covered by trees (“calculated area covered by trees”) is reported in Table 6.5.1 of the NIR. Table 11.2 below summarizes changes of area under AR and D, whereas 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 sub-compartments). 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.

Table 11.2 *The size of annual land conversions (in terms of subcompartments) for (a) D, (b) AR and (c) FF for the years of the first and second commitment periods.*

(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	101	293	450
2010	59	47	102	208
2011	67	24	185	276
2012	113	389	280	782
2013	115	117	300	532
2014	153	97	352	602

(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
2013	539	119	39	697
2014	891	392	138	1 422

(c) *FF*

Inventory year	Found Forests
	Area (ha)
2008	5 567
2009	6 495
2010	3 136
2011	4 224
2012	5 520
2013	4 369
2014	2 058

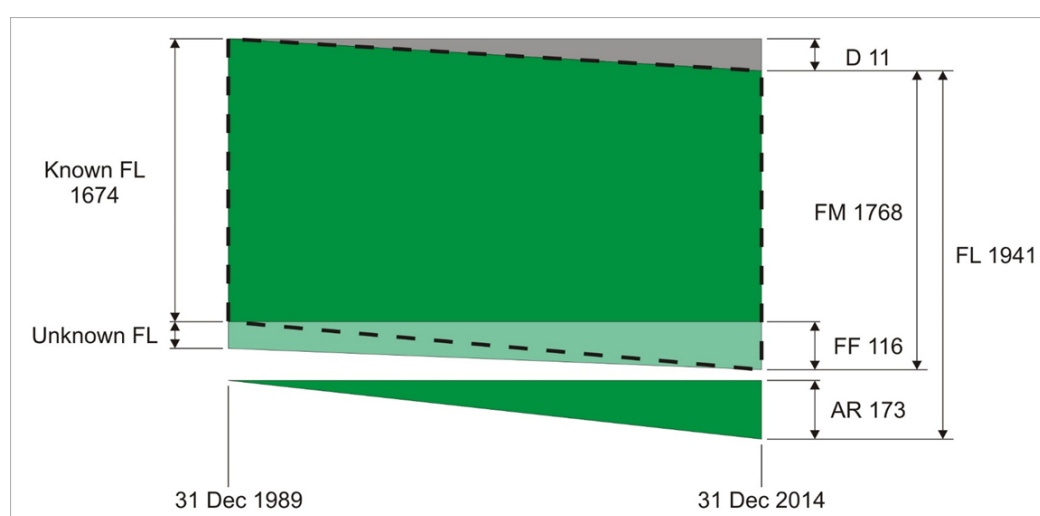


Figure 11.3. Graphical demonstration of changes in the area of the various activities under Articles 3.3 and 3.4 of the KP since 1990 (numbers after the activities are in kha). The area denoted by the dashed lines shows the development of the area over time identified by the NFD in each inventory year except for the AR area. For any given inventory year (i.e., at any vertical intersection of the graph), the distance between the dashed lines shows the area of FM including that part of the FF that was identified up to the inventory year. Data under various activities are total areas of sub-compartments (they may be 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 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, in the heading) of developing the data. The area of “FM since 1990” in 1990 (“TF89t2”) was 1,674,815 ha and, for any year later, the table then shows all changes according to the formulas in which t1 means the beginning of the inventory 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 compilations), whereas data in white cells are calculated in this table. All other notations are as in Tables 6.5.3. (The table is for demonstration only and may include rounding-off errors; for precise numbers, and for data by geographical locations, see the respective CRF tables.)

Inventory year	AREA (sub-compartments), ha													
	All Forest Land (FL)			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 + FF	t1 - ΔD + ΔFF
2008	1 890 866	1 903 360	12 494	8 128	294	8 422	72 779	5 567	78 346	151 401	7 220	158 621	1 739 465	1 744 739
2009	1 903 360	1 912 917	9 557	8 422	450	8 872	78 346	6 489	84 835	158 621	3 518	162 139	1 744 739	1 750 778
2010	1 912 917	1 922 108	9 191	8 872	208	9 080	84 835	3 138	87 974	162 139	6 261	168 400	1 750 778	1 753 708
2011	1 922 108	1 927 702	5 594	9 080	277	9 357	87 974	4 224	92 198	168 400	1 647	170 046	1 753 708	1 757 656
2012	1 927 702	1 933 604	5 902	9 357	782	10 139	92 198	5 520	97 718	170 046	1 164	171 210	1 757 656	1 762 394
2013	1 933 604	1 938 139	4 535	10 139	532	10 671	97 718	4 369	102 088	171 210	697	171 908	1 762 394	1 766 231
2014	1 938 139	1 941 016	2 878	10 671	602	11 273	102 088	2 058	104 146	171 908	1 422	173 329	1 766 231	1 767 687

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., 2,061,432 - 1,941,016 = 120,416 ha in 2014, see also Table 6.5.1) 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 IPCC (2013). This means that, in reporting area as well as emissions and removals, we identify regions for which we developed total areas under the various KP activities.

Two geographical locations are separated under the requirement of Annex II of 2/CMP.8 that the geographical location of the boundaries that encompass the lands subject to activities under Article 3.3 and FM under Article 3.4 must be reported. These locations 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 boundaries are the same as in the first commitment period.) 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”.

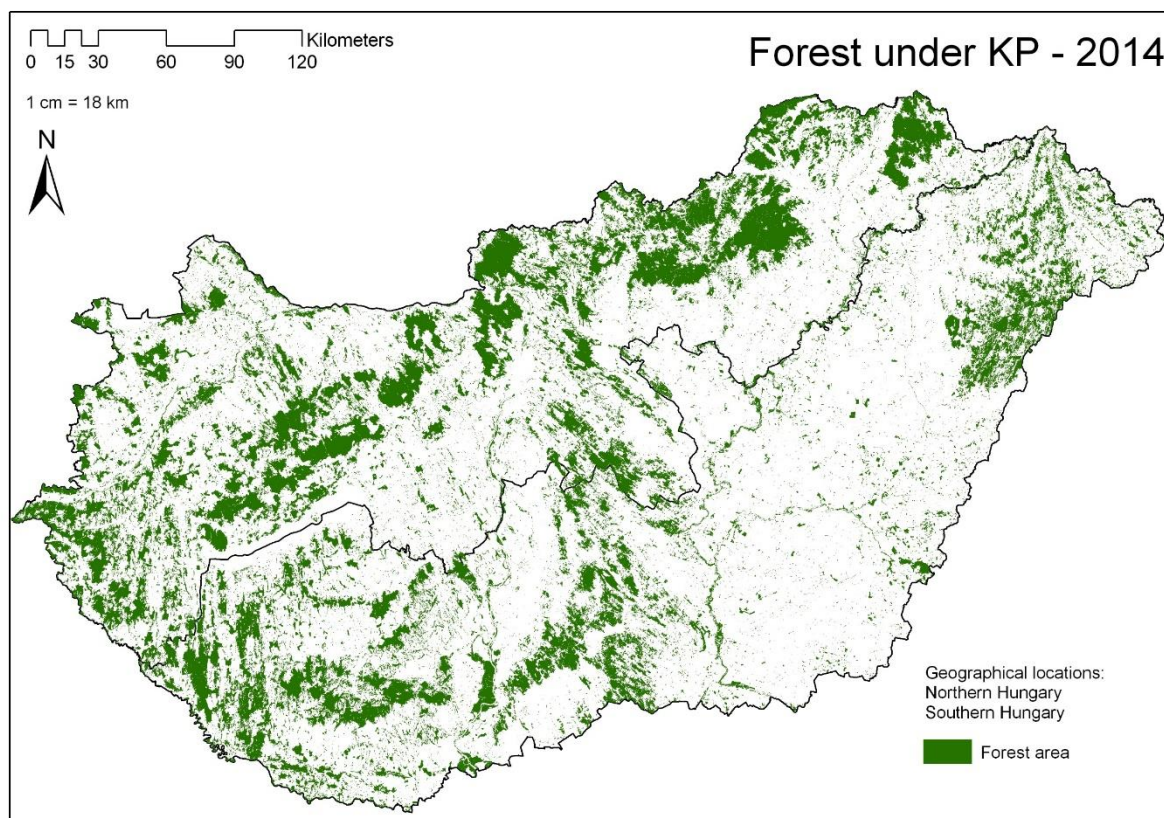


Figure 11.4. Map of Hungary with forests (green patches) and the border of the two geographical locations.

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) to which the sub-compartment is administered, the compartment (a larger piece of forest, e.g. a hillside or a valley) and the sub-compartment (which is part of a compartment). The sub-compartment is the basic unit of forest management, its mean size being approximately 4 ha. The number of municipalities was 3166 in 1990 and 3195 in 2014, 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 one and only one 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).

11.3 Activity-specific information

11.3.1 Methods for the estimation of carbon stock changes and GHG emissions and removals

11.3.1.1 Description of the methodologies and the underlying assumptions used

11.3.1.1.1 Definition of pools as applied in Hungary

The IPCC 2006 Guidelines define (in its Table 1.1. in Chapter 1 of Volume 4) 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, and those applied during the first commitment period. 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. Note that, in the Hungarian forests, the understory and shrub layers usually have very little biomass.

Below-ground biomass (BB): all living parts of the living trees below that above-mentioned potential cutting height. These parts thus include stumps, 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 2 cm (in case of roots). Note that as no quantitative measurement of the change of the litter has been attempted so far, the above diameter thresholds are just theoretical values 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. (Carbon stocks below 30 cm do exist, however, they are not considered, with respect to the greenhouse gas inventory, and consistently with IPCC (2006), in carbon equilibrium.)

11.3.1.1.2 Methodological issues

As AR and FM are different from L-FL and FL-FL, emissions and removals to be reported on land under AR and D are different from those under the respective categories under the UNFCCC. Therefore, these emissions and removals must be estimated using specific procedures. However, it is mainly the land to be accounted for that is different, and the methodology of the estimation is in general the same as that described in section 6.4 and 6.5. This methodology is accurate and precise as far as practicable.

In case of Hungary, the methodology is pool-dependent and depends on the non-CO₂ gases. The coverage of emissions and removals estimation and its main methodological elements are detailed in Tables 11.4 and 11.5, respectively.

Table 11.4. Emissions and removals by source on land under (a) AR, (b) D and (c) FM.

(a)

Inventory year	Emissions and Removals from AR since 1990, GgCO ₂						
	post-conversion biomass	pre-conversion biomass	minreal soils	organic soils	litter	dead-wood	burning (CH ₄ +N ₂ O), GgCO ₂ eq
2008	-1 160	4	demonstrated that not a source	IE	demonstrated that not a source	demonstrated that not a source	0.162
2009	-1 154	5		IE			0.170
2010	-1 294	3		IE			0.247
2011	-1 258	5		IE			0.853
2012	-1 234	5		IE			0.297
2013	-1 246	2		IE			0.430
2014	-1 092	2		IE			0.928

(b)

Inventory year	Emissions and Removals from D since 1990, GgCO ₂ eq					
	biomass	minreal soils	organic soils	litter	dead-wood	burning (CH ₄ +N ₂ O), GgCO ₂ eq
2008	27	31	IE	9	3	0.042
2009	58	33	IE	14	4	0.097
2010	28	35	IE	7	2	0.043
2011	46	34	IE	9	2	0.095
2012	132	34	IE	25	7	0.229
2013	62	35	IE	17	5	0.132
2014	85	35	IE	19	6	0.178

(c)

Inventory year	Emissions and Removals from FM since 1990, GgCO ₂					
	biomass	minreal soils	organic soils	litter	dead-wood	burning (CH ₄ +N ₂ O), GgCO ₂ eq
2008	-2 983	demonstrated that not a source	62	demonstrated that not a source	demonstrated that not a source	11
2009	-2 062		62			10
2010	-1 858		62			11
2011	-1 710		62			26
2012	-2 604		62			22
2013	-1 878		62			16
2014	-3 283		62			18

Table 11.5. Methodological summary for (a) FM, (b) AR, (c) D. (CS=country specific; D: default; EJ: expert judgment; IE: included elsewhere; AD: activity data; EF: emission/removal factor; NO: not occurring)

(a)

Category	Type of information	Carbon stock changes					Non-CO ₂ emissions
		AGB	BGB	DW	LI	SOIL	
FM	E/R	CS	D/EJ	Not estimated (demonstrated that not a source)	Not estimated (demonstrated that not a source)	Mineral: Not estimated (demonstrated that not a source); Organic: AD: CS; EF: D	N ₂ O (N fertilization): NO N ₂ O (drainage and re-wetting): NO C (liming): NO Burning: D, CS
	Uncertainty	Tier 2 (Monte Carlo)		N/A			Tier 2 (Monte Carlo, where applicable)

(b)

Category	Type of information	Carbon stock changes					Non-CO ₂ emissions
		AGB	BGB	DW	LI	SOIL	
AR	E/R	Post-conversion: CS Pre-conversion: CS	D/EJ D	Not estimated (demonstrated that not a source)	Not estimated (demonstrated that not a source)	Mineral: not estimated (demonstrated that not a source); Organic: not occurring	N ₂ O (fertilization): IE N ₂ O (drainage and re-wetting): NO C (liming): NO Burning: D, CS
	Uncertainty	Tier 2 (Monte Carlo)		N/A			Tier 2 (Monte Carlo) where applicable

Table 11.5 (ctd.). Methodological summary for (a) FM, (b) AR, (c) D. (CS=country specific; D: default; EJ: expert judgment; IE: included elsewhere; AD: activity data; EF: emission/removal factor)

(c)

Category	Type of information	Carbon stock changes					Non-CO ₂ emissions
		AGB	BGB	DW	LI	SOIL	
D	E/R	Post-conversion: 0 Pre-conversion: CS	0 CS	CS	CS	D	N ₂ O (disturbance): mineral soils: D; Organic soils: NO C (liming): IE (reported under Agriculture) Burning: D, CS
	Uncertainty	Tier 2 (Monte Carlo)					Tier 2 (Monte Carlo) where applicable

Biomass

Carbon stock changes of trees are estimated using the stock change method (in a fashion similar to 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. The estimation of emissions and removals on lands under the AR and D activities are directly estimated from the carbon stocks of consecutive calendar years, i.e. from carbon stocks as of 31 December 2007-2014 for AR, and of the inventory years 2008-2014 for D.

The forests included in the AR category are identified and mapped at the sub-compartment (stand) level. Growing stocks and stock changes in the afforested areas are estimated by using field measurements and applying yield tables by appropriate species and site classes. These yield tables (which are true yield tables and different from the volume stock functions applied for the L-FL category) are planned to be updated once information is available that the growing conditions may have deteriorated. (We note here that, according to Somogyi, 2008, the growth of trees accelerated in Hungary recently. Not adjusting the yield tables for this acceleration means an underestimation of the removals, thus, it is conservative.)

The parameters of the equation used for the estimation are as detailed in section 6.5.3. 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), and thus 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.

Consistent with section 6.3, 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 and D. (Emissions and removals from FL-FL and L-FL in an inventory year exclude carbon stocks of FF found in that 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, which includes NR of FF, but excludes NE (net emissions) of deforested land) and NR on land under AR (Table 11.6).

Total NR of forests under FM in 2014 =
+ Total NR of FL-FL in 2014
+ Total NR of L-FL in 2014
- NR of AR in 2014

Table 11.6 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 6.5.3 and 7.3.7. (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 ₂					
	FL (includes FF and AR since 1990)		AR since 1990		FM since 1990	
	NR	IEF	Δ	IEF	Δ	IEF
	from DB	NR/area (Gg CO ₂ /ha)	from DB	NR/area (Gg CO ₂ /ha)	FL - AR	NR/area (Gg CO ₂ /ha)
2008	-4 143	-0.00218	-1 160	-0.00731	-2 983	-0.00171
2009	-3 217	-0.00168	-1 154	-0.00712	-2 062	-0.00118
2010	-3 152	-0.00164	-1 294	-0.00768	-1 858	-0.00106
2011	-2 968	-0.00154	-1 258	-0.00740	-1 710	-0.00097
2012	-3 838	-0.00198	-1 234	-0.00721	-2 604	-0.00148
2013	-3 124	-0.00161	-1 246	-0.00725	-1 878	-0.00106
2014	-4 375	-0.00225	-1 092	-0.00630	-3 283	-0.00186

For AR, we have also developed a methodology to account for emissions from pre-conversion biomass losses due to afforestation. This is necessary as some of the afforestations take place in former orchards and vineyards. (The majority of the AR area is nevertheless done in former cropland with annual crops and grasslands with no woody vegetation.) To estimate these emissions, the country-specific loss rates of 9.4 and 18.8 tdm/ha are used for orchards and vineyards, respectively, consistent with data used under the UNFCCC (see section 6.6.2.1.1 on accounting for gains in carbon stocks of perennial crops on croplands). This loss, which is a mean value for all types of orchards and vineyards converted to forest, is assumed to be accumulated in 30 and 31.8 years, respectively, so the mean annual accumulation rates are 0.3 and 0.59 tdm/ha*yr.

For AR, we also estimated the loss of carbon from the pre-conversion biomass of other vegetation (predominantly the remains of annual crops, and herb vegetation on abandoned croplands and grasslands). The estimation was done the same way as described in Section Pre-conversion biomass of Section 6.5.5.2.1.

Dead organic matter

For the deadwood and litter pools, too, the same approach was taken for the categories under the KP as for categories under the UNFCCC. See methodological details in section 6.5.4.2.2 for D. For FM and AR, the option is applied that it is demonstrated that the dead organic pools in these categories are not a source, see section 11.3.1.2 below.

Soil

For soils, the approach described in details in section 6.5.4.2.3 was taken for D, however, only emissions were accounted for, whereas removals were not. For FM and AR, the option is applied that it is demonstrated that the dead organic pools in these categories are not a source, see section 11.3.1.2 below.

Non-CO₂ emissions

Non-CO₂ emissions are estimated based on the amount of harvests, and experience that almost all natural forest fires occur on FM land, and only very few on AR land. The methodology is the same as described in the various sections of Chapter 6. The resulting data are reported in Table 11.4.

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 based on the IPCC 2006GL methodology using country-specific and other data. The demonstration for DW and LI is based on expert judgment which is a practicable method in our situation (see below).

Demonstration for FM and AR that the soil carbon pool is not a source

This demonstration, which is separately for AR and FM land, is necessary because, until this point, there has not been any forest soil carbon monitoring program in Hungary. The below demonstration involves all available country-specific data and information, i.e., Tier 2 elements. This data notwithstanding, we continue to apply the conservativeness approach used before, 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 data suggests that the demonstration can be done with a high certainty.

(Note that, under the UNFCCC, it was not possible to estimate soil carbon stock changes for FL-FL, but it was possible for the L-FL category using a Tier 1 method. However, this estimation was regarded as not accurate enough to develop an acceptable carbon stock change estimate under the KP. Nevertheless, the estimates for the L-FL category will be cited below to further support the demonstration.)

A major research project was run 2009-2011 with the aim to develop more country-specific data for the demonstration, and all information from that project is used to support the demonstration.

The results of the project were published in a peer-reviewed research journal (Somogyi et al., 2013), therefore, only a summary of the most important arguments is presented.

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. The strata that are defined in this demonstration are based on relevant KP activities and available country-specific data.

The strata applied are the following:

for AR:

- areas where afforestations and reforestations occurred since 1990 on cropland, and
- areas where afforestations and reforestations occurred since 1990 on grassland,

for FM since 1990:

- land where final cutting and artificial regeneration following professional standards occur,
- land where final cutting and natural regeneration following professional standards occur,
- land where no final cutting occurs, only thinnings and other operations that cause no disturbance to the soil.

The area of each above stratum is known each year from the national forestry database. 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%. The land use change matrix as reported above shows almost exactly the same data, i.e., that the mean share of grassland converted to forest land in the period 1990-2014 is 14.9%, and that of all other conversions, which are equivalent to conversions of cropland to forest land, is 85.1. We used these last figures in the demonstration.

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 area-specific 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 (Horváth, 2006, Somogyi, 2005 and Somogyi et al. 2013) 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:

$$\Delta C_t = 43.5 * (1 - e^{-0.016 * t})$$

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 of the above equation by 0.33. The field measurements by Somogyi et al. (2013) reassessed 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, respectively. Carbon stock changes over age were estimated in this study to be $1.44x \text{ tCyr}^{-1} \text{ ha}^{-1}$ for Black locust and $0.34x \text{ tCyr}^{-1} \text{ ha}^{-1}$ for sessile oak (these two species are among the most frequently afforested species), 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 rather high. 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.

Note that the Tier 1 estimate, whose methodology is reported in section 6.4.1, yielded area-specific removals varying between 0.324-0.356 tCyr⁻¹ha⁻¹ for the period 2008-2014, so this, too, justifies the use of the above value of 0.3337x tCyr⁻¹ha⁻¹.

For the AR land since 1990 that was converted from grassland, the situation is quite different as converting grassland to forest is associated with a much more substantial disturbance as far as carbon emissions are concerned. This is mainly due to the fact that soils under grassland usually contain much more carbon than forests, thus, losses from the soil due to soil preparation, which may also be more intensive than on croplands, cannot be easily offset by the growth of forest vegetation. Indeed, a local study demonstrated that soil carbon is being lost for decades after conversion (Horváth, 2006).

This stratum will therefore be assumed to have an overall emission for decades, and the change of carbon over time will be assumed to take place according to the equation for grassland by Horváth (2006). Again, the original equation for grassland is rearranged to directly estimate carbon stock changes over time, t, after the afforestation:

$$\Delta C_t = 32.9 \cdot (1 - e^{-0.015 \cdot t}) - 29.0 \cdot (1 - e^{-0.046 \cdot t})$$

This equation, when combined with the above reduction by 0.33 to only consider a soil depth of 30 cm, yields a mean area-specific emission value of 1.56 tCyr⁻¹ha⁻¹ for a period of 20 years. We note that, as opposed to afforestations on former croplands, we continue to estimate emissions even after the 20 year default period (i.e., as long as the above formula yields emission values) in order to be conservative.

Note that the Tier 1 estimate, whose methodology is reported in section 6.4.1, yielded area-specific emissions varying between 0.646 - 0.725 tCyr⁻¹ha⁻¹ for the period 2008-2014, so this, too, justifies the use of the above equation, making the resulting estimate very conservative (see also Table 11.8 below).

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, 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 11.7) 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 6.4.1 for details).

Table 11.7. The distribution and carbon stock of forest soils in Hungary by climate and soil types (for details, see section 6.4.1).

Soil characteristics	WD HAC	CD HAC	WD sandy	CD sandy	Total
Distribution of area (%)	35.7%	53.6%	0.9%	9.8%	100.0%
SOC _{ref} (tC/ha)	58	48	21	15	48.09

Based on the above loss rate and reference carbon stock, the overall loss in a conversion is equal to 48.09*0.18 = 8.6 tCh⁻¹. The Tier 1 estimate of forest land – cropland conversions, whose methodology is reported in section 6.4.1, yielded mean area-specific emissions 6.45 tCyr⁻¹ha⁻¹ which

are thus smaller than the default IPCC estimate.

Until 2011, we used an area-specific emission value of 6 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 started to use another specific carbon loss for this stratum which we consider more appropriate for the Hungarian conditions, and which is based on the recent project by Somogyi et al. (2011, 2013). In this project, 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 carbon stocks also increase 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 m³ of above-ground wood volume (this value was only chosen for the sake of demonstration). If basic wood density is 0.5 t m⁻³ (a good approximation of national average), then the above-ground biomass is 160 t ha⁻¹, which translates to a carbon stock of 80 tCha⁻¹. 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 tCha⁻¹ in the roots 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 emissions from soils due to direct human induced disturbances from soil preparation are more than offset by the transfer of carbon from the dead roots to the soil. However, this transfer could not be measured separately from emissions which thus remain rather uncertain.

It must also 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 up 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 the demonstration for the 30 cm layer may not have to do anything with actual processes.

All the above, combined with the specific soil conditions of Hungary, would call for a substantial reduction of the mean area-specific emissions that is applicable for conversions so that it can be used in this demonstration. In order to stay conservative, however, we keep this rate at a still highly conservative value of 5 tCha⁻¹ until further evidence.

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, if any, is assumed to be quickly offset by the growth of the dense new generation of trees, if not offset right away by inputs from deadwood (mostly dead branches of harvested trees) and dead roots (of the same harvested trees) originating from the harvest of 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⁻¹**.

Here we again present one specific result from the above mentioned research project (Somogyi, 2013, Figure 11.5). 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.

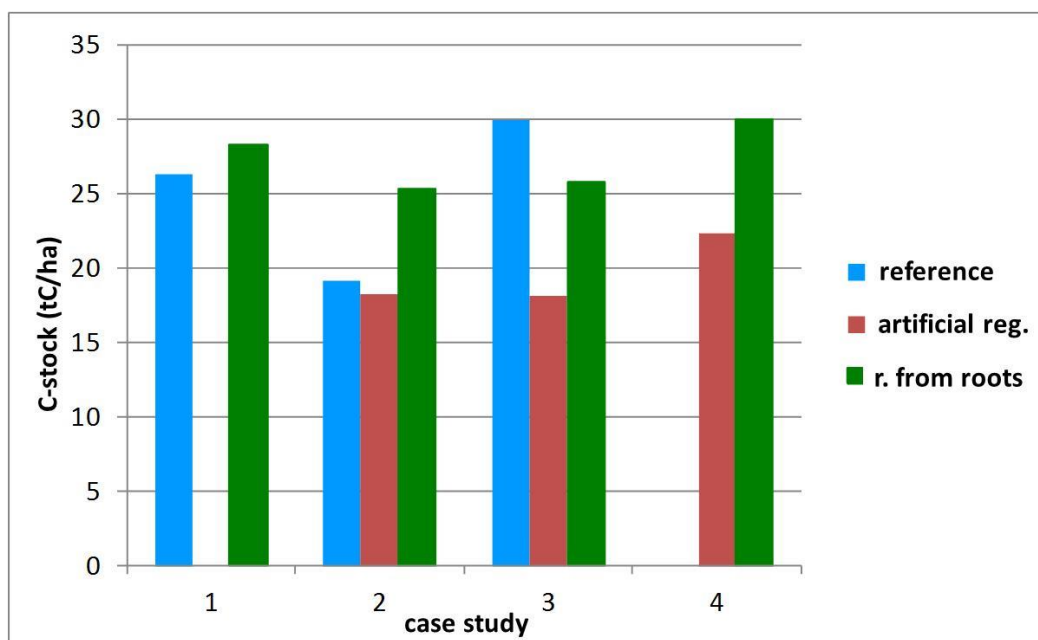


Figure 11.5. Soil carbon stock before (“reference”) and after regeneration (artificial regeneration: “artificial reg.”, and regeneration from roots: “r. from roots”) of chronosequences of Black locust stands in four case studies. (Somogyi et al., 2011).

Finally, the stratum of **all other land under FM since 1990** includes stands that are between regeneration and the beginning of the subsequent regeneration and final cutting and that may only be affected by normal silvicultural operations such as thinnings. This stratum is by far the biggest one by area, and it 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⁻¹**.

The summary of the data for AR and FM, and all of the above strata for 2014 are found in Table 11.8. The 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 the 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 11.8 The area, emission and removal data for the various AR and FM strata and for their total in 2014. See text for details.

Forest Land Stratum under the KP		Estimated area (kha)	Emission (+) and removal (-) factor (<i>IEF in italics</i>) (tC ha ⁻¹)	Total emissions (+) or removals (-) (ktC)
Land under AR since 1990	that was converted from cropland	173.3*0.878 = 149.1	estimated using functions by Horváth, 2006 (corrected for 0- 30 cm depth) and Somogyi et al. 2013	-41.2
	that was converted from grassland	173.3*0.122 = 24.3		7.0
	Total	173.3	-0.20	-34.3
Land under FM since 1990	where final cutting and artificial regeneration is made following professional standards	16.3	5	81.5
	where harvesting and natural regeneration is made following professional standards	4.1	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	1767.7 - 16.29983 - 4.12906 = 1747.3	-0.05	-87.4
	Total	1767.7	-0.0033	-5.9

The result of the calculations for the current inventory year is a considerable sink for AR land, and a very tiny sink for FM. However, for FM, values have been meandering around zero for 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.

For reasons of transparency, Table 11.9 below reports the time series for AR estimated using the

above methodology and that for L-FL using the Tier 1 methodology.

Table 11.9. *The time series of net removals of soils for AR using the methodology in the demonstration that AR soils are not a source, and for L-FL using the Tier 1 methodology under the UNFCCC.*

Category	Emissions (ktC)						
	2008	2009	2010	2011	2012	2013	2014
AR under KP	34.3	35.6	35.7	36.0	36.4	36.4	34.4
L-FL under UNFCCC	45.0	46.5	48.8	49.6	50.6	50.7	49.8

In order to further support the confidence in the above derivation for FM, 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⁻¹ for the emissions in this land 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 area-specific emission estimate of 5 tCha⁻¹ is with high probability a rather high overestimation, and it is applied for the sake of the demonstration only.
- The removal value of 0.05 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 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 kg C ha⁻¹yr⁻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 tCha⁻¹yr⁻¹, i.e. 50 kg C ha⁻¹yr⁻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 of 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 than those in Hungary, an annual rate of change in forest soils of 0.05 t ha^{-1} can be detected by a $4 \times 4 \text{ km}$ soil monitoring, which is certainly not a practicable method in Hungary, only if changes are monitored 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 in our view 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 either our Tier 1 or Tier 2 estimates for accounting, the method of the above demonstration is capable of serving one important aim, which is the final goal of preparing greenhouse gas inventories, i.e., 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 emissions 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 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, and 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^{-1} for both pools as suggested by our monitoring programs detailed below as well as Heil, Kovacs and Szabó, 2012), it can be safely concluded that the carbon in the deadwood and litter pools in AR lands were increasing between 2008-2014, 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. An earlier estimate showed that 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). This value is in about the mid-range of similar data for other European countries. A more recent estimate of standing deadwood (i.e., most of the deadwood) which was based on data collected in a 4×4 km sampling grid of the European-wide, so called ICP Forest monitoring network also shows a slightly increasing tendency (see *Figure 6.5.5* above).

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 those of plantation forestry (this process is related to our most recent Forest Acts, see section 6.5.4.2.2). 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 additional separation is necessary, and we have indeed not have done any.

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

We recalculated the emissions removals from FM land in 2015 mainly due to the fact that FF are now included in FM. This year we completed the methodology by adding the estimation of losses of carbon from pre-conversion biomass on AR land (this only involved a small adjustment of the estimated emissions under AR).

For other details, see Chapter 6.1.4.

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

6.5.7. 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.

One of the objectives of the uncertainty analysis is to demonstrate that emissions are not underestimated. It is therefore underlined here, too, that, whenever the inherent uncertainties of our estimation procedure justify 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.

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.

Concerning 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 some 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. However, when estimating the stand-level values during surveys, the area is used to upscale sampling plot information (or unit area information in case of using yield tables). Whether a land is identified or not, i.e. whether carbon stock changes on that land must be estimated or not, is also 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.

With respect to the estimation related to the biomass on FM land, data from the forest monitoring system is used, the primary objective of which 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 sub-compartment and forest enterprise level. The forest inventory was designed to collect data at the stand level, but to provide accurate estimates at various aggregate levels. In order to achieve efficiency and practicability, different levels of accuracy are applied in the survey of individual sub-compartments depending on the age of the trees and the estimated amount and value (quality) of their growing stock.

Due to needs for accurate emission and removal estimates from D, the data collection 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, the model estimates of yield tables are used as it is simply impractical to take field measurements. 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 FM or D. 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.

For FM, we conducted (in 2012) a thorough uncertainty estimation based on the above list. 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. (Concerning the estimation of the uncertainty of L-FL under the UNFCCC, a different method should have had to be applied as the methodology of estimating removals for the L-FL category is different from that for AR. However, we focused on the estimation of the uncertainty of the estimates at the activity level under the Kyoto Protocol, and assume that, some methodological differences notwithstanding, similar uncertainties will apply to both AR and L-FL.)

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 (Tier 2) Monte Carlo (MC) analysis. The methods of the uncertainty calculations are demonstrated first for forest area, then for carbon stock changes by pool and emissions by sources.

Forest area

As greenhouse gas information in general is related to the area of the various categories, it is important to estimate the error of area identification. This was done by assuming that the location of the borders of the stands as polygons have a maximum error of 6 m. 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 Figure 11.6 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.

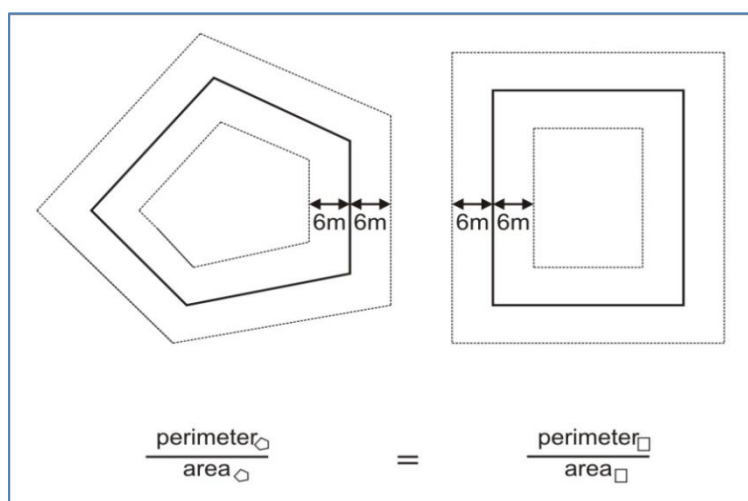


Figure 11.6. Possible largest, mean and smallest area of a stand if perimeters are assumed to be off (thin lines) from those in the database (i.e., those in the middle, thick lines) by a maximum 6 m in both directions (left). To simplify calculations, we used rectangles to actually estimate the error of the area (right).

Biomass pools

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

https://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT/nir1985-2011-ua.html. In essence, the National Forestry Database (NFD) contains a volume stock per unit area (m^3/ha) data for each species of each of the circa 450 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 uncertainty of the volume stock per unit area and that of 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. The study concluded that for stands of each slow growing species, the uncertainty of the volume stock per unit area for *individual stands* older than 40 years was typically between $\pm 30\text{--}40\%$. For these stands, the uncertainty in the MC analysis was assumed to be $\pm 40\%$. For stands younger than 40 years, the assumed uncertainty was $\pm 80\%$. 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 11.10.

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. Other parameters to estimate carbon content are the same as for biomass above.

The amount of carbon stored in the litter pool ($8.78 \text{ t C}/\text{ha}$) 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 LULUCF (IPCC, 2003). 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 EF_1 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 for LULUCF (IPCC, 2003). 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 is based on the formulas as reported in previous NIRs (i.e., not exactly as it is currently done as described in section 6.4.2 as the uncertainty estimation was done when the methodological basis was the GPG for LULUCF (IPCC, 2003) (however, this probably does not much affects the developed uncertainty estimates). Preliminary estimates of uncertainties of the various factors were provided by Rumpf (2013). 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 for LULUCF (IPCC, 2003; CH₄: $\pm 25\%$, CO: $\pm 33.3\%$, N₂O: $\pm 28.6\%$, NO_x: $\pm 22.31\%$), whereas that of the N/C is assumed to be $\pm 100\%$ based on the default value of Table A1-1 of Annex1 of the IPCC Revised 1996 Guidelines. The uncertainty of the fraction oxidized on site was set to $\pm 10\%$.

Concerning error 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 11.10.

Table 11.10. *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 ₂	area of forest subcompartment	AR, D, FM	L-FL, FL-L, FL-FL	normal	+/- 6 m in border lines	expert judgement (Mezei 2011)
biomass	CO ₂	m ³ /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 ₂	wood density	AR, D, FM	L-FL, FL-L, FL-FL	triangular	+/- 10 %	Somogyi (2008)
	CO ₂	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 ₂	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 ₂	carbon content of orchards and vineyards	AR (losses)	L-FL (losses)	triangular	+/- 40 %	expert judgement (Juhos and Tókei 2012)
deadwood	CO ₂	area of forest subcompartment	D	-	normal	+/- 6 m in border lines	expert judgement (Mezei 2011)
	CO ₂	m ³ /ha value on country level	D	-	normal	+/- 8 %	data of National Forest Monitoring and Observation System
	CO ₂	carbon fraction	D	-	triangular	+/- 10 %	GPG 2003 Appendix 3A.1 Table 3a1.4
	CO ₂	wood density	D	-	triangular	+/- 10 %	Somogyi (2008)
litter	CO ₂	t C/ha	D	-	N/A	-94/+308 %	expert judgement (Heil et al. 2012)
slash burning	CH ₄ , CO, N ₂ O, NO _x	m ³ /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 ₄ , CO, N ₂ O, NO _x	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 ³ beech wood is burnt on site on country level)	expert judgement (Rumpf 2012)
wildfires	CH ₄ , CO, N ₂ O, NO _x	burned fraction of the total standing volume on subcompartment level	AR, FM	FL-FL	triangular	+/- 20 %	expert judgement (Debreceni 2011)
slash burning, wildfires	CH ₄ , CO, N ₂ O, NO _x	fraction oxidized on site	AR, D (slash burning only), FM	FL-FL	triangular	+/- 10 %	expert judgement (Kottek and Tobisch 2012)
	CH ₄ , CO, N ₂ O, NO _x	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 ₄ , CO, N ₂ O, NO _x	wood density	AR, D (slash burning only), FM	FL-FL	triangular	+/- 10 %	Somogyi (2008)
	CH ₄ , CO, N ₂ O, NO _x	emission ratio	AR, D (slash burning only), FM	FL-FL	triangular	CH ₄ : +/- 25 %, CO: +/- 33.3 %, N ₂ O: +/- 28.6 %, NO _x : +/- 22.31 %	GPG 2003 Annex 3A1 Table 3A1.15
	N ₂ O, NO _x	N/C ratio	AR, D (slash burning only), FM	FL-FL	triangular	+/- 100 %	GPG_1996annex1ri, Table A1-1
soil	CO ₂ , N ₂ 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 ₂ , N ₂ O	SOCref on country level	D	FL-L	triangular	WD-HAC: +/- 85 %; CD-HAC: +/- 103 %; WD-SANDY: +/- 113 %; CD-SANDY: +/- 87 %	study of Zsembeli et al. (2011)
	N ₂ O	C/N ratio in forest soils	D	FL-L	N/A	-48.6 / +172.5 %	expert judgement (Heil et al. 2012)
	N ₂ O	EF1	D	FL-L	N/A	-80 / +380 %	GPG p. 3.47-3.48

Results

We report all results in Table 11.11 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 we estimated uncertainties somewhere in between the above estimates.

As the absolute value of total emissions from D are smaller than that of the removals 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. The resulting uncertainty of the volume stock changes at the level of various species or species group varies between 15-290%. 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 11.11. 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 ₂ eq.	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	%
biomass (stock-change)	CO ₂	-1256.35	-1256.353	-12.1	11.5	-17.65	11.83	-21.4	16.5	>99
slash burning	CH ₄	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 ₂ O	0.000105	0.032513	-3.2	3.1	-83.34	110.66	-83.4	110.7	<1
slash burning	NO _x	0.003792	0	-3.2	3.1	-83.84	110.46	-83.9	110.5	<1
wildfires	CH ₄	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 ₂ O	0.000248	0.076745	-18.4	19.3	-76.11	87.80	-78.3	89.9	<1
wildfires	NO _x	0.008951	0	-18.4	19.3	-75.90	90.46	-78.1	92.5	<1
TOTAL			-1255.167							100

(b) D

Sink/source	Gas	E/R	E/R	Activity data		Emission factor		Combined		Contribution to overall uncertainty
		Gg	GgCO ₂ eq.	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	%
Deadwood	CO ₂	2.397653	2.397653	-8.7	9.2	-9.52	12.10	-12.9	15.2	0.045
litter	CO ₂	8.879759	8.879759	-2.3	2.3	-93.67	307.49	-93.7	307.5	71.385
biomass (stock-change)	CO ₂	45.75307	45.75307	-9.9	10.5	-11.14	15.71	-14.9	18.9	22.245
slash burning	CH ₄	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 ₂ O	4E-05	0.012409	-9.2	10	-63.84	101.71	-64.5	102.2	0.000
slash burning	NO _x	0.001447	0	-9.2	10	-64.04	101.61	-64.7	102.1	0.000
soil	CO ₂	12.99638	12.99638	-2.3	2.3	-29.91	19.46	-30	19.6	6.192
soil	N ₂ O	0.000833	0.258115	-4.9	4.8	-57.79	552.18	-58	552.2	0.131
TOTAL			70.420							100

(c) FM

Sink/source	Gas	E/R	E/R	Activity data		Emission factor		Combined		Contribution to overall uncertainty
		Gg	GgCO ₂ eq.	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	%
biomass (stock-change)	CO ₂	-1560.13	-1560.134	-28.3	27.1	-13.83	11.91	-31.5	29.6	>99
slash burning	CH ₄	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 ₂ O	0.007688	2.383262	-0.7	0.7	-48.79	48.79	-48.8	223.4	<1
slash burning	NO _x	0.277964	0	-0.7	0.7	-49.20	49.20	-49.2	223.3	<1
wildfires	CH ₄	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 ₂ O	0.003343	1.036439	-6.7	5.8	-78.01	78.08	-78.3	87.7	<1
wildfires	NO _x	0.120882	0	-6.7	5.8	-78.31	78.39	-78.6	86.2	<1
TOTAL			-1523.018							100

11.3.1.6 Information on other methodological issues

It is important to highlight that we always use the best methods and data that is currently available.

This often, but not always, represents 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 nationwide assessments, whereas the emission factors and models applied do not consider the inter-annual variability of the physical processes. Therefore, the estimated emissions and removals partly, but not completely, reflect the inter-annual variability of the true processes. (The annual stock data mainly reflect actual harvests, but partly only modelled increment data.) It also needs to be underlined that the net removal values for either FM or AR represent rather small changes (i.e., net removals) relative to rather large stocks (i.e., the total carbon stocks of the biomass of all forests in the respective categories). It is due to the nature of such relatively small net values that they have a rather high inter-annual variability, and are not a result of some artefacts.

In principle, we consistently use the same methods for estimating carbon stock change and non-CO₂ greenhouse gas emissions for the whole 1990-2014 period, and data reported under the KP is consistent with those under the UNFCCC.

With respect to the methodological Tiers applied in this report, at least the same or higher Tiers are applied for the categories under the KP 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.

Concerning QA/QC, estimations and QC have been done by the Forestry Directorate of the National Food Chain Safety Office, whereas 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 ensures that all background data are collected and processed at the required quality, and the number of possible sources of errors and uncertainties are reduced. On the other hand, the expert of the Hungarian Forest Research Institute, which has been involved in the QA activities, used to develop the GHG inventory for the country, and is a lead author of various IPCC methodological Guidelines thus, he 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 report 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 23 in Annex to Decision 2/CMP.7.

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 2013 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). 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% (i.e., the minimum requirement to meet the definition of forests), but more time may be needed in parts of the regenerations where the first attempt is not successful (where seedlings cannot establish themselves due to, e.g., bad weather conditions, weed competition, browsing by game 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 these Rules, 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, trees will continue to normally develop after the regeneration has been deemed successful so it can already be regarded a forest. This stage is defined by the following criteria:

- species composition is within the limits as requested by the forest management plan
- an even distribution of trees over the entire area
- healthy tree individuals overall
- the number of trees with main shoots is more than a species-specific minimum value, usually between four and eight thousand trees per hectare
- no invasive tree species is widespread in the stand
- minimum height of the main species reaches 1.5 m.

This stage is to be reached by time limits that are also defined by the above Rules. The time limits depend on species and site conditions and can vary quite substantially (see Table 11.12 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 11.12. *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 mainly 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 11.13 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. For areas “under regeneration”, the same thresholds and criteria are in effect as for an afforested area (see section 11.4.2 and Table 11.12 above, and section 6.5.5 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 11.13. *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
2013	149 997
2014	155 822

11.4.4 Information related to the natural disturbances provision under article 3.3

This information will be provided at a later stage.

11.4.5 Information on Harvested Wood Products under article 3.3

As requested by para 26 of Annex to 2/CMP.7, carbon stock changes in the HWP pool are reported and accounted for in the Hungarian inventory. The methodology of estimation is described in Section 11.5.2.5. In applying the methodology it was assumed that all harvesting is allocated to forest management and that all forests in Hungary are managed because, due to lack of data, we are unable to separate harvest from AR and FM. Therefore, according to page 2.118 of the IPCC 2013 KP Supplement, “in case it is not possible to differentiate between the harvest from AR and FM, it is conservative and in line with good practice to assume that all HWP entering the accounting framework originate from FM”, thus we report carbon stock changes together for the two categories. In contrast, harvest from D is separated and excluded, and treated as instantaneous oxidation.

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

As mentioned above, all forests are rather intensively managed in Hungary. The basis for the management is forest management plans that 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. These plans thus demonstrate that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced.

11.5.2 Information relating to Forest Management

11.5.2.1 Conversion of natural forest to planted forest

This information will be provided at a later stage.

11.5.2.2 Forest Management Reference Level

As reported in our Submission of information on forest management reference levels (URL: https://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_hungary_2011.pdf), the forest management reference level (FMRL) for Hungary, a member state of the EU, was developed in cooperation with the Joint Research Centre (JRC) of the European Commission in 2011. First, annual net emissions for FM were estimated for 2000-2008 and projected until 2020, assuming a 'business as usual' scenario, for the total of the above- and below-ground biomass carbon pools using two models of EU modelling groups, i.e., the G4M (Global Forestry Model) (from the International Institute for Applied Systems Analysis, or IIASA) and the EFISCEN (European Forest Information Scenario Model of the European Forest Institute) models. Then, the emissions and removals estimated by the models in this run for the period 2000 to 2008 were calibrated/adjusted using an offset, defined as the difference between the average of the historical forest management net emissions for 2000–2008, included in the National GHG Inventory of 2011, and the average of the mean values from the two models for the same period. (The offset was applied to the model results in order to make the projection and the historical forest management values more consistent.)

Note that, at the request of the review team, the models were re-run during the technical assessment of the FMRL submission of Hungary, producing a somewhat different output. Then, the above calibration was also repeated, yielding the FMRL value that was officially approved by the Report of the technical assessment of the forest management reference level submission of Hungary submitted in 2011 (FCCC/TAR/2011/HUN), and is used in Appendix to Decision 2/CMP.7.

The only forest pools included in the construction of the FMRL were the above- and below-ground biomass pools. Later, emissions from organic soils, and non-CO₂ emissions from wildfires were added, but the dead organic matter (litter and dead wood) and the mineral soil organic carbon pools were not included as they are demonstrated that they are not a source. The contribution of HWP to the FMRL of Hungary was estimated using the approach proposed in document FCCC/KP/AWG/2010/18/Add.1, chapter II, annex I (see section 11.5.2.5 below).

Due to a number of methodological changes since the above estimation and review, a technical

correction of the FMRL has become necessary. This is described in the next section.

11.5.2.3 Technical Corrections of the FMRL

Pursuant to Paragraphs 14 and 15 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2011/10/Add.1, p.15, a technical correction was necessary for the above FMRL. This is because although the pools included in the FMRL are the same as those reported in both the 2011 NIR and the NIR last year and were consistent with previous reporting, there are several methodological changes that have been implemented in the estimation of emissions and removals from FM, including the HWP pool.

NOTE: due to some editing mistakes, the version of the below tables related to FMRL that can be found in our last NIR submission contains slightly different numbers. It is the tables in the NIR of this year that contain the correct numbers (these numbers replace the 2015 ones because the NIR this year is a resubmission of the report of last year, too). However, the CRF tables of both last and this year contain the respective correct values. Note also that, in order to apply the same methodological approach as all other Member States of the EU, we changed our choice so that we do not now account for the emissions from HWP originating from forests prior to the start of the second commitment period (see above), which has also had an effect on both the HWP estimates and the technical correction of the FMRL (see the respective tables below).

The HWP contribution was also revised in the last submission due to the revised methodology as reported in the IPCC 2013 KP Supplement (see section 11.5.2.5 below).

All these changes, which have been identified using Table 2.7.1 of the IPCC 2013 KP Supplement, are reported in Table 11.14. As a result, emission and removal estimates that are used in the estimation of the FMRL were changed. For the sake of transparency, Table 11.15 reports both historical and projected estimates from the submission of 2011 and this year as relevant.

Table 11.14. Elements of the Technical Correction (conducted in 2015) based on Table 2.7.1 of the IPCC 2013 KP Supplement.

Criteria	Change in the estimation of emissions and removals from FM	Partial technical correction (kt CO ₂)
1 Changes in the method used for GHG reporting of FM or Forest Land remaining Forest Land (FL-FL) after the adoption of FMRL	none	0
2. Changes in any of the following methodological elements used to establish the FMRL (as reported in the FMRL submission) after the adoption of FMRL		
a) New pools and gases	emissions from organic soils	62
b) Area under FM	area was increased by adding the area of Found Forests	-99
c) Historical data from GHG inventory	recalculated due to the change of several emissions/removal factors	-15
d) Forest characteristics and related management	all changes, if any, are reflected in the recalculation of historical data	
e) Historical harvesting rates	none	0
f) Climate data assumed by models for projecting	none	0
g) HWP: new/recalculated data and/or methods; inclusion of provisions	revised data and method according to the KP Supplement	12
h) Natural disturbances	Hungary has elected not to exclude emissions from natural disturbances	0
3. Other possible methodological inconsistencies	none	0
TOTAL		-40

Table 11.15. Emission and removal estimates of corrected elements: (a) historical values of non-HWP elements, and (b) projected values for the HWP pool, as reported in our FMRL submission of 2011 and in this year (data are in ktCO₂eq).

(a)

Emissions and removals (ktCO ₂ eq) from:	Submission	2000	2001	2002	2003	2004	2005	2006	2007	2008	average 2000-2008	difference
biomass pools	2011	95	-1 309	-672	-2 676	-1 555	-3 576	-1 536	-1 769	-2 808	-1 756	-99
	2016	120	-1 447	-591	-2 863	-1 743	-3 840	-1 613	-1 736	-2 983	-1 855	
organic soils	2011	0	0	0	0	0	0	0	0	0	0	62
	2016	62	62	62	62	62	62	62	62	62	62	
non-CO ₂ emissions	2011	35	32	32	32	27	44	28	39	27	33	-15
	2016	21	18	18	17	12	28	12	24	11	18	
TOTAL	2011	130	-1 277	-639	-2 645	-1 528	-3 532	-1 508	-1 729	-2 780	-1 723	-53
	2016	202	-1 368	-512	-2 785	-1 670	-3 750	-1 540	-1 650	-2 911	-1 776	

(b)

Emissions and removals (ktCO ₂ eq) from:	Submission	2013	2014	2015	2016	2017	2018	2019	2020	average 2013-2020	difference
HWP	2011	-107	-101	-100	-101	-105	-110	-116	-122	-108	12
	2016	-74	-78	-87	-94	-100	-106	-112	-119	-96	

It is important to highlight that the basis for the projection of emissions and removals from FM, i.e. the average of the estimates of the two above model, has not been changed since 2011. Thus, the methodology of the projection, including the effect of policies on the projections, is the same as before. Therefore, the technical correction should only concern the revised estimates of the historical time series of the emissions and removals from FM that are used for the adjustment.

Considering all the above, all elements of the necessary technical correction are reported in Table 11.6. The technically corrected FMRL was developed from the total of these elements using Equation 2.7.1 of the IPCC 2013 KP Supplement:

$$\text{FMRL}_{\text{corr}} = \text{FMRL} + \text{Technical_Correction}$$

where

FMRL_{corr} = the corrected FMRL,

FMRL = Forest Management Reference Level inscribed in Appendix to Decision 2/CMP.7

Technical_Correction = the total of the partial corrections in Table 11.16.

Table 11.16. *The development of the technically corrected FMRL and the related FMRLcorr based on the FMRL estimated in 2011, the various elements of Technical_Correction values, and the corrected FM projection (data are in ktCO₂eq).*

Derivation of data				average 2000-2008	2000	2005	2010	2015	2020	average 2013- 2020
FMRL as approved earlier	Step 1: models' results (only biomass)	EFISCEN		-1,394	-1,413	-1,406	-1,300	-365	522	-103
		G4M		-2,225	-2,055	-2,382	-2,020	-1,981	-1,611	-1,845
		Average of models		-1,809	-1,734	-1,894	-1,660	-1,173	-545	-974
	Step 2: ex-post processing	Offset	biomass	53						
			non- biomass pools and GHG sources	28						
			total offset	82						
			Calibrated average of models		-1,728	-1,652	-1,812	-1,578	-1,091	-463
	Step 3: Applying first-order decay function for HWP	Offset due to difference in accounting between instantaneous oxidation and first order decay function from HWP								-108
		Calibrated average of models		-1,728	-1,652	-1,812	-1,578	-1,199	-571	-1,000
Technical correction	due to new pools (i.e., organic soils)			62						62
	due to revision of biomass estimates			-99						-99
	due to revision of HWP estimates									12
	due to estimating non-CO2 emissions			-15						-15
	Total									-40
Corrected historical and projected FM as well as the technically corrected FMRL as the average of projected values				-1,781	-1,705	-1,865	-1,631	-1,240	-611	-1,040

11.5.2.4 Information related to the natural disturbances provision under Article 3.4

This information will be provided in the Initial Report.

11.5.2.5 Information on Harvested Wood Products under Article 3.4

From a methodological point of view, historical emissions and removals from HWP under FM are treated similarly than those under the UNFCCC, see Section 6.5.4.2.4.

The estimation was done with annual historical production data, specific half-lives for product types, application of the first-order decay function using equation 12.1 from the 2006 IPCC Guidelines, with default half-lives of two years for paper, 25 years for wood panels and 35 years for sawn wood and instantaneous oxidation assumed for wood in solid waste disposal sites. Historical data dated back to 1964. It was assumed that, with the exception of wood harvested in deforestations, all harvested wood is allocated to forest management and that all forests in Hungary are managed. The estimates include exports.

As a result of the above procedure, the net emission estimates from the HWP pool in the FM category under the KP are only different from those under the UNFCCC in that while the latter includes harvested wood products produced from all harvests from all forests, the former excludes harvested wood products from the Deforestation category.

Concerning the contribution of the HWP pool to the FMRL, data was developed for all other years

until 2020 using a projection with the below steps (following the example provided in Box 2.8.2 of the IPCC 2013 KP Supplement):

1. For harvests, the same projection of an increasing trend was used as those in the development of the projection of net removals of the forests under FM (Figure 11.7).
2. Annual changes (in percent) of the projected total annual wood harvest rates were calculated between subsequent years.
3. The averages of the historical inflow rates of the most recent five years before the projected years (i.e., 2005-2009) were calculated for the sawnwood, wood-based panel and paper and paper board categories.
4. These averages were increased using the annual changes under item 2 above to get projected inflow values for each HWP pool (Figure 11.7).
5. The projected inflow values were used in Equation 2.8.5 of the IPCC 2013 KP Supplement to estimate carbon stocks, as well as gains and losses.

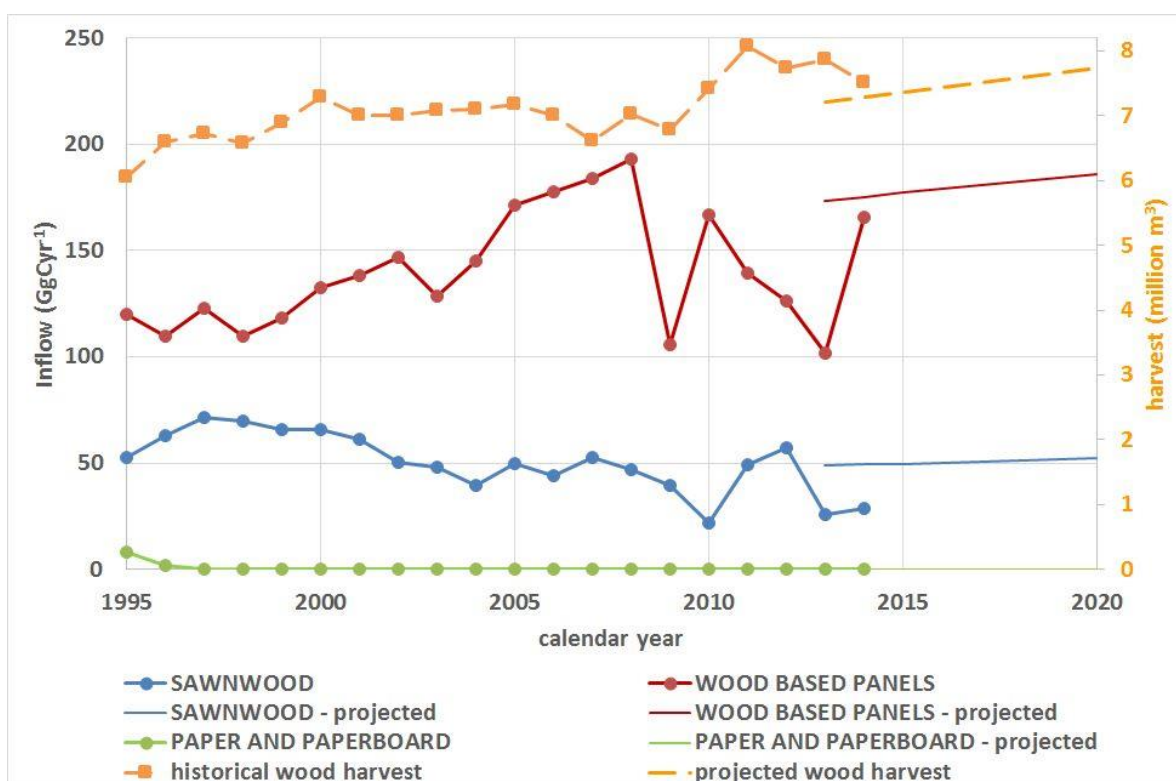


Figure 11.7. Projected (in 2015) rates of inflow, historical rates that were used to develop the projected ones, and the historical and projected (in 2011) trend of total wood harvests.

For the technical correction of the FMRL (see section 11.5.2.3 above), the average of the carbon stock changes for years 2013-2020 (projected as described above) was used.

For the sake of transparency, some additional information is provided below to demonstrate how the provisions in paragraph 16 of the Decision 2/CMP.7 are observed:

- "Emissions that occur during the second commitment period from harvested wood products removed from forests prior to the start of the second commitment period shall also be accounted for."

These emissions are only relevant for the non-firewood wood products, and are estimated using the first order decay approach.

- "In the case the forest management reference level is based on a projection, a Party may choose not to account for the emissions from harvested wood products originating from forests prior to the start of the second commitment period, ..."

Hungary's FMRL is based on a projection, and Hungary has chosen not to account for the emissions from HWP originating from forests prior to the start of the second commitment period. For any particular year, estimates of the emissions from the HWP pool are included in both the FMRL and the annual total emissions from the FM category and, under the assumptions of the construction of the FMRL, the difference between sums of the two estimates taken for the entire CP should result in zero credits/debits.

- "... and shall ensure consistency in the treatment of the harvested wood products pool in the second commitment period in accordance with paragraph 14 above."

Consistency is ensured by the application of the above described estimation and accounting methodologies through the entire CP.

- "Emissions from harvested wood products already accounted for during the first commitment period on the basis of instantaneous oxidation shall be excluded."

This requirement is met by only including during the second CP emissions from the non-firewood harvested wood product sub-categories (i.e., sawnwood, wood based panels, as well as paper and paperboard).

- "The treatment of harvested wood products in the construction of a projected forest management reference level shall be on the basis of provisions outlined in paragraph 29 below and shall not be on the basis of instantaneous oxidation."

This requirement is fully met by applying the first order decay functions, and other methodological elements as described in the IPCC 2013 KP Supplement.

11.5.3 Information relating to Cropland Management, Grazing Land Management, Wetland drainage and Rewetting, and Revegetation, if elected, for the base year

As Hungary did not elect either Cropland Management, nor Grazing Land Management, nor Wetland drainage and Rewetting, nor Revegetation, this is a non-issue.

11.5.4 Information relating to Forest Management

11.5.4.1 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.

11.5.4.2 That forest management is a system of practices for stewardship and use of forest land aimed at fulfil 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://net.jogtar.hu/jr/gen/hjegy_doc.cgi?docid=A0900037.TV.

11.5.3.3 Emissions and removals from Forest Management

The methodology is described in section 11.3.1.1, General methodological notes, whereas the estimated emissions and removals are reported in the KP CRF tables.

11.6 Other information

11.7 Information relating to Article 6

11.8 NIR tables

TABLE NIR 1. SUMMARY TABLE

Activity coverage and other information relating to activities under Article 3, paragraph 3, forest management under Article 3.4, and elected activities under Article 3.4

Activity	CHANGE IN CARBON POOL REPORTED ⁽¹⁾							GREENHOUSE GAS SOURCES REPORTED ⁽²⁾								
	Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil		HWP ⁽⁴⁾	Fertilization ⁽⁵⁾	Drained, rewetted and other soils ⁽⁶⁾		Nitrogen mineralization in mineral soils ⁽⁶⁾	Indirect N ₂ O emissions from managed soil ⁽⁵⁾	Biomass burning ⁽⁶⁾			
					Mineral	Organic ⁽³⁾			N ₂ O	CH ₄ ⁽⁷⁾			N ₂ O	N ₂ O	CO ₂ ⁽¹⁰⁾	CH ₄
Article 3.3 activities																
Afforestation and reforestation	R	R	NR	NR	NR	NO	IE	IE	NO	NO	NO	NO	IE	R		R
Deforestation	R	R	R	R	R	NO	IO	IE	NO	NO		R	IE	R		R
Article 3.4 activities																
Forest management	R	R	NR	NR	NR	R	R	IE	NO	NO	NO	NO	IE	R		R
Cropland management	NA	NA	NA	NA	NA	NA			NA		NA		NA	NA	NA	NA
Grazing land management	NA	NA	NA	NA	NA	NA			NA		NA		NA	NA	NA	NA
Revegetation	NA	NA	NA	NA	NA	NA		NA	NA	NA		NA	NA	NA	NA	NA
Wetland drainage and rewetting	NA	NA	NA	NA	NA	NA		NA	NA	NA		NA	NA	NA	NA	NA

Table NIR 2. LAND TRANSITION MATRIX

Areas and changes in areas between the previous and the current inventory year^{(1), (2)}

	ARTICLE 3.3 ACTIVITIES		ARTICLE 3.4 ACTIVITIES					Other ⁽⁶⁾	Total area at the end of the previous inventory year ⁽⁷⁾
	Afforestation and reforestation	Deforestation	Forest management ⁽⁵⁾	Cropland management (if elected)	Grazing land management (if elected)	Revegetation (if elected)	Wetland drainage and rewetting (if elected)		
	(kha)								
Article 3.3 activities									
Afforestation and reforestation	171.91	NO							171.91
Deforestation		10.67							10.67
Article 3.4 activities									
Forest management		0.60	1765.63						1766.23
Cropland management ⁽³⁾ (if elected)	NA		NA	NA	NA	NA	NA		NA
Grazing land management ⁽³⁾ (if elected)	NA		NA	NA	NA	NA	NA		NA
Revegetation ⁽³⁾ (if elected)	NA		NA	NA	NA	NA	NA		NA
Wetland drainage and rewetting ⁽³⁾ (if elected)	NA		NA	NA	NA	NA	NA		NA
Other ⁽⁴⁾	1.42	NO	2.06	NA	NA	NA	NA	7350.97	7354.45
Total area at the end of the current inventory year	173.33	11.27	1767.69	NA	NA	NA	NA	7350.97	9303.26

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 ⁽⁴⁾
		Associated category in UNFCCC inventory ⁽¹⁾ is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory ⁽²⁾ (including LULUCF)	Other ⁽³⁾	
Specify key categories according to the national level of disaggregation used ⁽¹⁾					
Afforestation and Reforestation					
CO ₂	CO ₂	Land converted to forest land	Yes	NO	as key in the UNFCCC inventory.
Deforestation					
CO ₂	CO ₂	to grassland, Land converted to settlements	No	NO	as key in the UNFCCC inventory.
Forest Management					
CO ₂	CO ₂	Forest land remains forest land	Yes	NO	as key in the UNFCCC inventory.

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12. Information on the Accounting of the Kyoto Protocol 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 Report Tool 3.6.1 The filename is: [ITL_HU_2015_2_1.zip]. There have been no transactions in 2015 involving CP2 units.
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	R2 report has been generated with UNFCCC SEF Report Tool 3.6.1. The filename is: [RREG2_HU_2015.xlsx].
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2015. R3 report has been generated with UNFCCC SEF Report Tool 3.6.1. The filename is: [RREG3_HU_2015.xlsx].
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2015. R4 report has been generated with UNFCCC SEF Report Tool 3.6.1. The filename is: [RREG4_HU_2015.xlsx].
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist at 31 December 2015. R5 report has been generated with UNFCCC SEF Report Tool 3.6.1. The filename is: [RREG5_HU_2015.xlsx].
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: http://ec.europa.eu/clima/policies/ets/registry/docs/hu_accinfo_en.xls - Article 6 project information detailed in 13/CMP.1 par. 46 are available at: http://ji.unfccc.int/JI_Parties/DB/BBOE0EE02Y77126OGTQ91OS4GBWMZN/viewDFP - Holding and transaction information detailed in 13/CMP.1 par. 47 are available at: http://ec.europa.eu/clima/policies/ets/registry/docs/hu_SEF_2015

	.xlsx - List of legal entities authorized by party detailed in 13/CMP.1 par. 48 is available at: http://ec.europa.eu/clima/policies/ets/registry/docs/hu_legal_en.xls
15/CMP.1 annex I.E paragraph 18 CPR Calculation	The commitment period reserve is calculated in accordance with 11/CMP.1 (and paragraph 18 of decision 1/CMP.8), based on the inventory of 2014 (NIR submission 2016).

12.1 Calculation of the commitment period reserve (CPR)

The commitment period reserve is calculated in accordance with decision 11/CMP.1 (and paragraph 18 of decision 1/CMP.8):

"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 eight 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 2012 (National Inventory Submission 2014). However, the inventory of 2014 (National Inventory Submissions 2016) is already available and by the time this document will be assessed, the inventory of 2014 might already be the "most recently reviewed inventory", so CPR is calculated based on 2014's data. (Please note that the above choice of the most recently reviewed inventory has no effect on the CPR.)

Calculations:

(a) On the basis of assigned amount:

90% of the assigned amount of Hungary

$$434,486,280 \times 0.9 = 391,037,652 \text{ Mg CO}_2\text{-eq}$$

(b) On the basis of the inventory of 2016 (NIR 2016)

eight times the inventory of 2014:

$$57,225,155 \times 8 = 457,801,242 \text{ Mg CO}_2\text{-eq}$$

Based on the above calculations, the commitment period reserve amounts to **391,037,652 Mg CO₂-eq**.

13. Information on changes in national system

In 2015, the division responsible for inventory compilation within the Hungarian Meteorological Service was renamed to Unit of National Emissions Inventories. Apart of that, there have been no other changes since the last submission.

14. Information on changes in national registry

The following changes to the national registry of Hungary have occurred in 2015:

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 not changed. Contact information of the registry administrator has not changed.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There was no change to the database structure as it pertains to KP functionality in 2015. Versions of the CSEUR released after 6.3.3.2 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database. These changes 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. The database model is provided in Annex A [Annex A_CSEUR_DB_MODEL_20150113.PDF]. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 6.3.3.2 of the national registry are listed in Annex B [Annex B - Changes From 6.3.3.2 to 6.7.3.xlsx]. 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 will be carried out in February 2016 and the test report will be submitted thereafter No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No change of security measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 6.3.3.2 of the national registry are listed in Annex B. 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 will be carried out in February 2016 and the test report will be submitted thereafter.

Contact information of the registry administrator

The primary contact is:

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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 its 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 its 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 endeavours, 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 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 was adopted by the Hungarian Parliament unanimously in early 2008 (Parliamentary resolution 29/2008. (III. 20.) OGY). It has not been modified since then, however its review is currently underway. The NCCS guarantees that in accordance with 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 alone does not take part in large scale development projects relating to climate change, however as a Member State, it fully supports the EU's activities in this regard.