Hungarian Meteorological Service
Greenhouse Gas Inventory Division

National Inventory Report for 1985-2007

Hungary

April 2009

Prepared by:

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

CONTENT

VEZETŐI ÖSSZEFOGLALÓ

VÖ.1. Bevezetés

Magyarország az Éghajlatváltozási Keretegyezmény (UNFCCC) részes feleként, az Éghajlatváltozási Kormányközi Testület (IPCC) által kidolgozott módszertan alkalmazásával évről évre elkészíti az üvegházhatású gázok kibocsátási leltárát, és azt a kapcsolódó jelentéssel együtt benyújtja az ENSZ számára. A leltár az emberi tevékenységekkel összefüggő kibocsátásokat veszi számba, és elsődlegesen a Kiotói Jegyzőkönyv által felsorolt üvegházhatású gázokat - széndioxidot (CO_2), metánt (CH_4), dinitrogén-oxidot (N_2O), részlegesen fluorozott szénhidrogéneket (HFC-k), perfluorkarbonokat (PFC-k) és kén-hexafluoridot (SF_6) – tartalmazza. A leltár minőségét nemzetközi szakértők rendszeresen ellenőrzik.

Az ÜHG leltárt a környezetvédelmi és vízügyi miniszter megbízása alapján jelenleg az Országos Meteorológiai Szolgálat állítja össze. Ebben a munkában külső szakértők és intézmények is részt vesznek, a Szolgálat kiemelt partnere a Központi Statisztikai Hivatal, az Energia Központ Nonprofit Kft., az Állattenyésztési és Takarmányozási Kutatóintézet, a Mezőgazdasági Szakigazgatási Hivatal Központ Erdészeti Igazgatóság, a Környezetvédelmi és Vízgazdálkodási Kutató Intézet Kht. és a Debreceni Egyetem.

Jelen leltár az 1985 és 2007 közötti kibocsátási (és elnyelési) adatokat tartalmazza az előírt ágazati bontásban. Az adatbázishoz kapcsolódó részletes, angol nyelvű nemzeti leltárjelentés fő célja, hogy biztosítsa a leltár átláthatóságát, vagyis részletesen ismertesse a számításokhoz felhasznált adatokat és az alkalmazott módszertant. A nemzeti jelentés ezen túlmenően bemutatja a leltárkészítés intézményi hátterét, minőségbiztosítását, a legfontosabb kibocsátási ágazatok, vagyis a kulcskategóriák elemzését, ismerteti a trendeket, bizonytalansági becslést közöl, s kitér az újraszámolásokra és az előttünk álló feladatokra is. A részletes adatok és a nemzeti leltárjelentés bárki számára hozzáférhetőek az ENSZ honlapján.
(http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/4303.php)

VÖ.2. A főbb trendek alakulása

Magyarország 2007. évi ÜHG kibocsátása 75,9 millió tonna szén-dioxid egyenérték volt, ami a leltár teljes időszakát tekintve (1985-2007) messze a legalacsonyabb érték. Ha figyelembe vesszük az erdeink által elnyelt szén-dioxidot is, a (nettó) kibocsátásunk 71,8 millió szén-dioxid egyenértékre csökken. A 7-8 tonna közötti egy főre jutó kibocsátás Európában viszonylag alacsonynak számít. A Kiotói Jegyzőkönyv aláírásával hazánk 6%-os csökkentést vállalt az 1985-87-es évek átlagos kibocsátási szintjéhez viszonyítva, a jelenlegi kibocsátásunk viszont 34%-kal alacsonyabb annál. A markáns csökkenés jelentős részben a rendszerváltozás következménye: már 1992-re mintegy 30%-kal csökkent az emisszió az energetikai, ipari és mezőgazdasági termelés visszaesésének következtében.

A 2007-es ÜHG kibocsátás azonban a rendszerváltás utáni időszakra jellemző értékeknél – a kibocsátásokat tekintve viszonylag stabilnak mondható 1996-2005-ös időszak átlagánál – is 5%-kal alacsonyabb. 2006 és 2007 között 4%-kal, 2005 és 2007 között pedig csaknem 6%-kal csökkent a teljes ÜHG kibocsátás, elérve az eddigi legalacsonyabb szintet (még a második legalacsonyabb kibocsátású évben, 2000-ben is 2,1 millió tonnával nagyobb volt az emisszió).

A 2006 és 2007 közötti 4%-os csökkenés nagyrészt az energiaszektorban zajló folyamatok eredménye (-2,3 millió tonna).

- A lakossági energiafogyasztás 20%-kal, ezen belül a földgázfelhasználás 12%-kal csökkent. A csökkenést elsősorban a rendkívül enyhe téllel, az alacsonyabb fűtési energiaigénnyel magyarázhatjuk, de a növekvő energiaárak és a lakóépületek korszerűsítése is hatással lehettek a fogyasztás alakulására.
- Az ipar energiafelhasználása is csökkent, ami az ágazat kibocsátását 4%-kal mérsékelte.
- A fentiekkel szemben a villamos energiatermelés továbbra is növekvő tendenciát mutat, s ez megmutatkozik az energiaipar növekvő kibocsátásában is (+6%).
- A közlekedési kibocsátás is tovább nőtt, bár a növekedés üteme csökkenni látszik: 2005 és 2007 közötti 5%-kos növekedésből csak 1%-nyi esik 2006-2007-re.

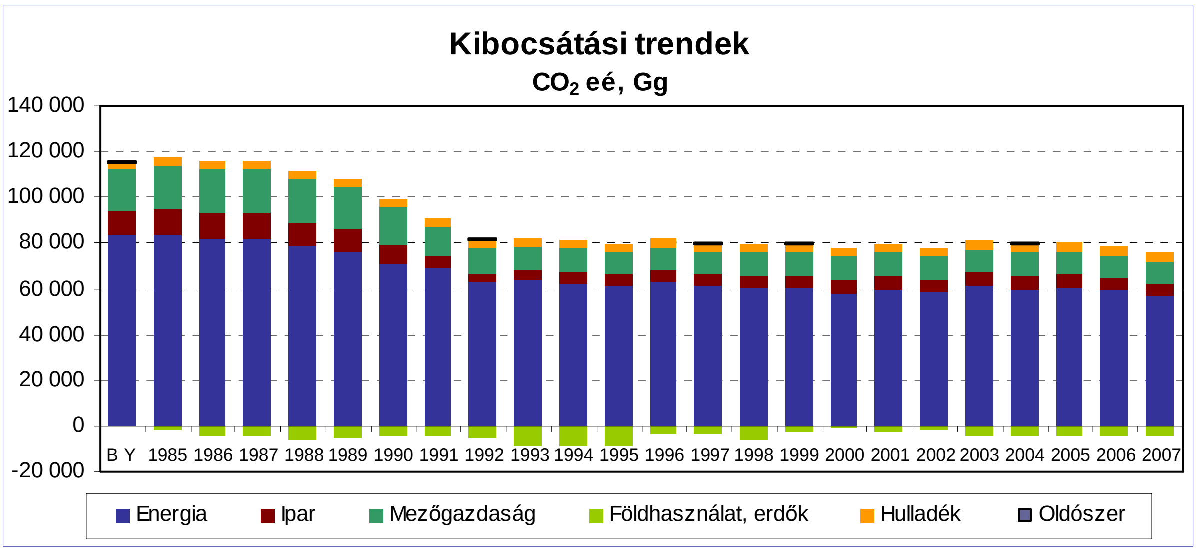
Az ipari folyamatok szektorban 8%-os (-0,5 millió tonna) kibocsátás csökkenés volt tapasztalható - elsősorban a salétromsav-gyártás területén végrehajtott modernizáció következtében. Az Nitrogénművek Zrt. új üzeme tényleges fajlagos mutatói alapján immár Európa legjobbjai közé tartozik.

Üvegházhatású gázok kibocsátása (CO_2 eé, Gg)	Bázisév (rögz.)	1990	1995	2000	2005	2006	2007
CO_2	85,795	72,472	61,502	58,492	61,099	59,757	57,752
CH_4	10,139	11,153	9,225	9,368	8,798	8,710	8,545
N_2O	19,224	15,275	8,880	9,599	9,558	9,544	8,858
HFC-k	2	0	2	206	518	607	615
PFC-k	167	271	167	211	209	2	2
SF_6	70	40	70	140	201	244	172
Kibocsátás (nyelőkkel)	**112,661**	**95,000**	**71,227**	**77,188**	**75,766**	**74,756**	**71,806**
Kibocsátás (nyelők nélkül)	**115,397**	**99,210**	**79,845**	**78,016**	**80,382**	**78,865**	**75,944**

A legfontosabb üvegházhatású gáz a szén-dioxid, amely az összes kibocsátás 76%-áért felel. A szén-dioxid emisszió döntő részben az energiaszektorban keletkezik, a fosszilis tüzelőanyagok elégetése révén. A CO_2 kibocsátásunk 32%-kal csökkent a 80-as évek közepe óta. A metán 11%-os súlyt képvisel a teljes ÜHG kibocsátásban. Elsősorban az állattenyésztés és a hulladékgazdálkodás során keletkezik, de pl. a földgáz szállításakor is elillan belőle nem is kis mennyiség. 1985-87-hez képest a kibocsátás 28%-kal csökkent. A 12%-nyi dinitrogén-oxid elsősorban a mezőgazdasági talajokból, illetve vegyipari termelés következtében kerül a levegőbe. A mennyisége a felére esett vissza a bázisévhez képest. Az F-gázok összesen 1%-ot képviselnek, de tendenciájuk növekvő, főleg a hűtő- és klímaalkalmazások miatt.

VÖ.3. A kibocsátások és elnyelések ágazati jellemzése

A teljes kibocsátás háromnegyede az energiaszektor számlájára írható. A mezőgazdaság 13%-kal, az ipari folyamatok további 7%-kal járulnak hozzá az üvegházhatású gázok kibocsátásához, míg a hulladék szektor 5%-ot képvisel a leltárban. A rendszerváltozás következtében jelentősen csökkent a kibocsátás az energiaszektorban, a mezőgazdaságban és az iparban, a hulladékszektor kibocsátása viszont növekedett. Az erdők, a földhasználat változásai nyelőként viselkednek, vagyis összességében általában kivonják a szén-dioxidot a levegőből.



1. ábra *Az ÜHG emisszió változása (1985-2007)*
Megjegyzés: BY=a bázisév az 1985-87-es évek átlaga és 1995 az F-gázokra

2007-ben az *energiaszektor* a teljes kibocsátás 75%-áért volt felelős. A fosszilis tüzelőanyagokból keletkező szén-dioxid a legnagyobb tétel az üvegházhatású gázkibocsátások között, a szektor kibocsátásában 94%-ot képvisel, ezt követi a metán 4%-kal, majd a dinitrogén-oxid 2%-kal. A tüzelőanyagok közül az elégetett gáz okozza a legnagyobb kibocsátást (45%), majd a folyékony és a szilárd tüzelőanyagok következnek, s ez utóbbiaknak már csak 23% a részesedésük. A 90-es években lezajlott tüzelőanyag-szerkezetváltásnak köszönhetően a 80-as években még elsődlegesnek számító forrást, a szilárd tüzelőanyagot mindinkább kiszorítja a fajlagosan kisebb kibocsátású földgáz, ezáltal is csökken a teljes kibocsátás. Az energiaszektoron belül legjelentősebb az "energiaipar" alszektor 36%-kal, majd ezt követi a közületek, háztartások és mezőgazdaság fogyasztása ("egyéb szektor"), mely 24%-ot képvisel a teljes kibocsátásban. A legdinamikusabban ugyanakkor a közlekedés kibocsátása nőtt, 2005-höz képest 6%-kal, a 80-as évek közepéhez viszonyítva pedig 66%-kal volt magasabb az emisszió.

2007-ben a *mezőgazdaság* volt a második legjelentősebb szektor Magyarország üvegházhatású gáz leltárában, 13%-kal járult hozzá a teljes kibocsátáshoz. Az ágazat hozzájárulása a teljes emisszióhoz 1985 óta kismértékben ugyan, de folyamatosan csökkenő. (1985-ben még 17% volt az aránya.) A kibocsátás jelentősen csökkent 1985 és 1995 között, míg 1996 és 2006 között kisebb ingadozásokkal ugyan, de állandónak tekinthető. Mezőgazdasági tevékenységek CH_4 és N_2O kibocsátással járnak, a N_2O kibocsátásunk legnagyobb része (77%) ebből a szektorból származik. Az ágazati ÜHG emisszió legfontosabb forrásai a mezőgazdasági talajok N_2O kibocsátása, a trágyakezelés (N_2O és CH_4) emissziója és a haszonállataink emésztése (CH_4).

Az *ipari folyamatok* szektor a harmadik legnagyobb kibocsátó hazánkban, a teljes kibocsátás 7%-áért felelős. A legjelentősebb üvegházhatású gáz az ipari tevékenységek során a CO_2, amely 67%-ban járul hozzá a szektor kibocsátásához, ezt követi a N_2O 17%-kal és az F-gázok 15%-kal. A szektor kibocsátása 50%-kal csökkent a bázisévhez képest, az elmúlt évhez viszonyítva pedig 8%-os a csökkenés. A legnagyobb kibocsátók közé tartozik a cement- és az ammóniagyártás. Az *oldószerek és egyéb termékek használata* szektor a teljes kibocsátás szinte jelentéktelen részét, 0,2%-át teszi ki.

A *hulladékszektor* 5%-kal járul hozzá a teljes kibocsátáshoz. Szemben az előzőekben felsorolt ágazatokkal, a hulladékkezelésből származó emisszió növekszik, 2007-ben 35%-kal volt magasabb a kibocsátás, mint 20 évvel korábban. A szilárd hulladék lerakásából keletkezik a kibocsátás zöme (72%), míg a szennyvízkezelés 18%-os, a hulladékégetés pedig 10%-os részarányt képvisel. Az elmúlt néhány évben a hulladékégetésből származó kibocsátás növekedett dinamikusan, a szennyvízkezelés súlya tovább csökkent.

Jelenlegi eredményeink alapján Magyarországon a *földhasználat, földhasználati változások és erdészet* szektor nyelőnek tekinthető. Messze a legtöbb szén-dioxidot az erdők kötik meg, ugyanakkor az erdő, szántó és gyep művelési ágak megváltoztatásából származó elnyelés mértéke folyamatosan csökken, sőt az elmúlt néhány évben a 0 érték körül ingadozik. Összességében a szektor elnyelésében/ emissziójában trend nem mutatható ki, a földhasználat, földhasználati változások bonyolult dinamikája miatt a szektor elnyelése jelentős fluktuációt mutat az 1985 és 2007 közötti időszakban.

VÖ.4. Indirekt üvegházhatású gázok és a kén-dioxid

Az NOx, CO és NMVOC gázokat azért nevezzük indirekt gázoknak, mert közvetve, másodlagos hatások révén befolyásolják (csökkentik vagy növelik) a légkör melegedését. A nitrogén-oxidok, a szén-monoxid és a (nem metán) illékony szerves vegyületek kémiai folyamatok révén elősegítik az ózonképződést, az ózon pedig üvegházhatású gáz. A kén-dioxidból olyan kis lebegő részecskék (aeroszolok) alakulnak ki, amelyek befolyásolják a légköri sugárzási viszonyokat. A kibocsátások trendje az alábbiak szerint alakult (Gg):

Indirekt gázok	*1985*	*1990*	*1995*	2000	2005	2006	2007
NO_X, Gg	*262.5*	*238*	*190.07*	185.1	203.1	202.5	185.0
CO, Gg	*931.1*	*997*	*761.29*	592.4	585.2	596.3	573.7
NMVOC, Gg	*232*	*205*	*150.3*	166.0	176.2	186.7	167.7
SO_2, Gg	*1403.6*	*1010*	*704.96*	489.0	146.6	123.1	98.5

2. táblázat *Indirekt gázok kibocsátása.*

A kén-dioxid jelentős (több mint 90%-os) csökkenését a kevesebb fosszilis energiahordozó felhasználása mellett azok csökkenő kéntartalma is okozza. A 2000-től bekövetkezett további csökkenés a széntüzelésű erőművekbe beépített SO_2 leválasztó működésének az eredménye. A szén-monoxid csökkenés oka egyértelműen a felhasznált tüzelőanyag csökkenése. Az NOx csökkenés azért kisebb mértékű, mert azt részben ellensúlyozza a közlekedés növekvő kibocsátása.

EXECUTIVE SUMMARY

ES.1. Background information

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

The GHG inventory is compiled by the Hungarian Meteorological Service, based on a mandate of the Minister of Environment and Water. Also other institutions and outside experts are involved in the process of inventory preparation, e.g. the Hungarian Central Statistical Office, Energy Efficiency, Environment and Energy Information Agency, Research Institute for Animal Breeding and Nutrition, Karcag Research Institute of University of Debrecen and Central Agricultural Office (Forestry Directorate), 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 1985-2007. The NIR provides relevant background information on institutional arrangements, QA/QC procedures and other information underlying the inventory compilation in Chapter 1. In Chapter 2 the trends for aggregated greenhouse gas emissions are discussed. The following chapters provide detailed information on each of the main source categories. Chapter 10 discusses details of recalculations and planned improvements. In the Annexes key category analysis and complementary methodological information can be found.

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

In 2007, total emissions of greenhouse gases in Hungary, were 75.9 million tonnes carbon dioxide equivalents (excluding the LULUCF sector). This is 5 percent below the 10 years average of the quite stable period of 1996-2005. With less than 8 tonnes, the Hungarian per capita emissions are below the European average. By ratifying the Kyoto Protocol, Hungary committed to reducing its GHG emissions by 6%. Now, our emissions are 34% lower than in the base year (average of 1985-87). However, this significant reduction is 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 GHG relevant energy, industry and agriculture.

Taking into account also the mostly carbon absorbing processes in the LULUCF sector, the net emissons of Hungary were 71.8 million tonnes CO_2 eq. in 2007. This is the second lowest value in the whole time-series (1985-2007).

Emissions (excluding LULUCF) decreased by almost 4% (-2.9 million tonnes) between 2006 and 2007 and by 6% between 2005 and 2007. Emissions in 2007 were by far the lowest in the whole inventory period (second lowest was 2002 with 78.0 million tonnes).

The reduction between 2006 and 2007 is mainly due to processes in the energy sector (-2.3 million tonnes):

- Most importantly, the total fuel consumption in the residential sector decreased by 20% (including a 12% decrease in natural gas use) - mainly due to extreme mild winter in 2007 but probably the growing energy prices and the support for modernisation of buildings might have played a role as well.
- Fossil fuel needs of “other” manufacturing industries also decreased considerably which led to 4 percent lower emissions in this subcategory.
- In contrast with the above trends, the emissions from energy industries grew by 6% in line with the growing tendency of electricity generation.
- The growth in the transport sector slowed down: emissions grew only by 1% between 2006 and 2007 but by 5% between 2005 and 2007.

Emissions from industrial processes decreased by 8% (-0.5 million tonnes). This change is mainly due to the modernization of nitric acid production. Through putting the new acid plant into service in Nitrogénművek PLC which is recently the most up-to-date and high capacity plant in Europe, the company’s N_2O emission volumes have considerably fallen back.

By far the most important greenhouse gas is carbon dioxide accounting for 76% of total GHG emissions. The main source of CO_2 emissions is burning of fossil fuels for energy purposes, including transport. CO_2 emissions decreased by 32% since the middle of the 80’s. Methane represents 11% in the GHG inventory. Methane is generated mainly in waste disposal sites and animal farms, but the fugitive emissions of natural gas are also an important source. CH_4 emissions are 28% lower than in base year. Nitrous oxide contributes 12% to the total GHG emissions. Its main sources are agricultural soils, manure management and chemical industry. The N_2O emissions were halved in the years of political and economic changes. The total emissions of fluorinated gases amount to 1%. However, they are showing a fluctuating, slightly growing tendency especially due to their applications in the cooling industry.

Table ES. 1. BY=average of 1985-87 (1995 for F-gases) as fixed in 2007

GREENHOUSE GAS EMISSIONS (CO_2eq, Gg)	BY fixed	1990	1995	2000	2003	2004	2005	2006	2007
CO_2, without LULUCF	85,795.5	72,470.8	61,501.8	58,491.8	61,640.2	59,897.9	61,098.9	59,757.5	57,751.8
CH_4, without LULUCF	10,139.2	11,153.1	9,224.5	9,368.3	9,257.6	8,921.0	8,797.7	8,710.5	8,545.3
N_2O, without LULUCF	19,223.7	15,275.3	8,880.2	9,598.6	9,485.2	10,180.0	9,557.6	9,544.3	8,857.9
HFCs	1.74	0.0	1.74	205.7	498.9	525.8	517.6	606.9	614.5
PFCs	166.8	270.8	166.8	211.3	189.6	201.1	209.4	1.5	2.4
SF_6	70.2	39.9	70.1	140.1	161.9	178.2	201.0	244.4	171.6
Total (including LULUCF)	**112,661**	**95,000**	**71,227**	**77,188**	**76,744**	**75,703**	**75,766**	**74,756**	**71,806**
Total (excluding LULUCF)	**115,397**	**99,210**	**79,845**	**78,016**	**81,233**	**79,904**	**80,382**	**78,865**	**75,944**

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

By far, the biggest emitting sector was the Energy sector contributing 75% to the total GHG emission in 2007. Agriculture was the second largest sector with 12.5% while emissions from Industrial Processes (with Solvent and other product use) accounted for 7% and the waste sector contributed 5.5%. Compared to the base year, emissions were significantly reduced in the Energy, Agriculture, Industry and Solvent sectors. In contrast, the emissions in Waste sector are increasing. In the Land Use, Land-Use Change and Forestry (LULUCF) sector removals (negative value) show fluctuating behaviour.

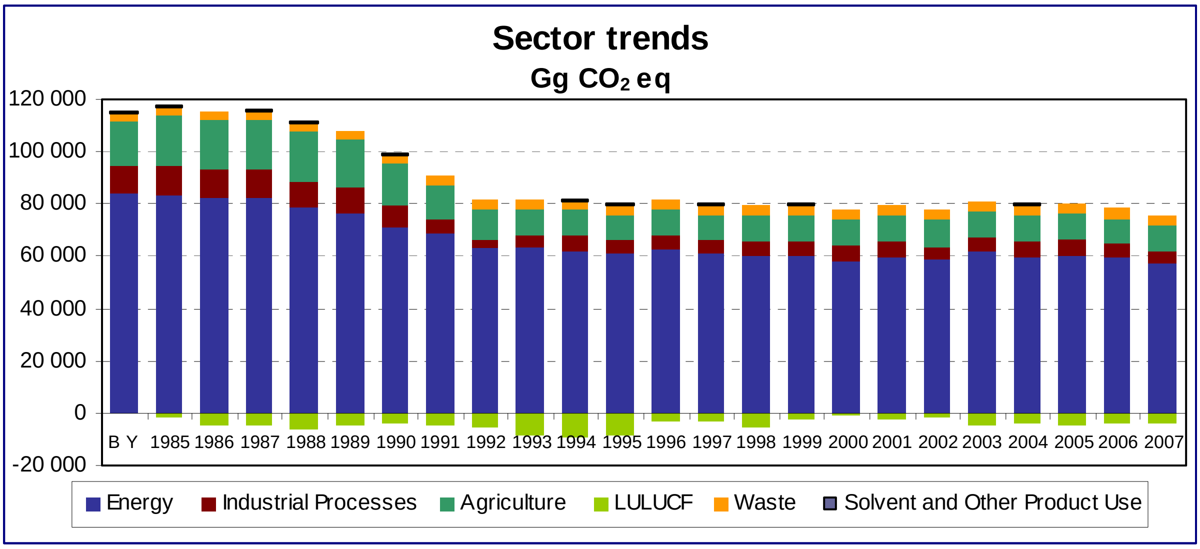


Figure ES. 1. *Change in greenhouse gas emissions from base year (1985-2007)*
Note: BY=average of 1985-87 but 1995 for F-gases

The *Energy sector* was responsible for 75.0% of total GHG emissions in 2007. Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 94.4% to sectoral emission, followed by CH_4 with 4.1% and by N_2O with 1.5%, in 2007. Among fuels, gases have the highest proportion (44.7%), liquids have less, and solids have the lowest, but the latter still represents 23.4% of the sectoral CO_2 emissions. Besides the sudden decrease in energy demand in the years of economic transformation, also the changes in the fuel-structure in the '90s when the most important source in the base years namely solid fuel has been replaced by natural gas, led to decreased total emission. The most important subsector of the energy sector is Energy Industries with a proportion of 36%, followed by Other Sectors and Transport representing 24 and 23% of the total emissions in this sector, respectively. Fugitive Emissions from Fuels play only a small role in emissions of the sector with 4%. The most dynamically increasing category is Transport which has 66% higher total emission in 2007 compared to the base year.

In 2007, *Agriculture* was the second largest source of greenhouse gas emissions in Hungary. It accounted for 12.5 percent of total emissions. The contribution of agriculture to total emissions decreased over the period 1985-2007 from 17% to its present share. Emissions from Agriculture include CH_4 and N_2O gases. Most of the total N_2O emissions are generated in agriculture; it amounts to 77 percent of total N_2O. The total emissions from agriculture decreased over the period 1985-2007. The bulk of this decrease occurred in the years between 1985 and 1995, during which the agricultural production underwent a drastic decrease. The trend in emission is slightly fluctuating between 1996 and 2007.

The *Industrial Processes* is the third largest sector contributing 7% to total GHG emissions in

2007. The most important greenhouse gase is CO_2, contributing 67% to total sectoral GHG emissions, followed by N_2O with 17% and F-gases with 15%. The total sectoral emissions decreased by 50% between base year and 2007 and by 8% between 2006 and 2007. The most important emission subcategories are mineral products and chemical industry representing 46% and 34% of the industrial processes' emissions, respectively.

The *Waste sector* represents 5.5% of total national GHG emissions. In contrast with other sectors, the emissions of waste sector showed significant increase (+35%). In the base year the total GHG emissions from the waste sector accounted for 2.6% of total national GHG emissions. However, the growth of emissions seems to be slowing or even stopping in recent years. In all the years, the largest category was Solid Waste Disposal on Land, representing 72% in 2007, followed by Wastewater Handling (18%) and Waste Incineration (10%). Solid Waste Disposal on Land and Waste Incineration categories are showing an increasing tendency whereas the emissions from Wastewater Handling are decreasing.

The *LULUCF sector* was a net sink of carbon in all of the years. This result is determined largely by Forest Land, which is a major carbon sink. The Cropland living biomass can be a net sink of carbon but also a net source of emission in some years due to reduction of orchard and vineyard areas. The soil disturbance generates steadily decreasing removals of CO_2, as a consequence of reduction of agricultural land and afforestation of croplands. The complex dynamics of the land use and land-use changes leads to fluctuating trend in the LULUCF sector. In 2007, the net removal was -4.1 million tonnes.

ES.3. Indirect Greenhouse Gases and SO_2

NO_X, CO and NMVOC gases are referred to as indirect gases because they (together with SO_2) influence atmospheric warming indirectly, via secondary effects. Nitrogen oxides, carbon monoxide and (non methane) volatile organic compounds are precursor of ozone which is itself a naturally occurring greenhouse gas. Sulphur dioxide can contribute to formation of aerosols that scatter some of the solar radiation back into space. Calculation of the emissions of these gases was required by the IPCC 1996 Revised Guidelines and the CRF programme provided a certain level of information technology background. It should be noted that Hungary (as well as the other European countries) has calculated the emissions of such gases for several decades and the Geneva Convention of 1979 (CLRTAP) also laid down such obligations. Since 1999, the above-mentioned programme has also been used for calculating the emissions of indirect gases. No recalculations have been made for the preceding years because data from 1980 on are available from the National Emissions Database (NED).

The following table shows the main trends in emissions:

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

Indirect gases	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
NO_X, Gg	262.5	264.2	264.9	257.8	246.8	238	203.1	183.3	184	187.4	190.07
CO, Gg	931.1	--	--	963.1	--	997	913.4	835.8	796.1	774.29	761.29
NMVOC, Gg	232	263	228	215	205	205	149.6	141.8	149	142.4	150.3
SO_2, Gg	1403.6	1361.8	1285.3	1218	1102	1010	913	827.3	757.3	741	704.96
	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007
NO_X, Gg	195.81	199.5	202.62	185.1	183.2	182.9	210.7	185.3	203.1	202.5	185.0
CO, Gg	726.87	733.36	736.93	592.4	578.8	573.8	600.3	585.4	585.2	596.3	573.7
NMVOC, Gg	150.1	145.4	140.6	166.0	162.3	160.1	169.0	157.0	176.2	186.7	167.7
SO_2, Gg	673.23	658.51	591.79	489.0	403.9	364.9	347.8	248.8	146.6	123.1	98.5

The substantial reduction in sulphur dioxide emissions (-90%) is attributable to the decreased use and lower sulphur content of fossil fuels. After 2000, further reductions were observed due to the introduction of SO_2 precipitators in coal-fired power stations. Reduced carbon monoxide emissions are obviously a consequence of decreased fuel uses. NO_X and NMVOC emissions show no significant trend in the last 15 years.

1. INTRODUCTION

1.1. Background information and climate change

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

With the introduction of additional greenhouse gases, it was necessary to select the corresponding base years. (This is particularly important for HFCs because such gases have been increasingly used since the early 1990's as replacements for ozone depleting chlorofluorocarbons.) Hungary has chosen the year 1995 as the base year for fluoride gases.

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

In early March 2007 the Expert Review Team of UNFCCC made a thorough in-depth in-country review. During this review a few potential problems were found. In collaboration between the ERT and the Hungarian experts, these problems could be fixed. However, some recalculations were necessary which led to changes also in the emissions of the base year and consequently in the assigned amount.

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

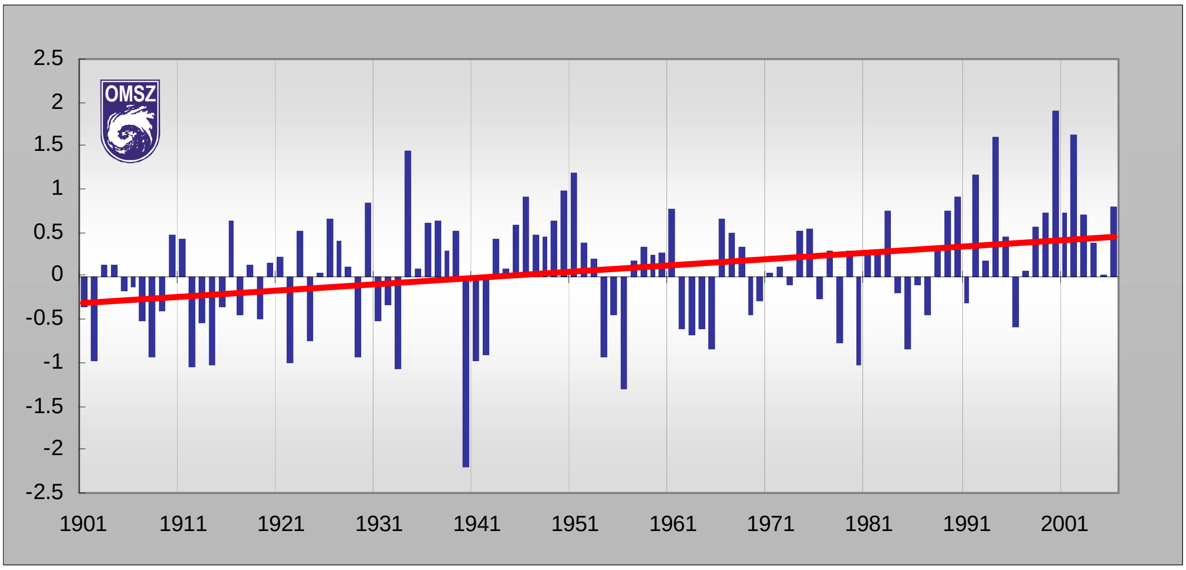


Figure 1.1. *Homogenized annual average temperature anomalies (°C) 1901-2006 relative to 1961-1990 in Hungary. The warming is 0.77°C by line ar estimation for 106 years.*

The year 2007 was the warmest year since 1901 with an average annual temperature of 11.7°C. Especially, winter months were extremely mi ld: the monthly average temperature in January, which was the warmest January of the last 100 years, was by 5 degrees higher than the 30 year average.

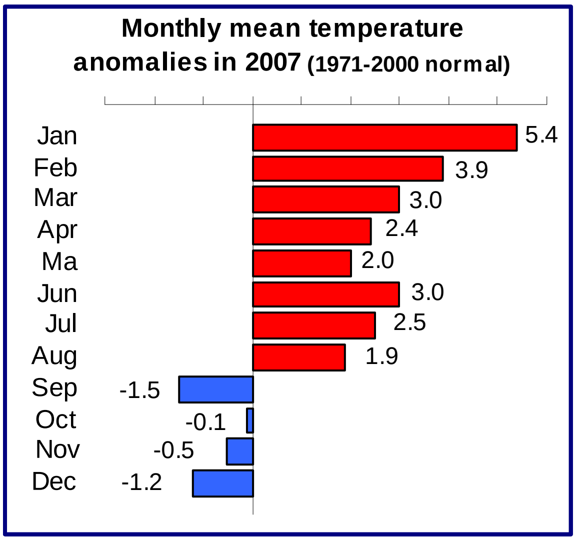


Figure 1.2. *Anomaly of the countrywide monthly mean temperatures 2007 (ºC) in Hungary*

1.2. Institutional arrangements

There were changes neither to the national system nor to the registry in the level of the main responsibilities. The single national entity is the Ministry of Environment and Water, the Hungarian Meteorological Service and the National Inspectorate for Environment, Nature and Water are responsible institutes for the inventory and the registry, respectively. However, new sectoral expert institute (Central Agricultural Office) has been involved in the preparation of the forestry part of the LULUCF inventory. It is planned that the participation of the Central Agricultural Office will be formalised by a government decree which is expected to enter into force in 2009.

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

Based on a mandate of the minister, a Greenhouse Gas Inventory Division (GHG division) was established in the Hungarian Meteorological Service (OMSZ) for the preparation and development of the inventory. This division is responsible for all inventory related tasks, prepares the greenhouse gas inventories and other reports with the involvement of external institutions and experts on a contractual base and supervises the maintenance of the system.

The GHG division can be regarded as a core expert team of four people. The division of labour and the sectoral responsibilities within the team are laid down in the QA/QC plan and other official documents of OMSZ. The Head of Division coordinates the teamwork and organizes the cooperation with other institutions involved in inventory preparations. He is responsible for compilation of CRF tables and NIR. Within the team there are coordinators of the different sectors and also a QA/QC coordinator and an archive manager were nominated.

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

The GHG division 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.

Some parts of the inventory (mainly energy, industrial processes and waste) are prepared by the experts of the GHG division themselves; the calculations of other sectors are made by outside experts / institutions on contractual basis as follows. The agriculture sector of the inventory has been prepared by the Research Institute for Animal Breeding and Nutrition for several years. This institute collects the data, chooses the calculation method, prepares the inventory in CRF format and sends it to the inventory compiler in xml format. We have a new partner for the forestry part of the LULUCF sector: the Forestry Directorate of the Central Agricultural Office. From now on, this institute is responsible for data collection, inventory preparation. However, in this inventory cycle our former contributor, an internationally recognized expert in this field, has been heavily involved in inventory preparation by permanent consultancy and quality control of the results. For the calculation of soil C stock changes Karcag Research Institute of University of Debrecen (Department of Soil Utilization and Rural Development) was contracted like in last year. The following table summarizes the institutional arrangements:

Function	***Institution***	***Responsibilities***
Single national entity	Ministry of Environment and Water	• Supervision of national system • UNFCCC National Focal Point • Official consideration and approval of inventory
Inventory coordination and compilation	OMSZ GHG division	• Provision of work plan • Contracting consultants • Inventory preparation of Energy, Industry and Waste sector • Completion of CRF and NIR • Archiving • Coordinating QA/QC activities • Reporting to UNFCCC secretariat
Inventory preparation of Forestry	Central Agricultural Office (Forestry Directorate) Contracted consultant	• Data collection, choice of methods and EFs, inventory preparation
Inventory preparation of Agriculture sector	Research Institute for Animal Breeding and Nutrition	• Data collection, choice of method, emission calculation • Inventory preparation
Inventory preparation of Soil C stock changes	Karcag Research Institute of University of Debrecen	• Data collection, choice of methods and EFs, inventory preparation

1.3. Inventory preparation

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

Data collection and processing

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

Since the use of ETS data has several advantages, the inventory team was granted access to the verified emissions database held by the National Inspectorate for Environment, Nature and Water.

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

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

The Act on Implementation Framework for UNFCCC and its Kyoto Protocol, which was enacted by Parliament in 2007, aims to give direct data collection authorization to the Ministry for Environment and Water in order to collect data for the national system for climate reporting and gives a permanent status to the system. Relevant paragraphs for data collection are the following: “All data required for the national system held by governmental institutions and all information about emissions more than 100 tons of CO_2-eq held by emitters shall be made available for the national system…the relevant data shall be made available even if they are confidential according to the Law on Statistics…” A government decree on the implementing rules of compulsory data provision for GHG inventory and forecasting purposes is in the final conciliation phase and is expected to enter into force this year. This decree will regulate also the functioning of the national system in more detail.

Method and emission factor selection

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

Activity data X emission factor

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

Preparation of emission estimates

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

Uncertainty assessment

The uncertainty values of the inventory – except LULUCF – are calculated on the basis of the method provided in the GPG.

Key source categories

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

Recalculations

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

Reporting

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

Submission and approval

About two weeks before submission, the complete NIR has to be sent to the sectoral experts for a final check. After that, the supervising ministry will approve the documents to be submitted. The above mentioned government decree on the implementing rules of compulsory data provision for GHG inventory, which is now in the final conciliation phase, will regulate the process of approval as well.

Review

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

Archiving

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

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

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

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

- Former inventories, NIRs and CRFs – Ministry of Environment and Water
- Data from individual industrial plants - Ministry of Environment and Water
- ETS data, registry - National Inspectorate for Environment, Nature and Water
- Agricultural data (livestock, manure, fertilizer etc.) - Research Institute for Animal Breeding and Nutrition
- Soil-classification - Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences (TAKI)
- Forestry statistics – Central Agricultural Office Forest Directorate
- Wastewater data - National Inspectorate for Environment, Nature and Water + Research Institute for Environmental and Water Management.

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

The directories of the server, where the data of the GHG Division are stored have access protection, so they are available only for the staff of the Division in charge of the different sectors of the GHG inventory. The structure of the GHG Division's data is as follows:

- Databases
- Working Folder
- Management (with the relevant contracts)
- Law & Guidelines
- Literature
- CRF Reporter Programmes
- Xml files
- QA/QC information
- Submissions/Reports
- Meeting documents
- Others

It is important to note that there are different directories for all the calculations and drafts (working folder) and for the submitted reports and incoming data which cannot be modified. Within the GHG Division of OMSZ, the nominated archive manager is responsible for the maintenance of the archiving system in close cooperation with the IT Department of the Service. A procedural manual for the management and maintenance of archiving system is under preparation. A harmonized or maybe unified computerized database containing all the data relevant to the National System as well as for the EU emission trading regime is under development. Further development of the system may include the incorporation of other emission data, which are relevant to air pollution.

10. Art. 8 reviews

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

Verification

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

1.4. Methodology

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

The emissions of individual technologies were calculated using the Tier 1, Tier 2 or Tier 3 method, attempting at the highest possible approximation except for cases where the required data were not available. (See CRF Inventory, Summary Table 3.) Methods other than the standard ones were used for the calculation of methane emissions for oil/gas mining, methane emissions from wastewater sludge, solvent uses (no method is available), HFCs and SF_6 gases. We were forced to apply such deviations primarily due to the insufficient or different availability of data/information.

Before, only a few specific emission factors were available for Hungary. In addition to the recalculations, our objective was to determine the specific emission factors for the key categories. Where such specific emission factors did not become available, the default values recommended by the guidebooks were taken, mostly using the values proposed for Eastern European technologies. However, where advanced technologies similar to those of the Western European countries were adopted, the values proposed for such technologies were used. In cases where intervals were provided as specific values, we usually used the arithmetical means. For certain technologies (e.g., aluminium production, CF_4 emission), the specific emission typical for the Hungarian manufacturing processes was determined on the basis of the Revised Guidelines. For the calculation of the emissions of 1980’s and 1990, we had to rely on expert estimates for missing data.

1.5. Key source categories

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

As a result of calculation without LULUCF, 17 key source categories using LEVEL Tier 1 method and 16 key source categories using TREND Tier 1 method were identified. *(The key source categories are shown in Annex 1.4, Table A1-8.)*

Whereas the most important emitting technology continues to be the “Stationary Combustion – Gas” (CO_2, 32%), “Fugitive Emissions from Coal Mining and Handling, CH_4” has the lowest contribution (CO_2 eq., 0.03%) among the key sources. The latter was included in this group despite its low contribution as determined by the TREND method because there was a significant difference in emissions between the base year and 2007. Using the concept of “Combined uncertainty” from the Tier 2 methodology, LEVEL 2 and TREND 2 key sources were also identified with 11 and 13 key sources, respectively. Input data and results of Tier 2 calculations differ from previous submissions according to the new methods in agriculture.

Results of key category calculation with LULUCF are summarized in *Table 1.1*. Since uncertainty estimates are not available for the LULUCF sector, Tier 2 method was applied to find key categories only for source categories (without LULUCF). The LEVEL and TREND methods found 18 and 17 key categories, respectively.

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

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

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

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

SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF				
Quantitative Method Used: ☒ **Tier 1** ☐ **Tier 2**				
A	**B**	**C**	**D**	**E**
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
2. Industrial Processes				
CO_2 Emissions from Ammonia Processes	CO_2	Yes	Level 1, Trend 1	
CO_2 Emissions from Nitric Acid Production	CO_2	No		
CO_2 Emissions from Metal Production	CO_2	No		
PFCs Emissions	PFCs	No		
Emissions from HFCs consumption	HFCs	Yes	Level 1, Trend 1	
SF_6 Emissions from Electrical Equipment	SF_6	No		
3. Solvent and Other Product Use				
CO_2 Emission from Solvent and Other Product Use	CO_2	No		
N_2O Emission from Solvent and Other Product Use	N_2O	No		
4. Agriculture				
CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	Yes	Level 1, Trend 1	
CH_4 Emissions from Manure Management	CH_4	Yes	Level 1, Trend 1	
N_2O Emissions from Manure Management	N_2O	Yes	Level 1, Trend 1	
CH_4 Emission from Rice Cultivation	CH_4	No		
Direct N_2O Emissions from Agricultural Soils	N_2O	Yes	Level 1, Trend 1	
Animal Production	N_2O	No		
Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O	Yes	Level 1, Trend 1	
Field Burning of Agricultural Residues	CH_4	No		
N_2O Emissions from Agricultural Residue Burning	N_2O	No		
5. Land Use. Land-Use Change and Forestry				
Forest Land Remaining Forest Land	CO_2	Yes	Level 1, Trend 1	
Forest Land Remaining Forest Land	CH_4	No		
Forest Land Remaining Forest Land	N_2O	No		
Conversion to Forest Land	CO_2	No		
Croplands Remaining Croplands	CO_2	No		

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

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

1.6. QA/QC information

The national system has to ensure high quality in the inventory, i.e. to ensure that the inventory is transparent, consistent, comparable, complete and accurate. These terms are defined in the UNFCCC guidelines on yearly inventories (FCCC/CP/2002/8). These principles guide the internal expert team maintaining the system. The external experts involved in inventory preparation have prepared or have participated in the preparation of national databases (emission databases, pollution databases) for several years and members of the team have “expert permissions” issued by the Minister for the Environment and Water, which were only granted to staff members with sufficient experience and trustworthiness. New team members are subject of thorough on hand training which lasts for two inventory circles.

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

ISO activities

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

Several regulatory ISO documents were created, among others:

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

This year a new ISO document was introduced to enable the documentation of sector specific quality checks. This document includes a compulsory check list, summary of results of checks, suggestions for corrective actions similarly to the example given in Annex 6A of the 2006 Guidelines. Although this document is in the testing phase, the first experiences are promising (See Fig. A6-3 in ANNEX 6)

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

- Specification of the sectoral responsibilities of the core team
- Nomination of an officer responsible for the QA/QC system: the QA/QC coordinator
- Documentation. All data, data sources and calculation methods need to be documented by the sectoral experts of the core team filling in an ISO form. Based on this documentation, sectoral reports are to be written about the status of the sector and possible future improvements.
- Data quality check. Besides self-checking, the entries of data providers and external experts are checked regularly which is an interactive process during the whole inventory cycle. Significant changes compared to previous data shall be explained. A new ISO document for these quality checks is in testing phase (See Fig. A6-3 in ANNEX 6).
- Reviews. We passed an in-depth ISO audit end of January 2009. Two external QA audits are planned for those sectors where new sectoral experts have taken over the tasks of inventory preparation: one in the industrial processes and one in the forestry subsector. The Quality Assurance Report on the forestry sector has already been prepared (See Annex 3.4. P. A55-56). The recommendations of the latest centralised review by the expert review team of the UNFCCC will be taken into consideration as much as possible.
- Development plan. Based on the outcome of all reviews and own experience, a development plan were made in order to further improve the system.
- The Hungarian Meteorological Service funds two research and development projects for the improvement of the inventory. A new project has been started with the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) in order to improve our land-use area system to be able to apply the Approach2 method in the future. Our second important project relates to forest management: within a pilot project with the involvement of the Forestry Directorate of Central Agricultural Office and Forestry Research Institute, we intend to prepare unofficially the new LULUCF reporting tables under the Kyoto Protocol already in the first half of this year.
- Incorporation of ETS data in broader extent for revision of the used EFs and for better sectoral allocation of emissions
- Training.

Having an ISO system in place has an advantage of being subject to regular internal and external audits. During our last external audit the activities of the GHG Division were audited as well. Our system was audited favourably in the end of March 2007; and our ISO certification has been renewed in January 2009. Therefore we can claim that the GHG inventory is subject to ISO 9001:2008.

Other QA/QC activities

For every sector of the inventory, there is a responsible person within the core team in the Met. Service. These sectoral responsibilities are laid down in the yearly QA/QC plan. Especially in case of external experts, this responsible member of our team conducts several quality checks on the provided calculations. Moreover, this exercise can be regarded as an interactive process throughout the whole inventory cycle, since the used methodologies, early results are discussed during the process of the emission/removal calculations. This QC procedure led to some modifications of the inventory; see the Recalculations chapter for more details.

Although not fully (but more and more) documented, many elements of the general Tier1 QC procedure are applied. The used parameters and factors, the consistency of data are checked regularly. Completeness checks are undertaken and previous estimates are compared every time. Data entry into the database is checked many times by a second person. The recalculations are based on the findings of our QC procedures.

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

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

Checking: The results of the calculations and the implied emission factors are checked and considerable differences, if any, are revised again. The modifications and improvements from the previous year are documented and recorded in the NIR. Another factor that improves the quality of the inventory is that many of the recommendations by the UNFCCC ERT have been followed.

The national system's quality system is based on the structure described in UNFCCC decision 19/CPM.1. The structure complies with the PDCA cycle (Plan, Do, Check, Act), which is an adopted model for how systematic quality and environmental management activity is to be undertaken according to international standards in order to ensure that quality is maintained and developed. Budget line is maintained for the external quality assurance of the reports prepared within the framework of the National System.

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

1.7. Uncertainty

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

In summary, the reliability of the inventories can be characterised as follows:
The CO_2 calculation has the highest reliability and has a weight of 76.0% in the total emission (in CO_2eq.). The least reliable is N_2O calculation representing 11.7%. CH_4, which has a medium reliability, has a similar proportion (11.3%). Fluoride gases are irrelevant here because their contribution to the total emission in only 1.0%. Accordingly, the calculated uncertainties of the emissions of different gases are as follows (more details in *Table A7-3* in the Annexes):

CO_2	3.5%
CH_4	18.1%
N_2O	62.0%

On the basis of Table 6.3 of the GPG we have determined the total uncertainty according to the Tier 1 method. Accordingly, the combined uncertainty as % of total national emissions (in the year 2007) is 8.0% and the uncertainty introduced in trend in national emissions is 2.3%.

1.8. Completeness

GHG inventory data are provided for the base year (the average of the three years 1985–1987) and the years 1985–2007. All relevant gases, sectors and categories are included. The inventory is complete in terms of geographic coverage. The notation keys are used throughout the tables. However, some of the time-series are subject to ongoing revisions, especially in the LULUCF, transport (CH_4, N_2O), F-gases, cement production and wastewater categories, therefore the time-series are not fully consistent and some explanations connected to the notation keys are missing. For the Wastewater category more precise activity data are expected during 2009.

2. TRENDS OF GHG EMISSION

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

2.1. Trends for Aggregated Greenhouse Gas Emissions

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

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

GREENHOUSE GAS EMISSIONS (CO_2eq, Gg)	BY fixed	1990	1995	2000	2004	2005	2006	2007
Total (including LULUCF)	112,661	95,000	71,227	77,188	75,703	75,766	74,756	71,806
Total (excluding LULUCF)	115,397	99,210	79,845	78,016	79,904	80,382	78,865	75,944

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

(It should be noted that CH_4 and N_2O emissions in road transport category between 1988 and 2003 are not consistent with the emissions in other years.)

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

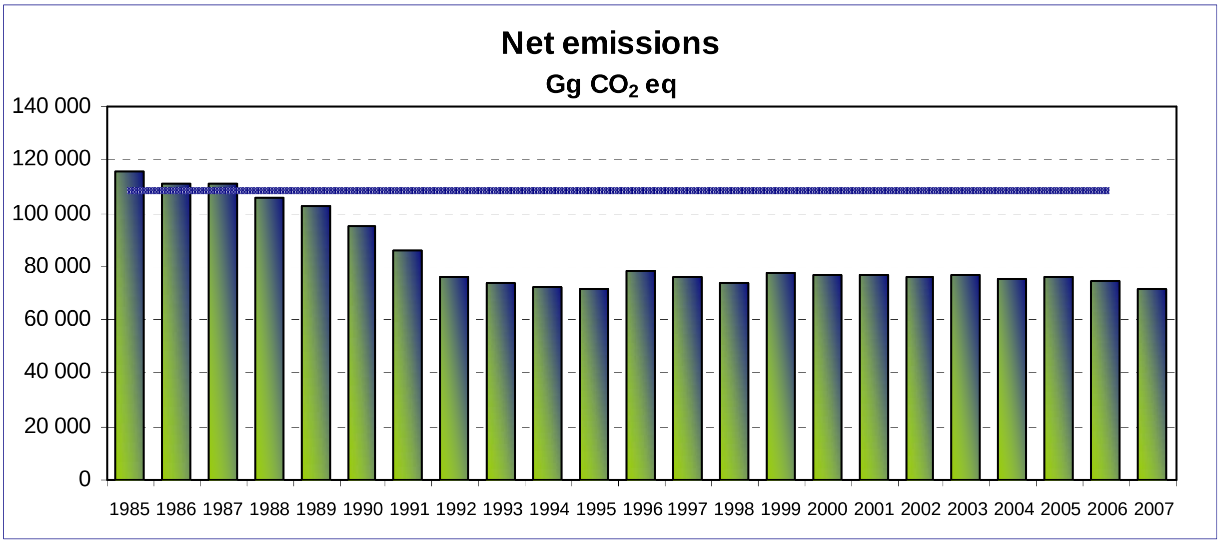


Figure 2.1. *Total emission (including net CO_2 from LULUCF) between 1985-2007*

Upon the collapse of the centralised planned economy, economic production decreased significantly until 1992 which was also reflected in the emission levels. The trend in the last 10-15 years is also slightly decreasing – mainly due to the relatively low emissions in the last two years.

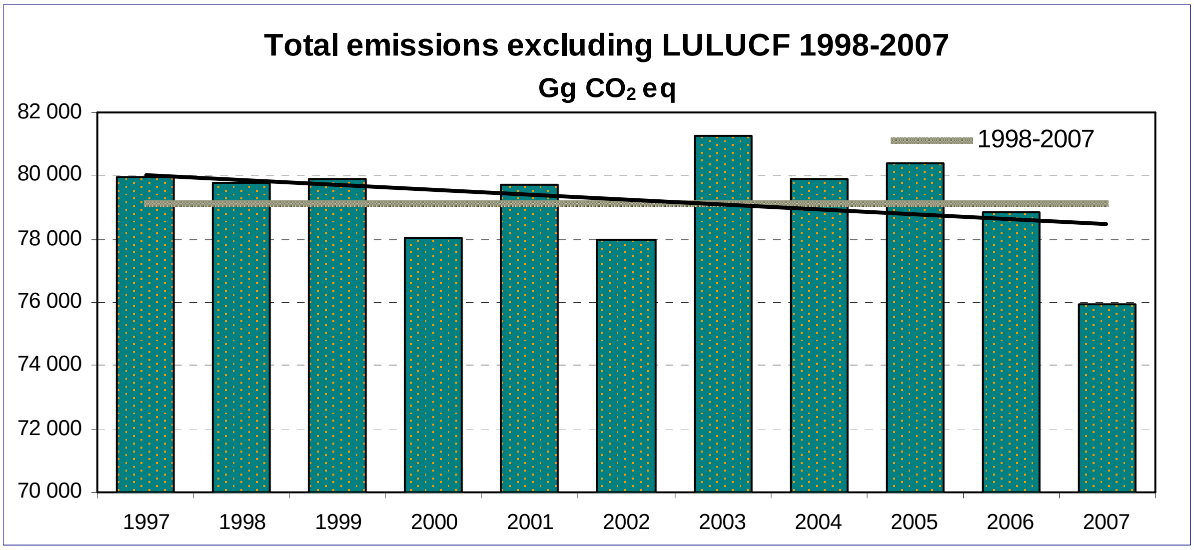


Figure 2.2. *Emissions in the last 10 years show decreasing trend*

By 1999, the GDP reached the pre-1990 level; however, emission levels remained significantly below the levels of the preceding years. Thus, the emissions per GDP are decreasing.

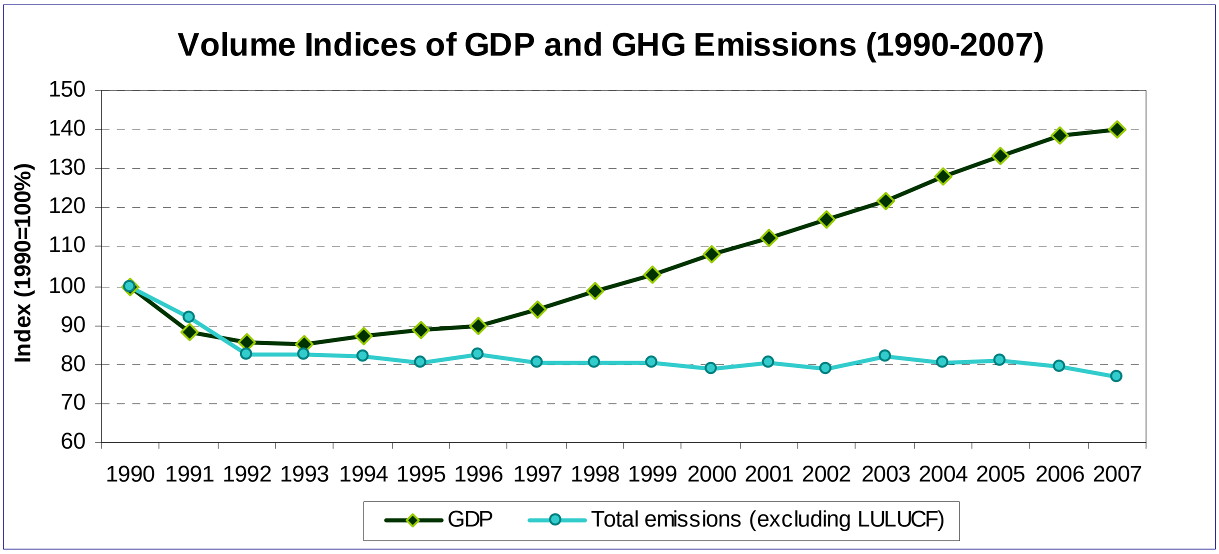


Figure 2.3. *Comparison of trends of GDP and GHG emissions*

2.2. Emission Trends by Gas

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

Table 2.2. *Trends in emissions of greenhouse gases in Hungary (1985-2007)*

GREENHOUSE GAS EMISSIONS (CO_2eq, Gg)	BY fixed	1990	1995	2000	2003	2004	2005	2006	2007
CO_2, without LULUCF	85,795.5	72,470.8	61,501.8	58,491.8	61,640.2	59,897.9	61,098.9	59,757.5	57,751.8
CH_4, without LULUCF	10,139.2	11,153.1	9,224.5	9,368.3	9,257.6	8,921.0	8,797.7	8,710.5	8,545.3
N_2O, without LULUCF	19,223.7	15,275.3	8,880.2	9,598.6	9,485.2	10,180.0	9,557.6	9,544.3	8,857.9
HFCs	1.74	0.0	1.74	205.7	498.9	525.8	517.6	606.9	614.5
PFCs	166.8	270.8	166.8	211.3	189.6	201.1	209.4	1.5	2.4
SF_6	70.2	39.9	70.1	140.1	161.9	178.2	201.0	244.4	171.6
Total (including LULUCF)	**112,661**	**95,000**	**71,227**	**77,188**	**76,744**	**75,703**	**75,766**	**74,756**	**71,806**
Total (excluding LULUCF)	**115,397**	**99,210**	**79,845**	**78,016**	**81,233**	**79,904**	**80,382**	**78,865**	**75,944**

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

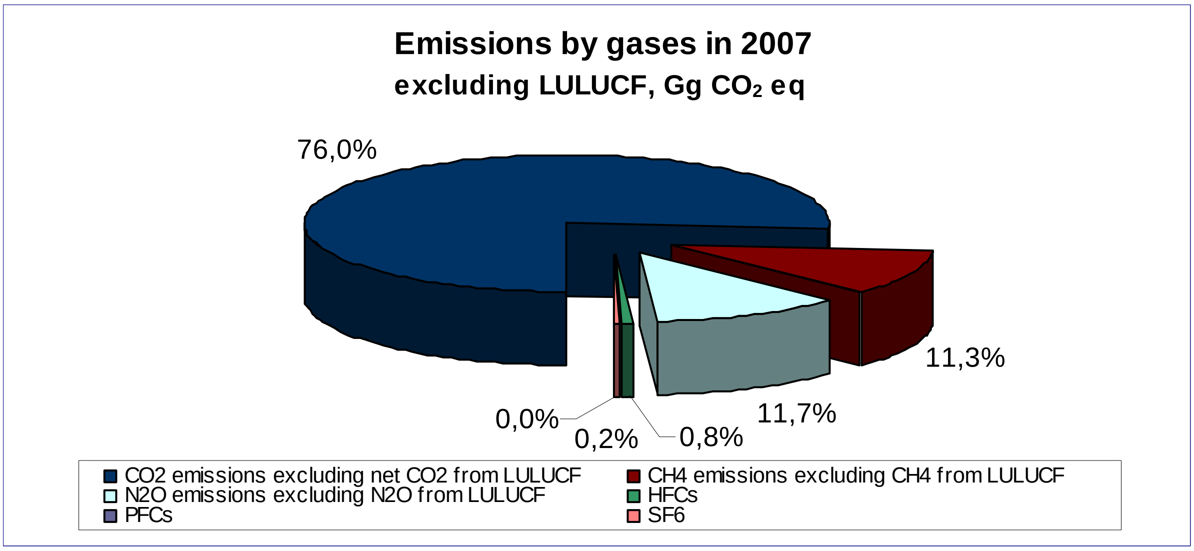


Figure 2.4. *Shares of gases in 2007*

The drop in CO_2 emissions during the early 1990's was attributable to the reduction of fuel uses in conjunction with the national output decline. From the second half of the 1990's emissions showed stagnating or slightly decreasing tendencies reflecting the effects of restructuring following the economic growth. The changes in the fuel-mix resulted in reduction of the specific emission levels.

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

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

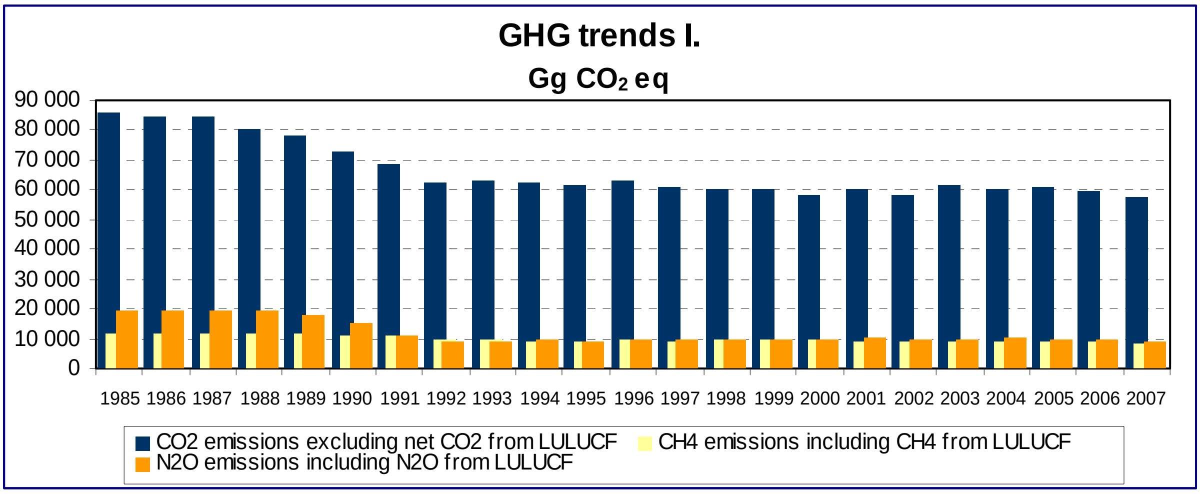


Figure 2.5. *Trend of emissions by gases*
Note: BY=average of 1985-87 but 1995 for F-gases

The use of HFC gases became more intensive in the second half of the 1990's in conjunction with the restriction of the use of chlorofluorocarbons as refrigerants. The rise of emissions is obvious.
PFCs emissions are principally related to aluminium production processes. Therefore, the tendencies of PFC emissions reflect the changes in aluminium production. Following a drastic reduction in the beginning of the period, the levels showed a slow but steady increase. Then the aluminium production ceased suddenly in 2006.
SF_6 emissions primarily depend on the uses in the power generation industry. The tendencies vary according to the manufacturing/application needs and show an increasing trend.

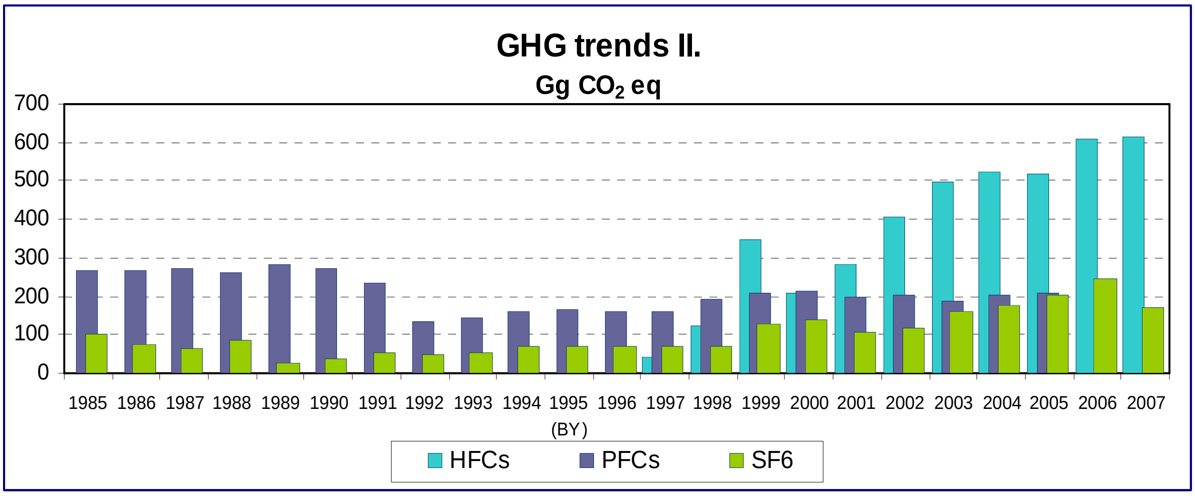


Figure 2.6. *F-gases trend (1985-2007)*
*Note: *BY=average of 1985-87 but 1995 for F-gases*

2.3. 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.

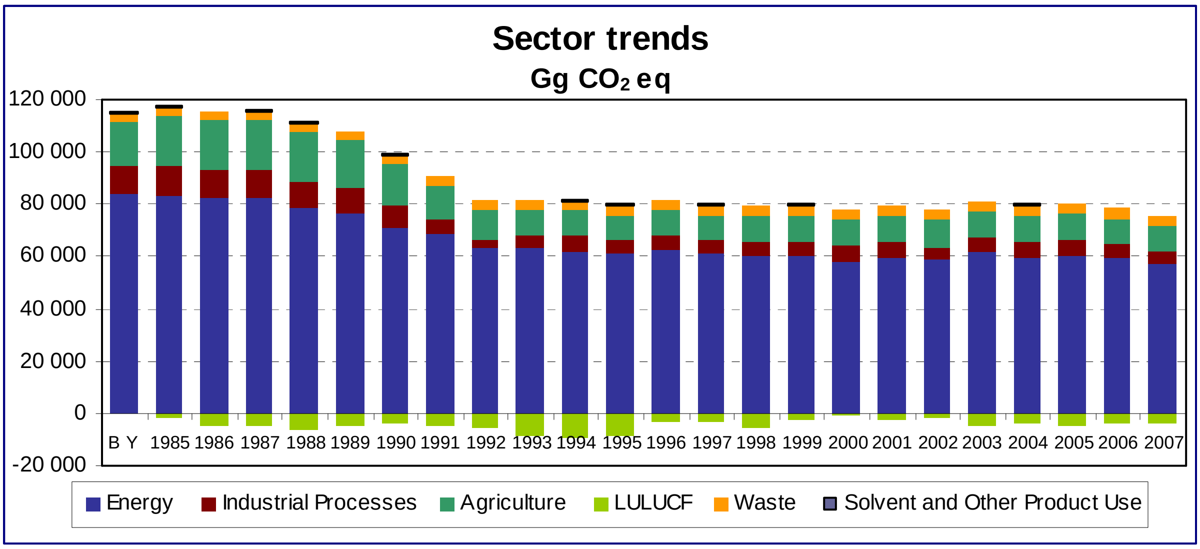


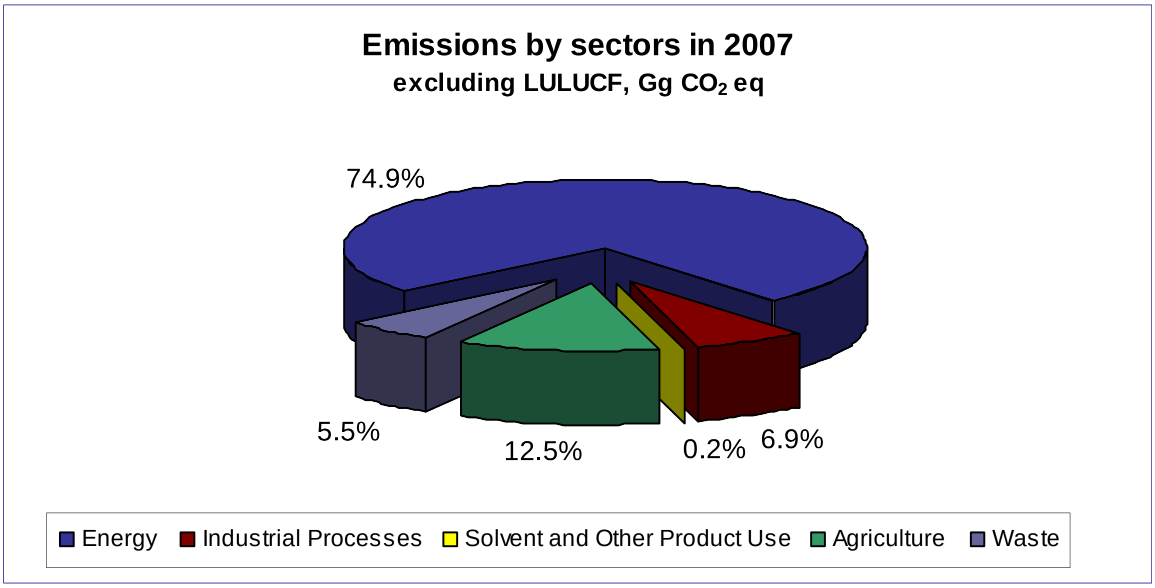
Figure 2.7. *Trends in emissions of greenhouse gases from each sector*
Note: BY=average of 1985-87 but 1995 for F-gases

Emissions by the Energy sector decreased in the first part of the period as a result of reduced energy consumption and use of fuels with more favourable composition. In the last two years, growing emissions from energy industries and transport could be observed which were more than offset by drastic reduction of emissions by the residential sector and manufacturing industries.

The energy sector was responsible for 75.0% of the total GHG emissions in 2007. Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 94.4% to sectoral emission, followed by CH_4 with 4.1% and by N_2O with 1.5%. Among fuels, gases have the highest proportion (44.7%), liquids have less and solids have the lowest, but the latter still represents 23.4% of the sectoral CO_2 emissions. Besides the sudden decrease in energy demand in the years of economic transformation, also the changes in the fuel-structure in the '90s when the most important source in the base years namely solid fuel has been replaced by natural gas, led to decreased total emission. The most important subsector of the energy sector is Energy Industries (1.AA.1) with a proportion of 36%, followed by Other Sectors (1.AA.4) and Transport (1.AA.3) representing 24 and 23% of the total emissions in this sector, respectively. Similarly to the previous year the least contribution to the emission from fuel combustion has Manufacturing Industries and Construction Sector (1.AA.2). Fugitive Emissions from Fuels (1.B) play only a small role in emissions of the sector with 4%. The primary energy use of Hungary was 1125.4 PJ in 2007, by 2.3% lower than in 2006 (1152 PJ). The decreasing energy demand in 2007 is due to the joint impact of several factors, such as more favourable weather conditions than in the previous year and the higher energy (principally electicity) demand of the industry and transport.

In 2007, the Agriculture sector was the second largest source of greenhouse gas emissions in Hungary. It accounted for 12.5 percent of total emissions. The contribution of agriculture to total emissions decreased over the period 1985-2007 from 16.7 percent in 1985 to its present share. Emissions from Agriculture include CH_4 and N_2O gases. Most of the total N_2O

emissions are generated in agriculture; it amounts to 77 percent of total N_2O. The total emissions from agriculture decreased over the period 1985-2007. The bulk of this decrease occurred in the years between 1985 and 1995, during which the agricultural production underwent a drastic decrease. The trend in emission is slightly fluctuating between 1996 and 2007. The greenhouse gas emissions of agricultural activities were changed essentially in accordance with production.



2.8. Figure *Shares of sectors in 2007*

The Industrial Processes sector was the third largest sector contributing 7% to total GHG emissions in 2007. The total sectoral emissions decreased by 50% between base year and 2007 and by 8% between 2006 and 2007. Nitric acid, cement, ammonia productions dominate the trend in these days.

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

The LULUCF sector was a net sink of carbon in all the years. The result is determined largely by Forest Land, which is a major carbon sink. The Cropland living biomass is a net sink of carbon in most years and a net source of emission in some years due to reduction of orchard and vineyard areas. The soil disturbance generates steadily decreasing removals of CO_2, as a consequence of the reduction of agricultural land and the afforestation of croplands. (All mineral soils are taken account combined in our estimations.) The complex dynamics of the land use and land-use changes lead fluctuating trend in the LULUCF sector.

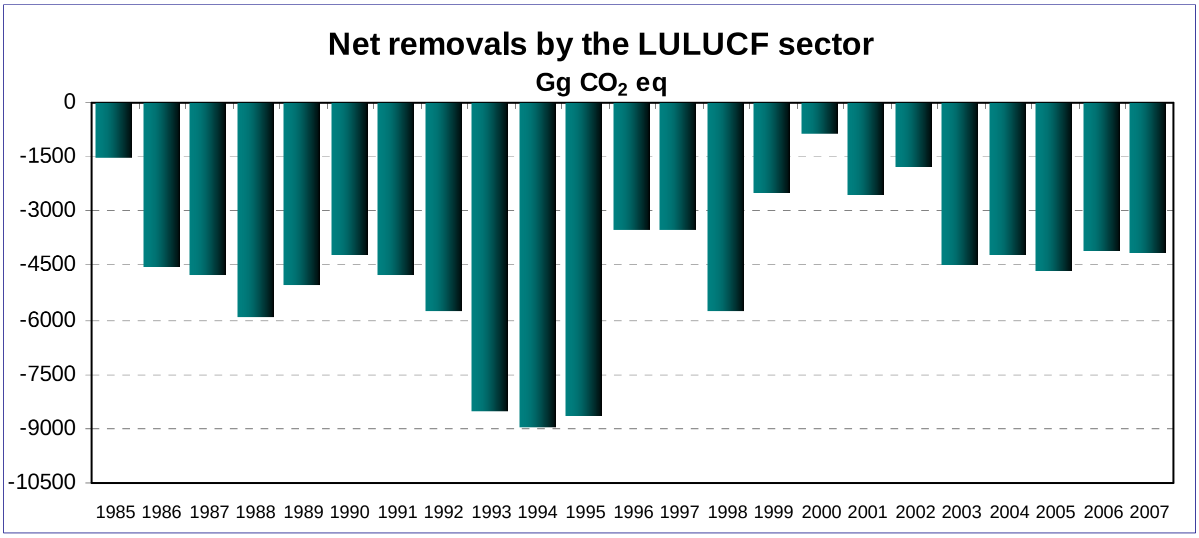


Figure 2.8. *Sinks of LULUCF*

2.4. Trends of indirect gases and SO_2

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

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

Indirect gases	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
NO_X, Gg	262.5	264.2	264.9	257.8	246.8	238	203.1	183.3	184	187.4	190.07
CO, Gg	931.1	--	--	963.1	--	997	913.4	835.8	796.1	774.29	761.29
NMVOC, Gg	232	263	228	215	205	205	149.6	141.8	149	142.4	150.3
SO_2, Gg	1403.6	1361.8	1285.3	1218	1102	1010	913	827.3	757.3	741	704.96
	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007
NO_X, Gg	195.81	199.5	202.62	185.1	183.2	182.9	210.7	185.3	203.1	202.5	185.0
CO, Gg	726.87	733.36	736.93	592.4	578.8	573.8	600.3	585.4	585.2	596.3	573.7
NMVOC, Gg	150.1	145.4	140.6	166.0	162.3	160.1	169.0	157.0	176.2	186.7	167.7
SO_2, Gg	673.23	658.51	591.79	489.0	403.9	364.9	347.8	248.8	146.6	123.1	98.5

The significant reduction in sulphur dioxide is attributable to the reduction in fossil fuel uses, as well as to the decreasing sulphur content of these fuels. The further decrease in 2000 was caused by the introduction of SO_2 precipitators in carbon-fuelled power stations. The decrease in carbon monoxide is the result of the reduction in the quantities of fuels used, as well as that of factory closings and technology changes in the preceding years. NO_X and NMVOC emissions show no significant trend in the last 15 years.

3. ENERGY (CRF sector 1.)

Overview of the energy situation of Hungary in 2007

Source: Energy Centre (Energia Központ Nonprofit Kft.)., 2008

The primary energy use of Hungary was 1125 PJ in 2007, by 2.3% lower than that in 2006 (1152 PJ).
The decreasing energy demand in 2007 is due to the joint impact of several factors, such as more favourable weather conditions than in the previous year and the higher energy demand of industry and transport:

- in the heating period the daily mean temperature was by 1.1°C higher than in the previous year. As a consequence the total fuel demand of the residential sector decreased by 20% which included a drop of natural gas use by 12%.
- volume index of total industrial production was 8.1% higher than in 2006, but this growing rate is smaller compared to the 9.9% of 2006. It is the main reason for stagnant energy use of industry (less than 1% increasing).
- Energy use of transport also added 1.2% compared to the previous year, but the former quick growth (3-15%) cannot be observed in 2007.

In addition to energy use, the economy also grew in 2007 by 3.4%, therefore the energy efficiency of the economy (energy use per unit GDP) declined by 3.4%.
To meet the total energy demand, sources of 1125 PJ were available of which 38% came from domestic production (427 PJ, including 37.5% nuclear production) and 62% (697.3 PJ) was net imported energy.
Within energy use the share of coals increased from 11.6% to 11.9% in 2007. The share of oil and petroleum products further grew from 26.8% to 27.5%, while the share of the other key energy type, gas decreased from 41.7% to 39.8%. Among primary electricity sources nuclear electricity accounted for 14.2% in 2007 and imported electricity represented 1.3% within the total primary energy use. The share of renewables' use increased from 4.8% to 5.2% in 2007. *Figure 3.1* shows the distribution of energy consumption during the last 18 years.
Use of natural gas was 13.3 billion m^3 in 2007 – 2.6 billion m^3 of domestic gas and 10.7 million m^3 of imports were available to ensure uninterrupted natural gas supply. Households' gas consumption in Hungary has one of the highest shares in Europe (40.1%) including fuel used in cars and purchased heat. 70% of households are supplied with natural gas.
In 2007 the amount of electricity generated from renewable energy sources was bigger than in previous year, especially combustion of municipal solid waste and electricity from hydro power increased this amount. At the same time the amount of electricity generated by wind power plants was doubled, and the installed wind power capacity exceeded 65 MW. The amount of electricity generated from biogas also increased by 28%.
The share of electricity generated from renewable energy sources represents 4.5% of the total electricity consumption of the country.

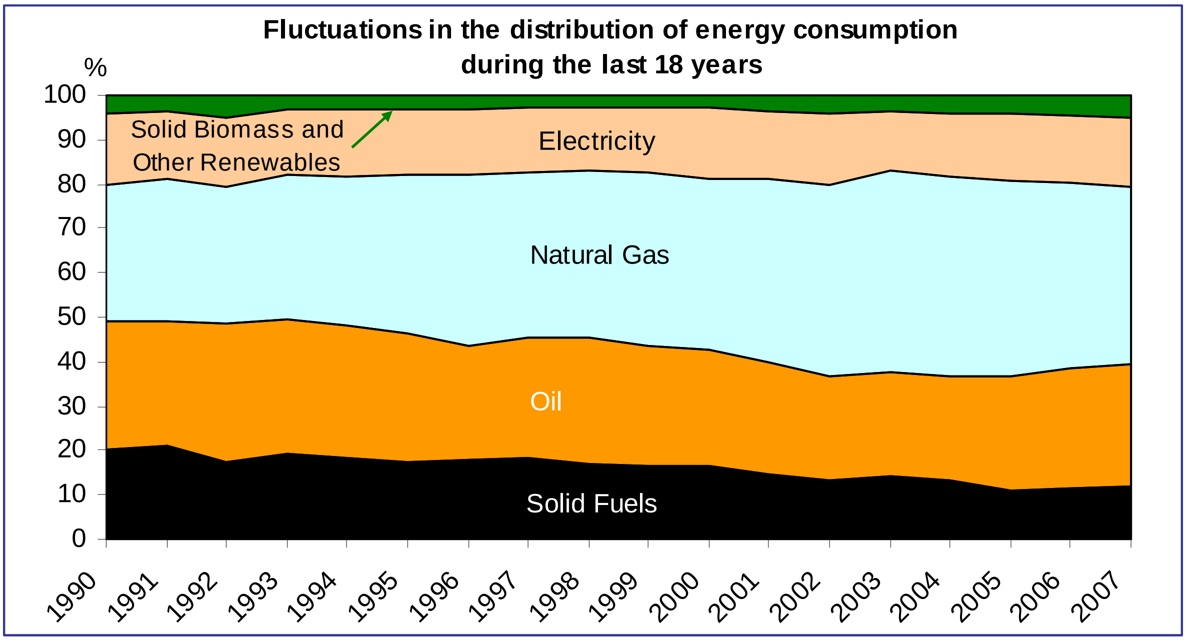


Figure 3.1. *Distribution of total energy consumption in Hungary during the last 18 years. Electricity means imported electricity and electrcity produced by nuclear power plant (Source: Energy Centre, 2008)*

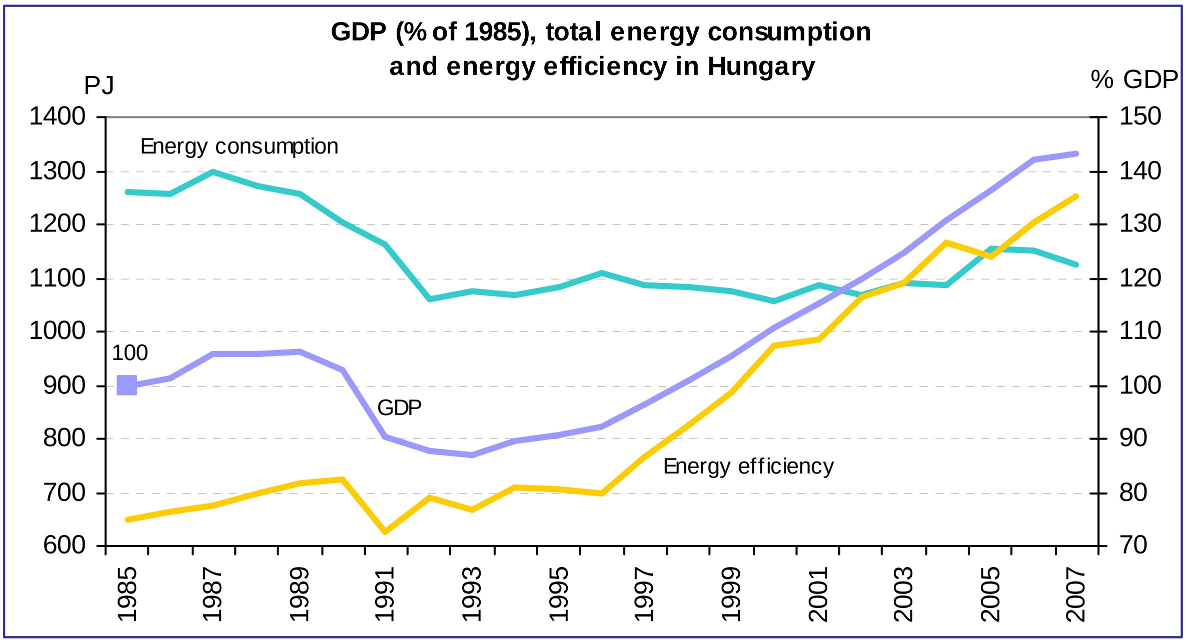


Figure 3.2. *GDP, total energy consumption and energy efficíency in Hungary (1985-2007) (Source: HCSO, 2008; Energy Centre, 2008)*

3.1. Overview of the sector

This sector covers emissions from combustion processes and fuel-related fugitive emissions from exploration, transmission, distribution and conversion of primary energy sources. The principal driver of emissions in this sector is fuel consumption. *Figure 3.3* represents the distribution of combusted fuel types in the base year and 2007.

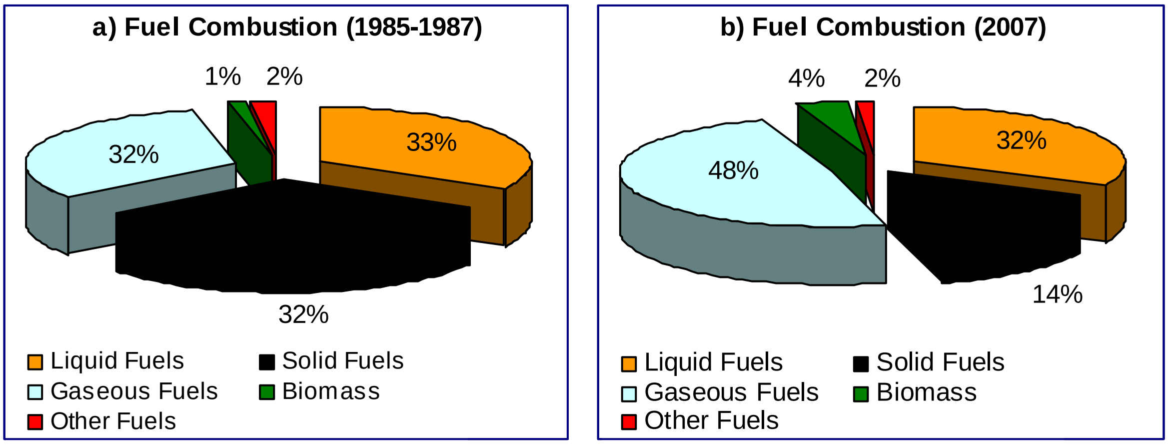


Figure 3.3. *Fuel combustion in the base year (a) and 2007 (b)*

The most important subsector of the energy sector is *Energy Industries* (1.AA.1) with a proportion of 36%, followed by *Other Sectors* (1.AA.4) and *Transport* (1.AA.3) representing 24 and 23% of the total emissions in this sector, respectively. Similarly to the previous year the least contribution to the emission from fuel combustion has *Manufacturing Industries and Construction Sector* (1.AA.2). *Fugitive Emissions from Fuels* (1.B) play only a small role in emissions of the sector with 4%.

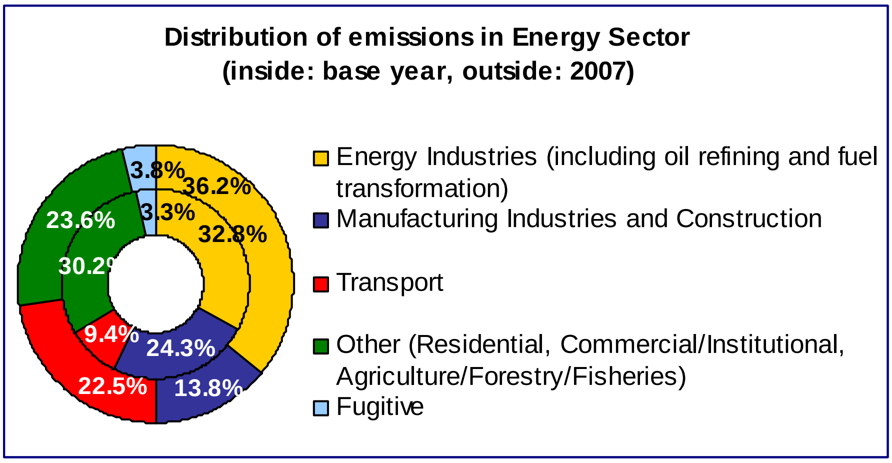


Figure 3.4. *Proportions of total GHG emissions in Energy Sector in base year and 2007*

Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 94.4% to sectoral emission, followed by CH_4 with 4.1% and by N_2O with 1.5%. Among fuels, gases have the highest proportion (44.7%), liquids have less and solids have the lowest, but the latter still represents 23.2% of the sectoral CO_2 emissions. Besides the sudden decrease in energy demand in the years of economic transformation, also the changes in the fuel-structure in the '90s when the most important source in the base years namely solid fuel has been replaced by natural gas, led to decreased total emission.

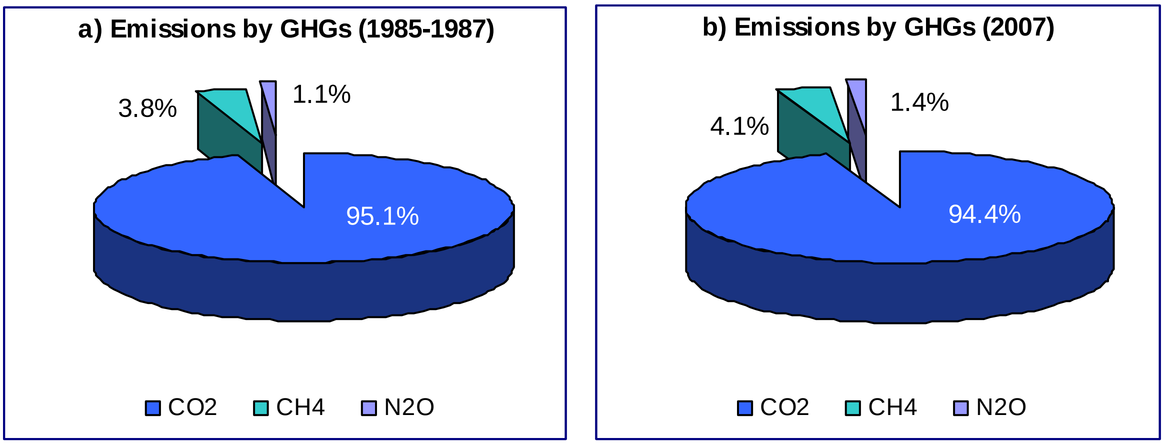


Figure 3.5. *Distribution of emission of GHGs in energy sector in the base year (a) and 2007 (b)*

As regards methane emission, this sector represents 3.3% (with LULUCF) of the total greenhouse gas emission. Primarily, this results from fugitive emissions associated with conventional oil and gas production and processing (which also includes fugitive emissions from natural gas transmission). Among methane emitters, this sector's proportion is 27.4%, which represents the third highest emission compared to other sectors *(Figure 3.6.)*.
As regards nitrous oxide emission, this sector represents 1.1% (with LULUCF) of the total greenhouse gas emission. Among nitrous oxide emitters, its proportion is 9.3%, which represents the third highest emission compared to other sectors *(Figure 3.6)*.

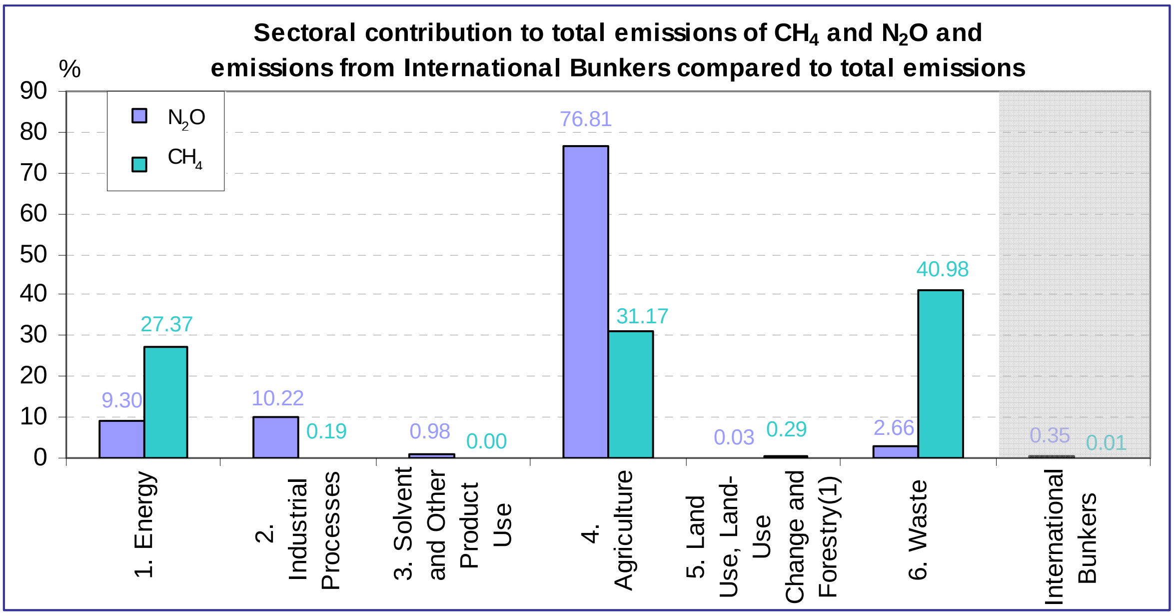


Figure 3.6. *Sectoral contribution to total emission of CH_4 and N_2O in 2007*

Figure 3.7 shows the emission tendencies in the sector by gases.

Calculation of the greenhouse gas emissions from combustion is based on the amount of fuel used. This was calculated using the energy balance of Hungary (summary table: see *Annex 2*), the fuel balance for each fuel type and fuel consumption for each subsector prepared by Energy Centre – Energy Efficiency, Environment and Energy Information Agency Non-Profit Company owned by the Ministry of Transport, Telecommunication and Energy. The energy statistics has a chapter about the energy carries balances by branches. Nowadays, division into branches follows mainly the structure of ISIC 3.1 (see *Annex 2*). Detailed EU-conform statistics from industrial and energy industrial activity help to compile the *sectoral approach*. Before 1998 some IPCC categories could be found only in aggregation with similar branches in the statistics, therefore the Hungarian inventory still follows this tradition in case of manufacturing metal products (IPCC 1.AA.2.A and 1.AA.2.B are included under 1.AA.2.A) to keep consistent time-series. Non-energy use of fuels and fuel used for transportation are included in the consumption of branches, therefore tables of fuels related with the mentioned activities cannot be adopted completely in their original form. Tables from the different transportation forms and non-energy use of fuels as well as personal communication with the statistics' provider allow to fill in the CRF tables according to the guidelines.

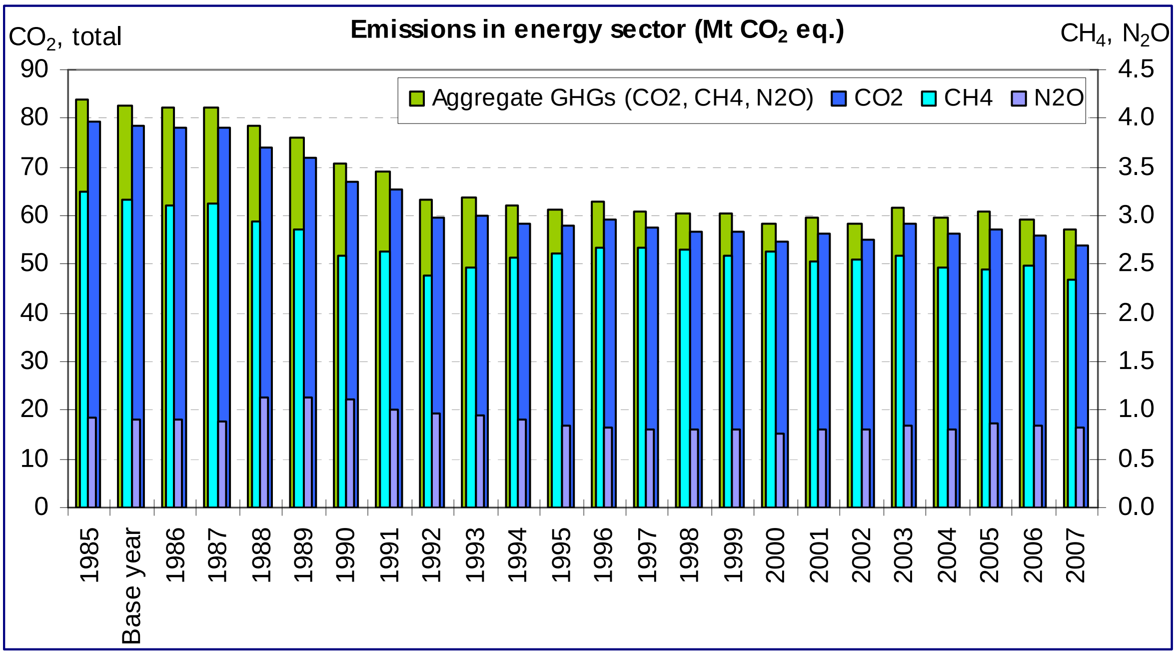


Figure 3.7. *CO_2, CH_4 and N_2O emissions in energy sector (1985-2007)*
Between 1988 and 2003 CH4 and N2O emissions from road transport are inconsistent with emissions from other years.

Input data for the fugitive emission calculation came from the Statistical yearbook of Hungary (HCSO, 2008) and Energy Statistics, discussions with the Hungarian Oil and Gas Company Plc. (MOL). We would like to refine methods, input data and uncertainty, hopefully the government decree (see Ch. 1.3) allows us to establish a database with help of the Mining and Geological Bureau of Hungary.
The quantity of CO_2 from energy consumption was determined on national level (*Reference Approach*, more details in *Annex 2.4*) and on sectoral level (*Sectoral Approach*) as well. Comparing the two approaches the difference was 2.17% in energy consumption and 3.44% as regards CO_2 emission in 2007. Detailed discussion of this comparison is provided in *Annex 4*.
The Revised 1996 Guidelines (IPCC, 1997) were used for the determination of the non-energy uses of fuels (concerning the consumption of fuels as raw materials for the production of other products, or the use of fuels for non-energy purposes), for both approaches in case of liquid fuels; and the potential CO_2 emissions from there were taken into account by filling in the CRF tables appropriately. As a result of inclusion of these items in the inventory, the IEF value is often significantly different from the emission factor actually applied, particularly in the chemical industry sector (1.AA.2.C), where non-energy uses are remarkable. The IEF is only 18.18 t CO_2/TJ (in contrast to the 70 to 75 t/TJ of other sectors), because 44,702 TJ of the 60,839 TJ is used as feedstock (naphtha), and

only 26.5% of this is converted to carbon dioxide. Emission and consumption of natural gas used as feedstock was removed from *sectoral approach* (see Chapter 10. - Recalculations). After consultation with Energy Centre, the Energy Statistics's provider, it became clear that emission from natural gas as feedstock is already handled in the sector of industrial processes. Nowadays, natural gas is used for producing ammonia, ethylene and carbon black.
LPG and petroleum coke was taken into account as liquid fuels having significant influence on the IEF value of this fuel type.
Two new categories were added to feedstocks in 2006, since emissions of these fuels are calculated in the industrial process sector using the EU ETS database of manufacturing bricks and ceramics. Coal and petroleum coke serve as additives increasing the porosity of bricks.
Non-energy uses have been considered in connection with sectors presented in *Table 3.1.*
The amount of fuels used is normally the same or nearly the same as the values published by IEA, because Energy Centre prepares the database for IEA, too. In case of liquid fuels, differences may be present because certain minor items in the inventory, such as white spirits, paraffins etc. are included under *Other Fuels*. It should be emphasised that these poolings have no significant effects on the emission calculations.

Fuel type	Allocated under the sector …	IPCC code
Naphtha	Manufacturing Industries and Construction – Chemicals	1.AA.2.C
Bitumen	Manufacturing Industries and Construction – Other	1.AA.2.F
Gas/Diesel Oil	Manufacturing Industries and Construction – Other	1.AA.2.F
LPG	Manufacturing Industries and Construction – Chemicals	1.AA.2.C
Coal (lignite)	Industrial Process – Mineral Products – Bricks and ceramics	2.A.7
Petroleum coke	Industrial Process – Mineral Products – Bricks and ceramics	2.A.7

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

Last year's S&A report stated, that time series for imports and exports of coke oven coke are not complete in the CRFs. It was a complicated situation, because the energy statistics were revised in 2004 after joining the European Union. Between 1993 and 2002 gas coke distillation was not part of the energy statistics and energy balance of this fuel type was handled otherwise. We have corrected the time-series (for 1992-1994, 1996-1997 and 2000) on the basis of the most recent publication, which corresponds with international statistics. Also the balances of coking coal have been corrected in the CRFs. These changes have affected the apparent energy consumption of the given year and have modified the figures in the comparison of reference and sectoral approach. Changes have not appeared in the sectoral approach, because it seems to be correct, but it requires more effort to clarify the situation.

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

Air transport	2000	2001	2002	2003	2004	2005	2006	2007
Passengers carried (thousands)	2,476	2,359	2,297	2,719	3,550	5,074	6,850	8,290
Transported quantity of goods (kt)	22	24	10	13	19	16	16	17
Quantity of kerosene (TJ)	8,957	7,602	8,150	8,358	8,610	9,368	9,210	10,145

Table 3.2. *Air travelling and transport performance in Hungary since 2000 (Source: HCSO, 2008; Energy Centre, 2008)*

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

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

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

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

3.2.1. Category description

Emitted gases: CO_2, CH_4, N_2O
Key source: CO_2 – Level 1, Trend 1 with and without LULUCF; Level 2, Trend 2 without LULUCF (see "Stationary Combustion" oil, coal, gas)
N_2O – Level 1 with and without LULUCF; Level 2 without LULUCF (see "Non-CO_2 Emissions from Stationary Fuel Combustion")

This subsector includes facilities generating electricity, district heating stations, oil refineries and coking and briquetting plants. On an overall level, there are the largest energy consumers. In 2007, 34% of the domestic energy consumption, of which 94% was fossil fuel, was used by energy industries (see *Figure 3.8*).

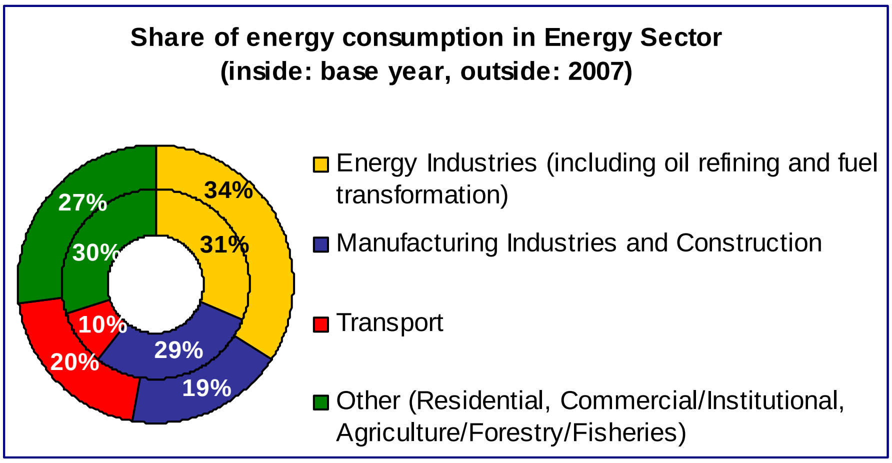


Figure 3.8. *Share of energy consumption in the base year and 2007*

3.2.2. Methodology

Energy consumption data were taken from the energy balance (1985-2007) of the Energy Statistics Yearbooks prepared by Energy Centre. Data obtained from Energy Centre – particularly old data – were not always in compliance with the IPCC resolution. These include, for example, the approach to LPG fuel. In Hungary, this is classified into the "gas" category because it is combusted in a gaseous form and is closer to natural gas as regards composition and emission characteristics. However, IPCC classifies LPG as a liquid fuel although its emission characteristics are much more favourable than those of oils. Therefore, in terms of the specific emission factors, LPG should not be taken together with oil derivatives, otherwise it will affect the implied emission factor. It should be noted that in Hungary, the importance of LPG has been decreasing during the recent years as a result of the development of the natural gas supply network.
The Hungarian coal terminology slightly differs from that of the IPCC. The partitioning is created according to the age of coal; *Table 3.3* shows the classification according to the Hungarian and IPCC categories. Energy Statistics Yearbook deals with antracite, hard coal, brown coal and lignite in the fuel balance, while the sectoral energy consumption for coal is the aggregate of hard coal, brown coal, lignite, gas coal and coking coal. In the latter case it is necessary to use additional information, from e.g. statistical yearbooks (HCSO, 1985-2007) or annual coal questionnaries (1990-2007) prepared for IEA by Energy Centre, for the distribution of the use of each coal type.

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

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

In Energy Statistics Yearbooks, the quantities of fuels are expressed in calorific values (see *Annex 2, Table A2-4*). Therefore, these were directly used for the emission calculations and the values of the conversion factors are globally 1.0 in all of the categories.
Figure 3.9. shows the changes in fuel consumption in the *Energy Industries* sector.

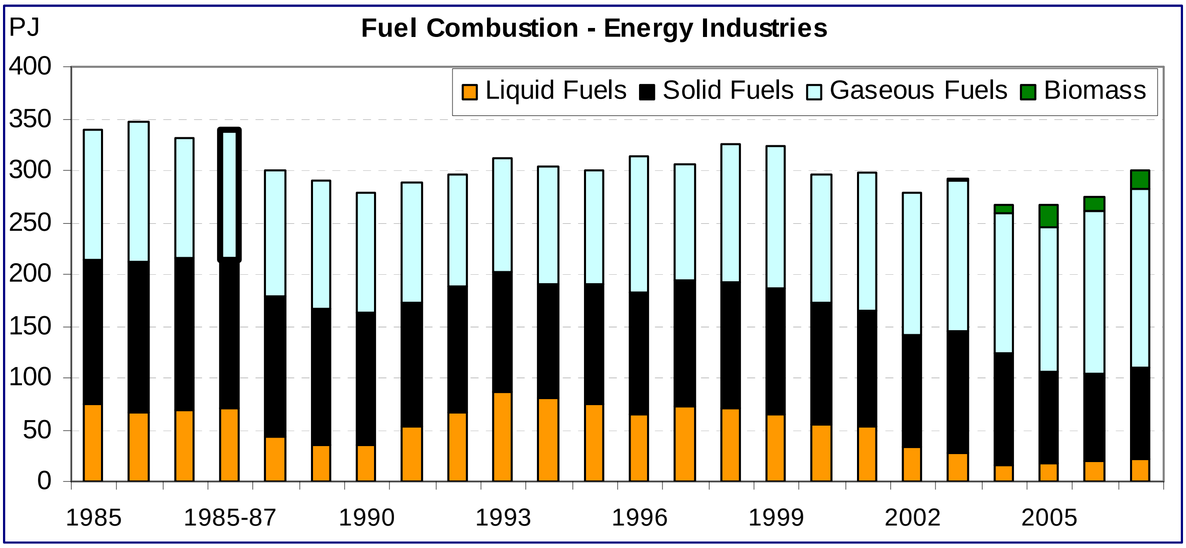


Figure 3.9. *Fuel combustion in energy industry (1985-2007)*

The total fuel consumption shows a slight decrease after the second peak in 1998, along with a strong fluctuation. Within this, the consumption of liquid and solid fuels has decreased significantly. In contrast, the consumption of natural gas has increased to a slight extent. The biomass use due to burning and the so-called co-burning in power plants has became more and more important and exceeds in amount the liquid fuel use in 2005. In 2006 the greatest power plant of Hungary reduced biomass-use, because the amount of obligatory purchased electricity was less than in 2005, this is illustrated on *Figure 3.9*. In 2007 the produced electricity increased by more than 11%, 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.

Emission factors

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

Fuel type	Emission factor (CO_2 t/TJ)	Oxidation factor
Coking coal	94.6	0.98
Other Bituminous Coal	***95.7***	***0.98***
Lignite	***108.3***	***0.974***
BKB	94.6	0.98
Coke Oven/ Gas Coke	108.17	0.98
Coke Oven Gas	***43.8***	***0.98***
Crude Oil	73.34	0.99
NGL	63.07	0.99
Gasoline	69.3	0.99
Jet Kerosene	71.5	0.99
Gas/Diesel Oil	***83.76***	***0.99***
Residual Fuel Oil	***78.9***	***0.99***
LPG	63.07	0.99
Bitumen	80.67	0.99
Petroleum Coke	98.08	0.99
Other Oil	***80.71***	***0.99***
Natural Gas	56.1	0.995
Biomass (Solid and Gaseous)	109.63	0.99

Table 3.4. *CO_2 emission factors used in energy industryin 2007 inventory year (Source: Revised 1996 Guidelines (IPCC, 1997); in bold and italics – EU ETS database of Hungary see Annex 2.3)*

As a result of the CO_2 emission trading introduced by the EU, coal-fired power stations started to measure the calorific value and the carbonate content of the fuels used. This revealed a significant underestimation of the emission factor for lignite in the Revised 1996 Guidelines. Therefore, for this type of coal the previous value of 101.2 t/TJ was replaced by 108.3 t/TJ in 2007. It should be noted that emission factor for the Hungarian lignite was 112.5 t/TJ according to the 2007 EU-ETS measurements. It is very important to mention that the IPCC terminology differs from the Hungarian system (see *Table 3.3* and *Annex 4, A2.3. Source of the Country Specific Emission Factors*), and the Hungarian brown coal is taken into account as lignite. Therefore the emission factor for lignite is derived according to the mass proportion of lignite and brown coal. Default emission factors for methane and nitrous oxide have been used in the case of liquid fuels since last year. Country specific N_2O emission factor for solid fuels was changed to default value from 2006 IPCC Guidelines. For other fuel types the original country specific values are kept. Accordingly, different values were used for power stations and for district heating stations using smaller boilers. Thus, the following values were used for the calculations:

Special Emission Factors (kg/TJ)	Power station		District heating station		Petroleum refining	
Fuel type	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O
Coal	1.25 [3)]	1.50 [2)]	1.50 [3)]	80.00 [3)]	–	–
Natural Gas	0.50 [3)]	3.00 [3)]	2.40 [3)]	5.00 [3)]	1.00 [2)]	0.10 [2)]
Residual Fuel oil	3.00 [2)]	0.60 [2)]	3.00 [2)]	0.60 [2)]	3.00 [2)]	0.60 [2)]
Gas/Diesel Oil	3.00 [2)]	0.60 [2)]	3.00 [2)]	0.60 [2)]	3.00 [2)]	0.60 [2)]
LPG	–	–	–	–	1.00 [2)]	1.00 [2)]
Firewood	30.00 [1)]	4.00 [1)]	–	–	–	–

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

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

3.2.3. Uncertainties and time-series consistency

Practically, the accuracy and uncertainty range of the energy statistics data are determined by the accuracy of the measuring equipment (except for stock changes, which are based on expert estimates and are not comparable with the quantity of fuels from other sources). Taking all this into account, the estimated uncertainty of the energy consumption data is ±2%. This is particularly likely because the quantities of fuels used by power stations were verified using the report of MVM Rt. (Hungarian Power Companies Plc.)
The estimated specific uncertainty for CO_2 is 5%. The uncertainty of the methane factor is slightly higher (8%), while that of N_2O may be really high (50%). According to the CORINAIR Handbook, it may be as high as 100%.

The time-series are not consistent. Energy consumption of the *manufacturing of solid fuels* is calculated for only 2006 and 2007 in this subsector. Until 2005 it is part of the *chemical industry* category. The statistics of gas coke distillation was revised in 2003, but the fuel consumption of this activity can not be reconstructed from the actual statistics. We are investigating this problem and would like to provide the whole time-series in the next submission.

The inconsistency in non-CO_2 GHG emission of pertoleum refining have been solved for the previous years.

3.2.4. QA/QC information

As mentioned above, energy consumption data were subject of several rounds of verification before use (more details in *Annex 2*).
Energy statistics with those provided to international organisations (prepared also by Energy Centre) will be compared after their submission to IEA.
Verified energy use from EU-ETS was compared to statistical data (more details in *Annex A2.3*). It was noticed that data in metric tonnes are similar in the ETS to those in the statistics, but there are some differences in energy values due to different NCVs. Since the

energy consumption in *sectoral approach* should be compared with those of *reference approach*, we kept the NCVs of energy statistics, however emission factors of coals were corrected to achieve consistency in energy balance and verified emissions, too. Measured oxidation factor was also applied in the calculation for the above mentioned reason.
As the main fuel consumption is related to public electricity and heat production, a comparision was also performed with independent dataset collected by the Hungarian Energy Office. Fairly detailed data were available from combustion installations with a rated thermal input exceeding 50 MW, while under 50 MW only aggregated statistics can be obtained from reports of the Office. Data of the large public electricity and power plants from ETS was compared with the Office's database. It was found that energy content of fossil fuel used in the mentioned 18 large public electricity and power plants differs only by 0.12% in 2007. This difference can be explained by the fact that the Office collects data on monthly base while the ETS is working with annual reports. It should be noted that combustion of biomass in one power plant have regularly been misssing in the database of the Office since 2005, because the biomass burning with a rated thermal input not exceeding 50 MW seceded from the management in 2004, but it is still one installation according to the EU-ETS definition.

Key category analysis indentified the "*1.AA CO_2 emission from stationary natural gas combustion"* as key category, therefore according to the QA/QC plan for 2008/2009 quality check was performed using checklist (see *Annex 6*).

3.2.5. Recalculation

Until 2008 submission petroleum refining was reported under *manufacture of chemical products* (1.AA.2.C). During the segregation process the original CH_4 and N_2O emission factors were kept, which were used in chemical industry, for petroleum refining until 2005. For 2006 and 2007, calculation was made with default IPCC 2006 values. In this submission the old factors were changed to default ones to create consistent time-series. This recalculation decreased the aggregated emission of the sector by 33 Gg CO_2 eq. on the average.

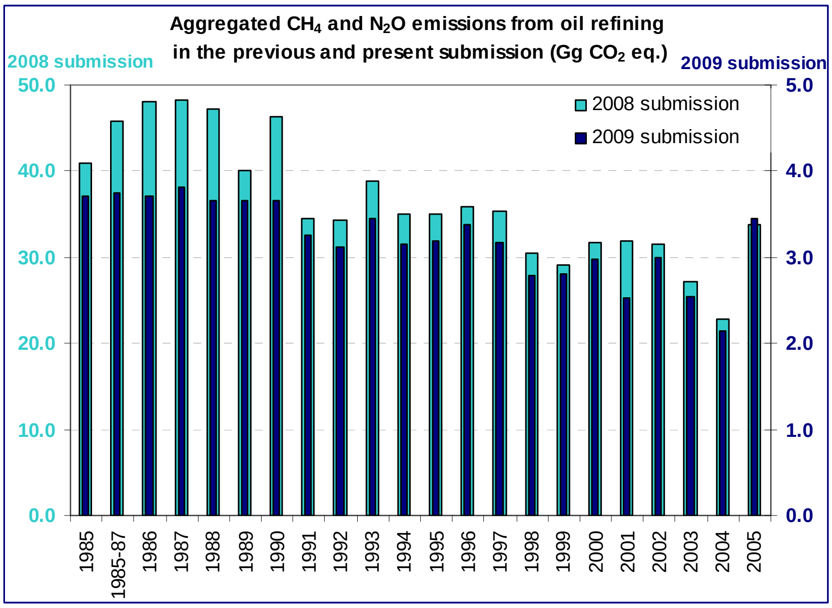


Figure 3.10. *Changes in aggregated CH_4 and N_2O emissions as a consequence of recalculation to have consistent time-series*

3.2.6. Planned improvements

We visited the Hungarian Power Companies Ltd. (MVM), the leading electricity company in Hungary to ask for cooperation in developing more precise and higher quality inventory for emissions from public electricity and power plants. It was the first step to harmonize different emission reports in Hungary.

A new project will be started to increase the consistency between different emission databases, especially the GHG inventory and the E-PRTR data. Also the development of a common central database is planned.
The inventory division is going to have direct access to emission reports from polluters under the governmental decree 21/2001. We would like to analyse the dataset and update the current country specific emission factors.

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

3.3.1. Category description

Emitted gases: CO_2, CH_4, N_2O
Key source: CO_2 – Level 1, Trend 1 with and without LULUCF; Level 2, Trend 2 without LULUCF (see "Stationary Combustion" oil, coal, gas)
N_2O – Level 1 with and without LULUCF; Level 2 without LULUCF (see "Non-CO_2 Emissions from Stationary Fuel Combustion")

This subsector covers emissions from the combustion of fuels in the industrial sector. Owing to the traditions of the national statistics system, combustion emissions from energy conversion (coke production) was also calculated here between 1985 and 2005. Special attention was paid to avoid double accounting. In the *other* subsector (1.AA.2.F) emissions from all the sectors that are not included in the previous listing (A to E) are calculated.
These include:

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

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

3.3.2. Methodology

The energy consumption data were also calculated on the basis of the national energy balance prepared by Energy Centre The calculation method and the associated problems are the same as those described under the Energy Industry (see 3.2.2).
Figure 3.11 illustrates the energy consumption of the sector. After 1990, i.e., following the economic changes, the quantities of fuels used were significantly decreasing. The underlying reasons are clearly illustrated by the decreasing production data until 2005 and presented in the industrial processes sector (*Chapter 4*). In 2005 the rising energy use of the industry is linked to the growth of industrial production, namely a number of energy intensive sectors: manufacture of non-metallic mineral products, primarily glass and

chemical industry. In 2006 the non-energy use of petroleum products increased by 4%. It has an effect on implied emission factors in the chemical industry, because activity data contains feedstocks, as well. Unrealistically low IEFs are the sign of very large amount of feedstocks in the *chemicals (1.AA.2.C)* subsector. In 2007 the combusted fuel decreased only by 7%, which caused 6% emission reduction in this sector. Significant changes occurred in the *other fuels* category (see *Figure 3.11*), which contains only feedstocks. We would like to transfer these fuels to the appropriate industrial sectors in the next submissions after compiling the different type of statistical sources (industry and energy).

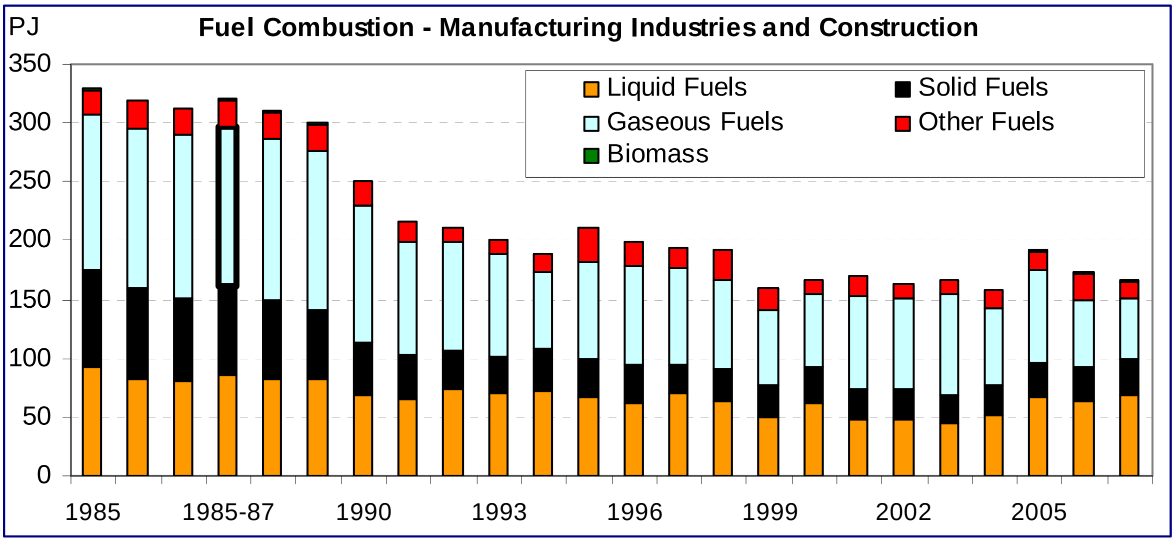


Figure 3.11. *Fuel combustion in manufacturing industries and construction (1985-2007)*

Emission factors

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

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

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

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

3.3.3. Uncertainties and time-series consistency

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

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

The time-series data is not consistent, because energy consumption of the *manufacturing of solid fuels* is calculated for only 2006 and 2007 in the *energy industry* subsector, but it is included in the *chemicals* until 2005.

3.3.4. QA/QC information

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. Last year this comparison drew attention to sugar manufacturers, where this difference was by far the greatest. This action increased the reliability of coal consumption in the food processing sector for 2007.

Key category analysis indentified the "*1.AA CO_2 emission from stationary natural gas combustion"* as key category, therefore according to the QA/QC plan for 2008/2009 quality check was performed using checklist (see *Annex 6*).

The sudden decrease of the solid fuel CO_2 IEF for iron and steel between 2005 and 2006 (2007) is due to the coke oven gas consumption. This type of fuel has very low CO_2 emission factors (see *Table 3.4*).

3.3.5. Recalculation

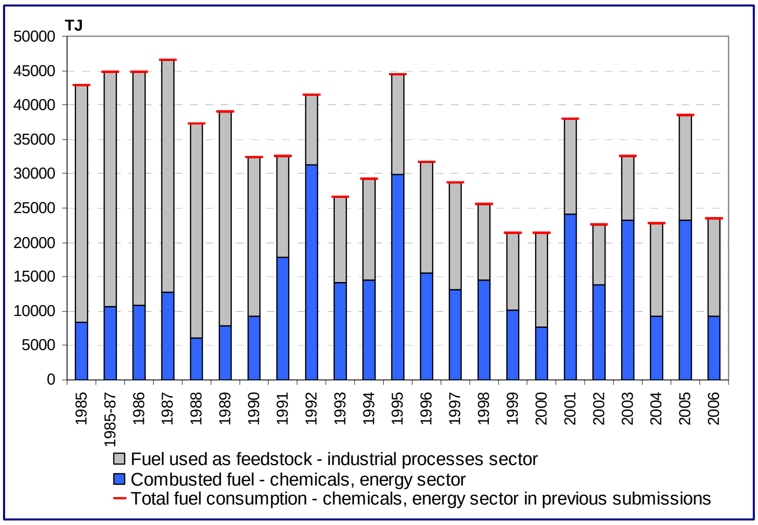


Figure 3.12. *Effect of recalculation on natural gas consumption in manufacture of chemicals*

Emission and consumption in sectoral approach of natural gas used as feedstock was removed from *energy sector*. After consultation with Energy Centre, the Energy Statistics's provider, it became clear that emission from natural gas as feedstock is already treated in the sector of *industrial processes*. Nowadays, natural gas is used for producing ammonia, ethylene and carbon black. Distribution of fuel cunsumption between the above mentioned sectors can be seen in *Figure 3.12*.

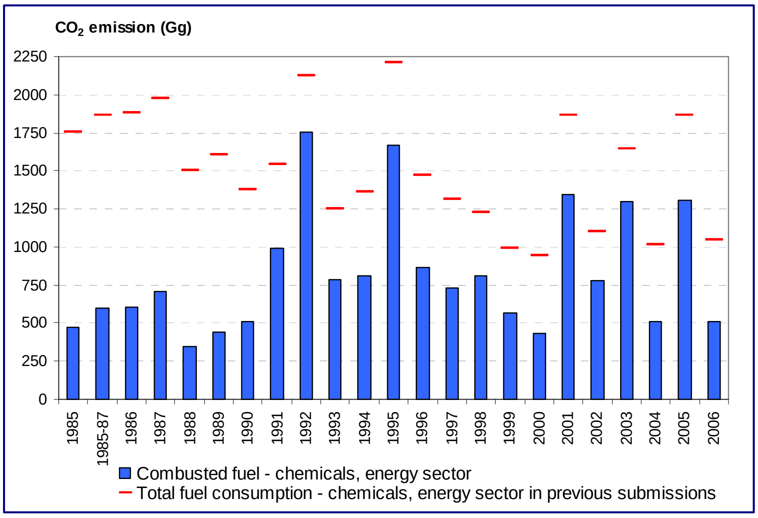


Figure 3.13. *CO_2 emission before and after the recalculation in the energy sector (1.AA.2.C).*

After the recalculation the emission of this sector decreased significantly, especially before 1991.

3.3.6. Planned improvements

The QC procedures pointed out that "manufacturing of non-ferrous metals" category contains "manufacturing of non-metallic mineral products". Due to statistical traditions manufacturing of metal products includes both the ferrous and the non-ferrous metals, and emission from this category was calculated in the category "manufacturing of iron and steel". To solve this problem we need more detailed dataset from energy statistics or EU-ETS. Because of limited capacity this improvement is a still marginal point in the inventory, especially as it is only a disaggregation problem.
Energy consumption of the manufacturing of solid fuels is calculated for only 2006 and 2007 in the *energy industries* subsector, it is important for having consistent time-series to reallocate and separate the used fuels and the emissions from chemical industry, nevertheless national statistics provided these categories together before 2003.

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

3.4.1. Category description

Emitted gases: CO_2, CH_4, N_2O
Key source: CO_2, road transport – Level 1, Trend 1 with and without LULUCF; Level 2, Trend 2 without LULUCF
CO_2, other transport – Trend 1 with and without LULUCF
N_2O – Level 2; Trend 2 without LULUCF

This sector covers all the emissions from fuels used for transportation purposes. International aviation and navigation are excluded.
During the second part of the analysed period, the composition of the national passenger car fleet underwent considerable changes. The proportion of Eastern European cars characterised by high fuel consumption decreased; currently, more than 80% of the vehicles are more advanced cars. *Figure 3.15* shows the changes in composition of the Hungarian car fleet from 1997.

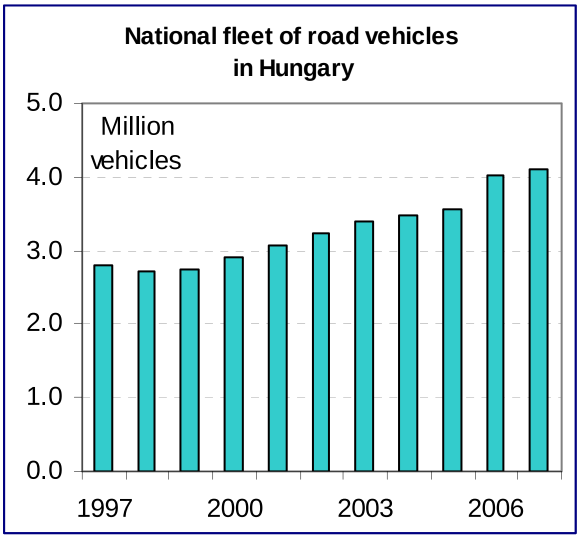


Figure 3.14. *National fleet of road vehicles in Hungary, 1997-2007 (Source: HCSO (1998-1999), Delta Informatika Zrt (2000-2008))*

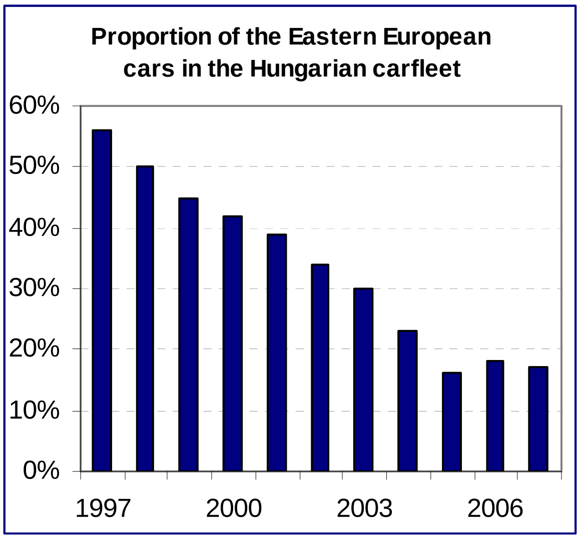


Figure 3.15. *Proportion of the Eastern European cars in the Hungarian car fleet (Source: KTI (2006), HCSO (2006), Delta Informatika Zrt (2007-2008))*

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

Emissions were calculated from the national fuel consumption data published in Energy Statistics Yearbook (1985-2008).

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

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

Figures below illustrate fuel consumption of the sector:

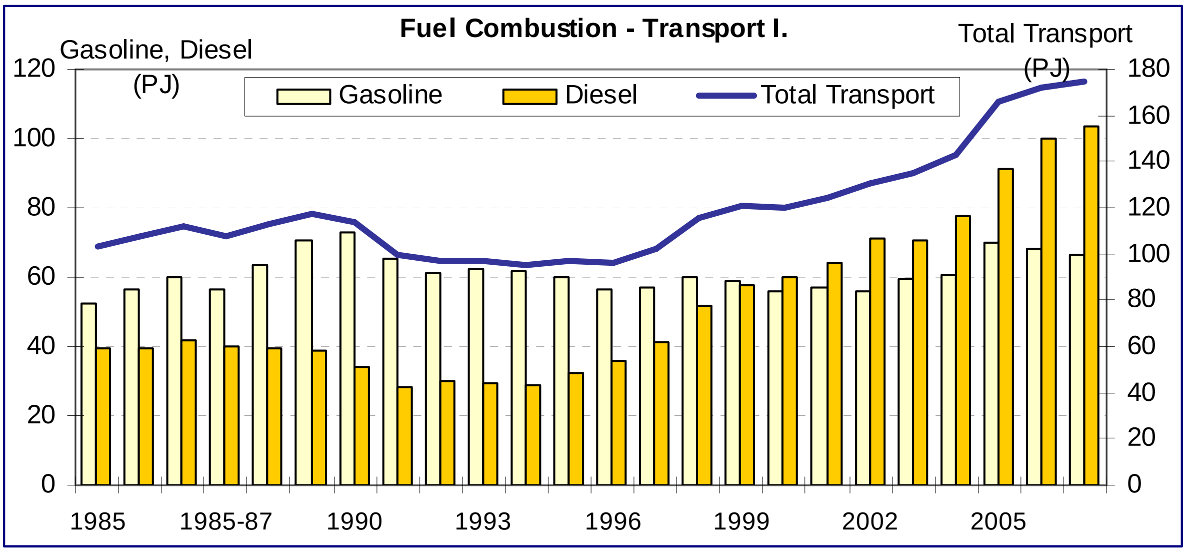


Figure 3.16. *Gasoline and diesel combustion, and total energy use in transport (1985-2007)*

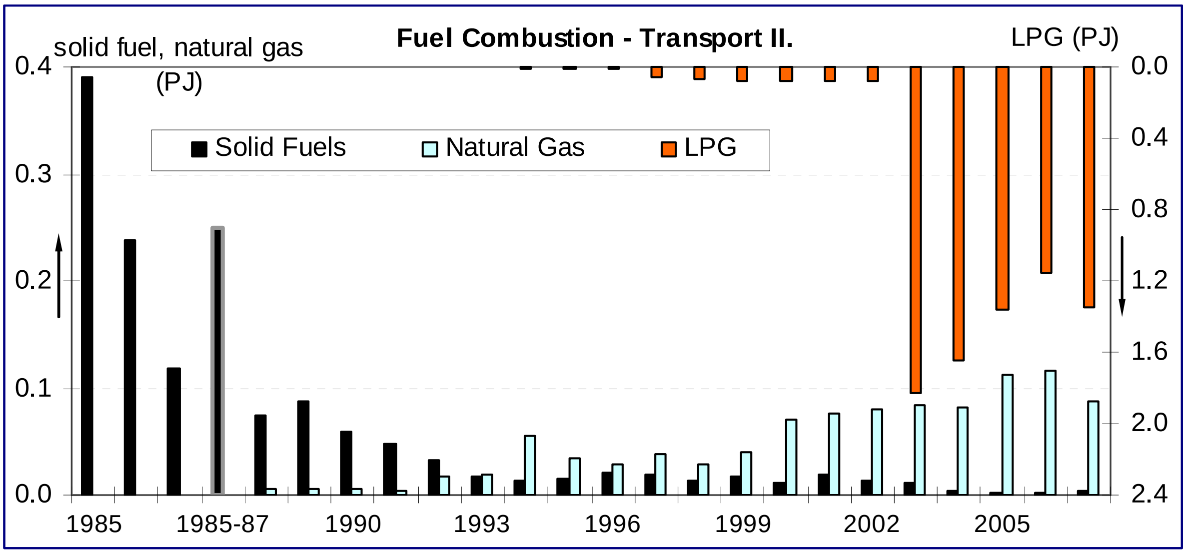


Figure 3.17. *LPG, natural gas and solid fuel combustion in transport (1985-2007)*

Figure 3.16. clearly shows that in contrast to the other described sectors, transport consumption shows a rising overall tendency.
LPG has been used since 1992. It should be noted that due to the current commercial practices, in-container (household, institutional) uses are difficult to separate from traffic uses (i.e., distribution at petrol stations). This may be the reason for the sharp increase in 2003, which does not fully reflect the actual changes but is the result of a change in the approaches used for the preparation of the statistics. Accordingly, liquid fuel uses by the general public (currently including LPG only) show a significant drop – on the basis of the national statistics (see *Chapter 3.5*).

3.4.2. Methodology

CO_2 emission from transport is calculated by multiplying fuel consumption taken from Energy Statistics Yearbooks (1985-2008) by the default IPCC emission factors.
Calculation of CH_4 and N_2O emissions from road transport was changed last year in conjunction with UNFCCC ERT from Tier 1 to Tier 2 as follows:
Quantification of the stock of each road vehicle type is based on Statistical yearbooks of Hungary (HCSO, 1985-2007) and annual reports of Ministry of Economy and Transport about the Hungarian vehicle fleet (*Figure 3.14*).
For the base years it was assumed that passenger cars with 2-stroke engine have same the share in traffic like other gasoline vehicles. This assumption can be applied in the early 1990s, too. For the last few years, data about the use of cars with 2-stroke engine were obtained from KTI (Institute of Transport Sciences) reports and personal communication with experts.
It should be noted that unleaded gasoline was sold after 1989 (*Figure 3.18*). Since lead is poison for catalytic converters, catalyst vehicle has been used after this time.
Emission factors in terms of g/MJ and average fuel consumption were obtained from the 2006 IPCC Guidelines and, in case of missing categories, from the 1996 IPCC Guidelines. In case of country specific information the default values were revised as follows:

- the “average passenger cars with 2-stroke engine” have an average fuel consumption of 8.4 litre/ 100 km according to official fuel consumption database (60/1992. (IV. 1.) governmental decree)
- N_2O emission of passenger cars with three-way catalyst, EURO-4 is one third of emission of the cars with early three-way catalysts (2006 IPCC Guidelines, Volume 2, p. 3.22.). Therefore, the default 18 kg/TJ was replaced with 6 kg/TJ. Use of three-way

catalyst in new cars is mandatory since 2005 in the European Union, as well in Hungary.

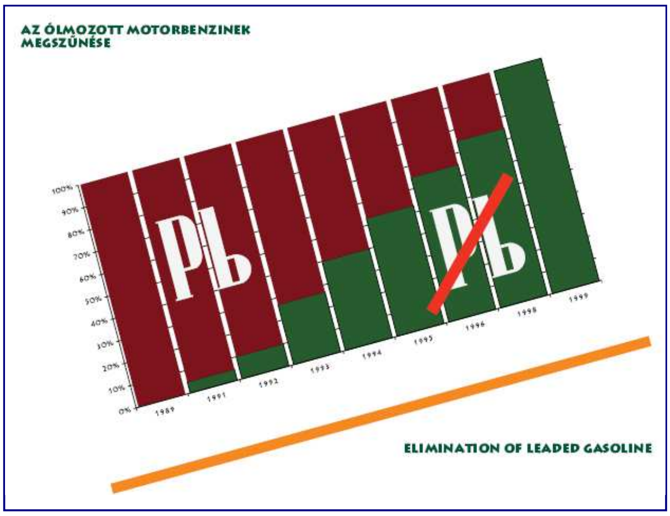


Figure 3.18. *Elimination of leaded gasoline in Hungary*
(Source: Hungarian Petroleum Association (MÁSZ), Annual Report 2005)

Emission factors

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

Category	Fuel type	Emission factor (t C/TJ)	Source of EFs
Liquid fuels	Gasoline	18.9	Revised 1996 Guidelines, Table 1-2
	Gas/Diesel Oil	20.2	
	LPG	17.2	
	Residual fuel oil	21.1	
Solid fuels	Brown Coal	26.2	Revised 1996 Guidelines, Table 1-2
Gaseous fuels	Natural Gas	15.3	Revised 1996 Guidelines, Table 1-2

Table 3.7. *CO_2 emission factors in transport*

Methane and nitrous oxide emission factors for road transport are summarized in *Table 3.9* and for railways and navigation are shown in the following table (*Table 3.8*). Emissions from in-country aviation, which represent a very low proportion, were taken equal to the emission from consumption of aviation gasoline, and calculated in those years when the related data were available in the energy balance. Where aviation gasoline was not indicated in a separate line, consumption and emissions are calculated together with road traffic gasoline, therefore civil aviation is not included in the table.

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

Table 3.8. *CH_4 and N_2O emission factors in transport (excluding road transport)*

3.4.3. Uncertainties and time-series consistency

We assume that the uncertainty of the transport-related fuel consumption data is higher than in case of immobile equipment because such data are more difficult to collect and verify. Considering the above, the estimated uncertainty of the energy consumption data is ±5%. The estimated uncertainty of the emission factors for CO_2 is ±5-15% for CH_4 is 50%, whereas that of N_2O is 100%. It should be noted, that in the 2006 IPCC Guidelines the uncertainty for default methane and nitrous oxide factors is much higher (200-300%).
The time-series data are not consistent in case of road transport between 1988 and 2003.

3.4.4. QA/QC information

QC check was performed in 1.AA.3.B – CO_2 emission (identified as key category) as part of the QA/QC plan of 2008-2009.

3.4.5. Recalculations

There was no recalculation.

3.4.6. Planned improvements

To achieve the consistent time-series, recalculation of CH_4 and N_2O emissions in the category of road transport will be continued. The offical statistics are not sufficent for the above mentioned method, thus we are searching for more detailed datasets.

Fuel type	Vehicle type	Emission control technology	Emission factor (kg/TJ)		Average fuel consump-tion (l/100km)	Source of EFs and average fuel consumption
			CH_4	N_2O		
Gasoline	Passenger car	Uncontrolled	33.0	3.2	10.0	IPCC, 2006 Guidelines, V2 Table 3.2.2
		Non-oxidation catalyst	25.0	8.0	10.0	IPCC, 2006 Guidelines, V2 Table 3.2.2
		2-stroke engine	20.0	1.0	8.4	EF: Revised 1996 Guidelines, Table 1-36; Fuel: country specific information
		Three-way catalyst	7.0	18.0	8.5	Revised 1996 Guidelines, Table 1-36
		Three-way catalyst EURO-4	1.5	6.0	8.5	Expert judgement using IPCC, 2006 Guidelines, V2 Table 3.2.3
	Motorcycles		100.0	1.5	4.0	Revised 1996 Guidelines, Table 1-42
	Light duty vehicle	Uncontrolled	20.0	1.0	13.6	Revised 1996 Guidelines, Table 1-40
		Catalyst (1997 or later)*	3.8	5.7	11.0	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2, Fuel: expert judgement
	Heavy duty vehicle	Uncontrolled	20.0	1.0	22.5	Revised 1996 Guidelines, Table 1-41
		Catalyst (1997 or later)*	3.8	5.7	22.5	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2, Fuel: Revised 1996 Guidelines, Table 1-41
	Bus		20.0	1.0	22.5	Expert judgement, assuming same performace like heavy duty vehicle
LPG	Passenger car		62.0	0.2	11.2	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: Revised 1996 Guidelines, Table 1-45
Natural Gas	Passenger car		92.0	3.0	9.0	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: expert judgement
Diesel	Passenger car		2.0	4.0	7.3	Revised 1996 Guidelines, Table 1-37
	Light-duty vehicle		3.9	3.9	10.9	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: Revised 1996 Guidelines, Table 1-38
	Heavy-duty vehicle		3.9	3.9	29.9	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel Revised 1996 Guidelines, Table 1-39
	Bus		3.9	3.9	29.9	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: expert judgement, assuming same performace like heavy duty v.

Table 3.9. *CH_4 and N_2O emission factors in road transport*

** It was assumed, that the technology change was slower in Hungary than in Western Europe or in the USA. IPCC, 2006 suggests the low EFs after 1995*

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

3.5.1. Category description

Emitted gases: CO_2, CH_4, N_2O

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

N_2O – Level 1 with and without LULUCF; Level 2 without LULUCF (see “Non-CO_2 Emissions from Stationary Fuel Combustion”)

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

3.5.2. Methodology

Activity data and the source of the specific emission factors for CO_2 are the same as those described in Section 3.2.2.

Figure 3.19 illustrates the fuel consumption of the sector by types.

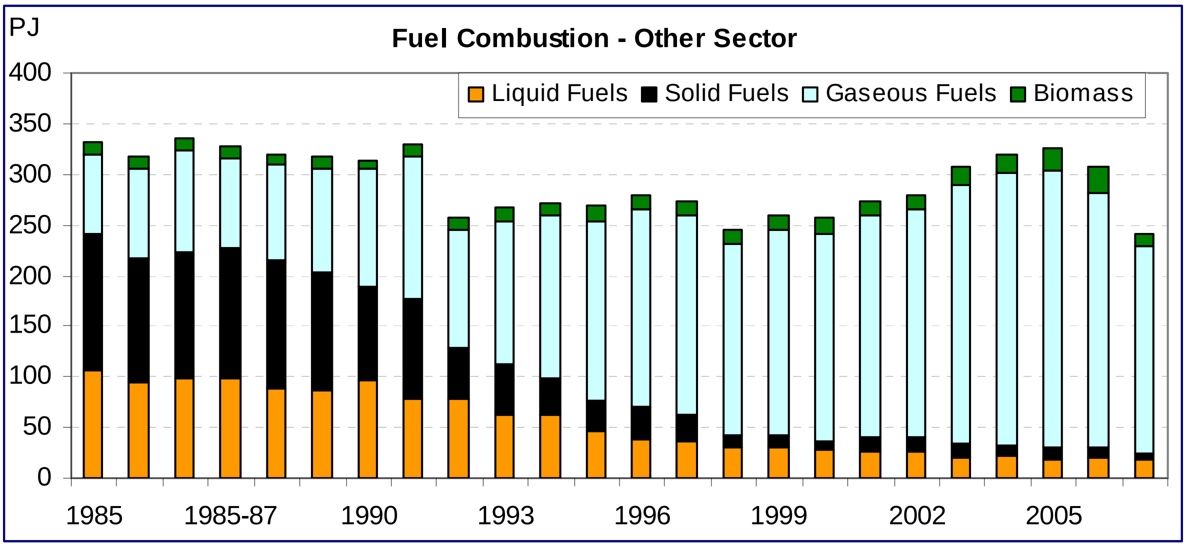


Figure 3.19. *Distribution of combusted fuels in the “other sector” (1985-2007)*

Since 59-74% of the fuel consumption is related to the residental sector, the fuel structure is influenced principally by the changes in this sector. In constrast with the significant reduction of coal and oil consumption, natural gas consumption has increased significantly. During the period 1985-2007 natural gas pipelines length has doubled (see *Table 3.17*), and the number of households supplied with natural gas has been increasing continuously. Population swithed from coal to natural gas combustion. Household heating oil was completely replaced by LPG during the last years of the analysed period, as shown in *Table 3.10*.

Sector	Fuel consump-tion (TJ)	2000	2001	2002	2003	2004	2005	2006	2007
Commercial/ Institutional	**Oil**	1,127	1,055	580	366	744	289	41	325*
	LPG	2,131	1,761	1,931	1,739	1,643	1,609	1,595	1,399
Residential	**Oil**	54	0	0	0	0	0	0	0
	LPG	12,091	10,483	10,659	9,353	8,836	6,688	6,890	3,943

Table 3.10. *Oil and LPG consumption in the institutional and residential sector (2000-2007)*
** without transport, storage and communication*

As the dominant fuel is natural gas in the *other sector*, the following basic statistical data will help to get acquainted with the Hungarian situation (source: HCSO, 2008).
Residential and Commercial/ Institutional consumption nowadays represents 61% of total natural gas consumption (transported by pipelines). 91% of the settlements were supplied with this facility in 2007. Some 84% of households use natural gas for heating purpose as well. Sold natural gas for residential consumer decreased by 14% in 2007 compared to 2006 for the following reasons: warmer-than-average winter period (see *Figure 3.20*) and consumer price index of natural gas increased significantly (meantime coal and fire-wood remained moderate expensive). After 1990 individual residential heating became widespread, but still more than 15% of dwellings (of which 37% exists in the capital city) are supplied with district heating based also mainly on natural gas – this emission was calculated under the *energy sector*.

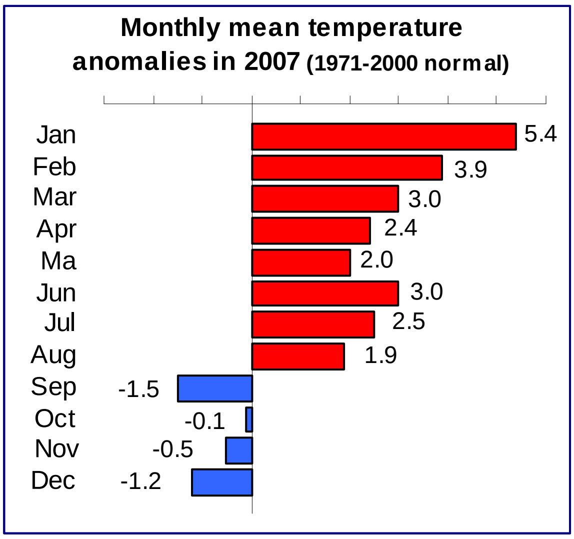


Figure 3.20. Monthly mean temperature anomalies in 2007 (1971-2000 climatical average)

Annual mean temperature was 1.7℃ higher in 2007 compared to 1971-2000 climatical average, therefore the total fuel consumption of the *other sector* relapsed by 21.6% compared to 2006. Besides, Budapest Gas Works Plc. have established that in the previous two years (2007 and 2008) the residential gas consumption dropped by 7-8% (after weather correction) in the capital city, which is the joint impact of the following factors: more expensive tariff, modern heating systems and insulations.

The consumption rates of the subsectors are shown in Figure 3.21.

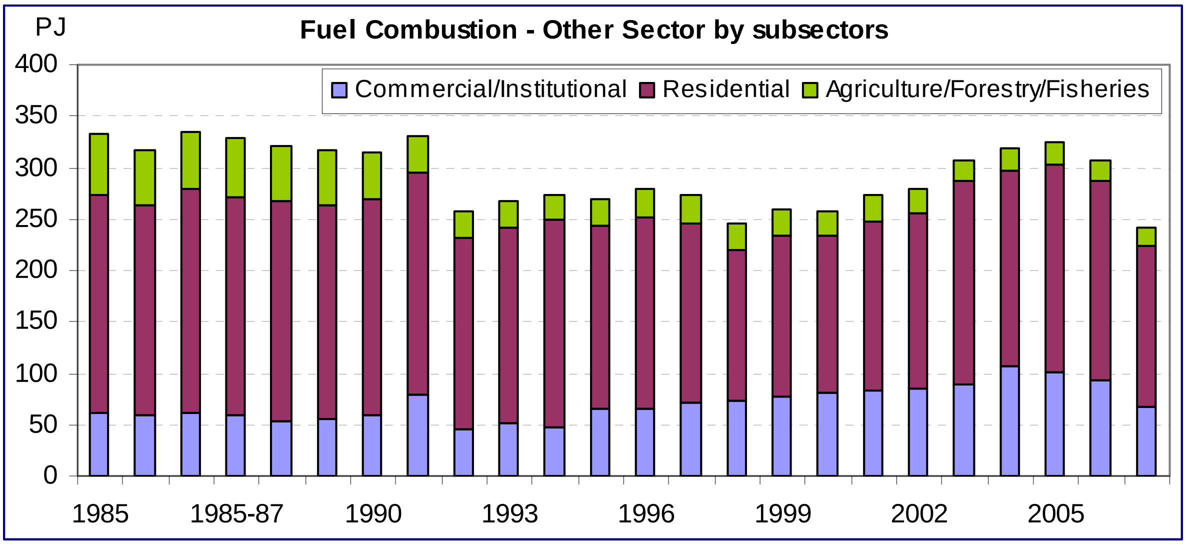


Figure 3.21. *Fuel combustion in the subsector of "other sector" (1985-2007)*

Emission factors

Since the entire quantity of liquid fuels used in residential combustion is LPG and the majority of institutional uses is also based on LPG, the IEF factor for CO_2 is very low. The value of EF for lignite is the same as listed in *Table 3.4*, the other CO_2 emission factors are taken from IPCC Guidelines.
Specific emission factors for CH_4 are shown in *Table 3.11*.

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

Table 3.11. *Specific emission factors for CH_4 in the "other sector"*

Due to the relatively high briquette consumption in the agriculture, the used average factor for solid fuels is lower than in the other sectors.
Country specific N_2O emission factors were replaced by IPCC 2006 default values in gaseous fuels in the *residential sector* and liquid and gaseous fuels in the *agriculture/forestry/fisheries sector* and solid fuels in general in the last submission. Specific emission factors for N_2O are shown in *Table 3.12*.

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

Table 3.12. *Specific emission factors for N_2O in the other sector*

3.5.3. HDD and energy demand of residential sector

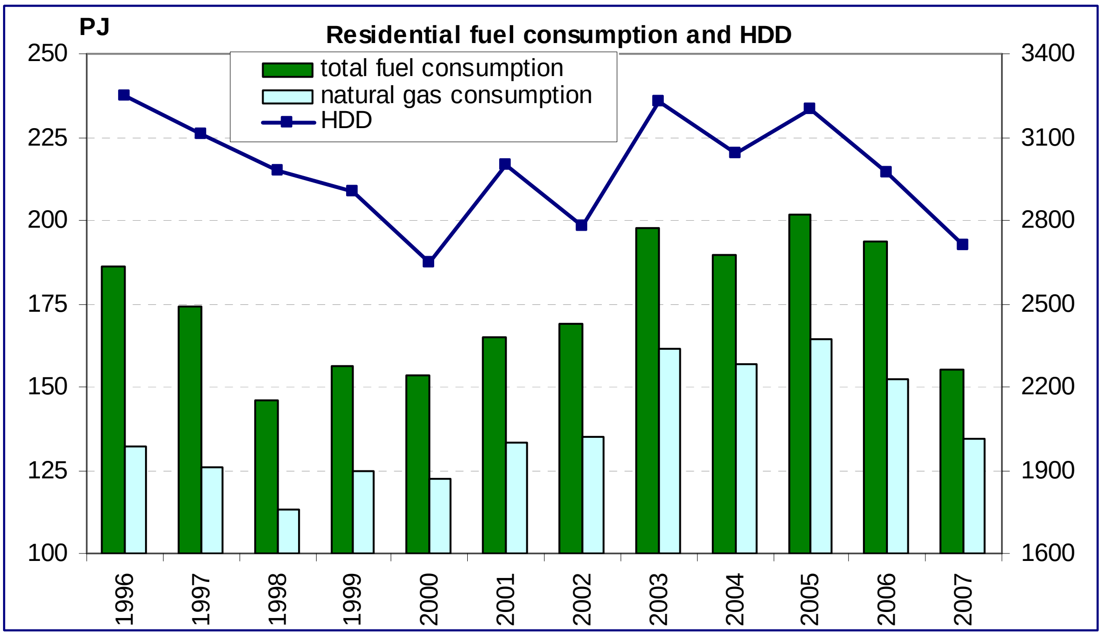


Figure 3.22. *Comparison of residential fuel consumption and HDD between 1996 and 2007*

Heating degree day (HDD) is a quantitative index which reflect demand for energy to heat houses and businesses. This index is derived from daily temperature observations. *Figure 3.22* illustrates the relationship between residential fuel consumption and HDD. Line of HDD and fuel consumption bars are running parallel, especially in the last 5-6 years.

3.5.4. Uncertainties and time-series consistency

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

3.5.5. QA/QC information

Key category analysis indentified the “*1.AA CO_2 emission from stationary natural gas combustion”* as key category, therefore according to the QA/QC plan for 2008/2009 quality check was performed using checklist (see *Annex 6*).

3.5.6. Recalculation

There was no recalculation.

3.5.7. Planned improvements

It is planned to investigate the relation of fugitive emission from natural gas pipelines and emission from *residential* and *commercial/institutional* natural gas consumption. Consumption of *other sector* will decrease by the amount of fugitive gas. Presumably it will affect only the *residential* and *commercial/institutional* category, but in some years this recalculation will lead to greater rearrangement.

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

3.6.1. Category description

Emitted gas: CO_2, CH_4, N_2O

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

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

This category includes fugitive CO_2, CH_4 and N_2O emissions released during coal mining and handling and oil and natural gas activities. Emissions from fuels used during these activities are calculated under sector 1.AA.2 (*Manufacturing Industries and Constructions*).

In Hungary, both underground and surface coal mines are present. Although underground mining was the predominant form in the 1960's and 1970's, it represents only 15% today. Underground mining continues to decrease in both relative and absolute terms.

In the past, oil production and processing was an important sector in Hungary, but production's importance is decreasing as the reserves are running out. Gas mining shows similar tendencies, although the reduction is less intensive. At the same time, natural gas uses show a significant increase as a result of the sharply growing import, as previously described (3.1 Overview of the sector).

3.6.2. Coal Mining

Methodology

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

In Hungary, both underground and surface coal mines are present. Although underground mining was the predominant form in the 1960's and 1970's, it represents only 15% today. Drastic reduction in coal production was observed between 1987 and 1988, as well as between 1989 and 1990. Underground mining continues to decrease in both relative and absolute terms, therefore distribution of mined coal types underwent significant changes (*Figure 3.23*).

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

Table 3.13. *Coal production of selected years in Hungary*

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

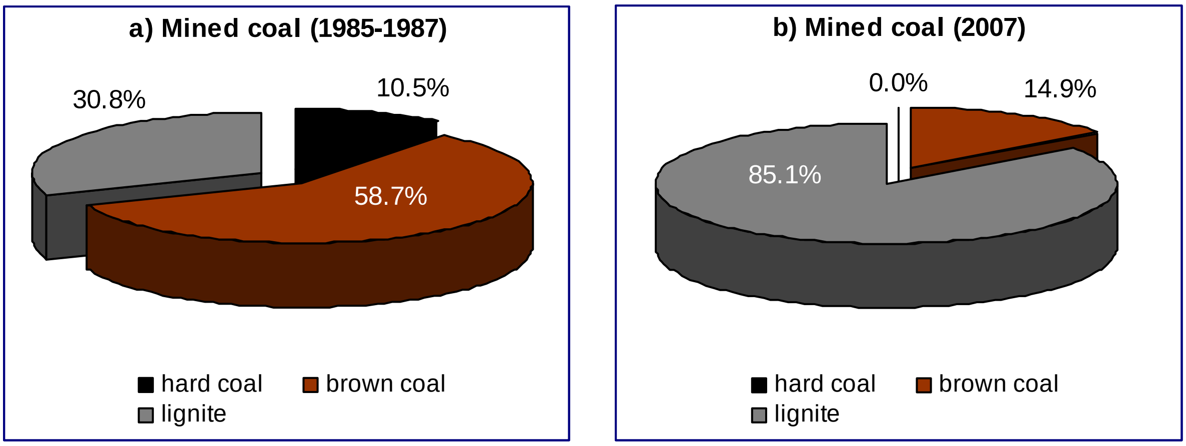


Figure 3.23. *Distribution of mined coal in the base year (a) and 2007 (b)*

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

Emission factors

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

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

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

Table 3.14. *In-situ CH_4 content in Hungarian mines*
(Source: REKK, 2004 (original data: Hungarian Geological Survey, disclosure of mines))

Table 3.14 shows the measured methane content of coal for the active mines in Hungary in the last few years. Mine of Lencsehegy closed in 2004, previously it had been producing significant amount of coal having 0.0 m^3/t methane. In 2007 the only one operating mine was Márkushegy with 0.93 m^3/t in-situ methane content. Lignite is mined only in surface mines; where – based on measurement data – methane is not emitted during mining activity, since the Hungarian lignite is relatively young in the coalification (NCV is under 10 MJ/kg).

Emission factors for coal mining and post-mining are summarized in the following table (*Table 3.15*). For mining activities emission factors were derived from measurement data, in case of post-mining according to the IPCC 2000 Guidance, emission factor was calculated as 10% of mining value. The new emission factors are lower than the default or perviously used values.

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

Table 3.15. *Comparison of IPCC default and country specific emission factors for coal mining*

3.6.3. Oil and gas activities

Methodology and emission factors

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

In the past, emissions were calculated using the specific emission factors provided for *Eastern European technologies* in the Revised 1996 Guidelines. In response to the comments of the ERT and also due to the ambiguous relationship between activities and specific emission factors, we contacted the production companies and the emission calculations were adjusted in cooperation with them, on the basis of the new information obtained. Such fundamental changes were required because the technologies used in Hungary are entirely based on “Western” equipment; therefore, the use of the specific emission factors for Eastern Europe, which are high and associated with great uncertainty, is not justifiable. Since we do not have own measurements, it was decided – on the basis of the data available from the production companies – that the Canadian calculation presented in the Background Papers published by IPCC (2002) would be used. Hungarian data for the activities indicated in this calculation were determined and multiplied by the provided specific emission factors.

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

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

Table 3.16. *Source-specific emission factors in oil and gas activities (Source: IPCC - Background Papers, 2002)*

In addition, trial calculations were made using the specific emission factors for “Western” technologies from the Revised 1996 Guidelines. The results were in the same order of magnitude as before. Energy Statistic Yearbook contains a special category, the network loss, which is a statistical concept. The real fugitive emission is about one third of the network loss in natural gas distribution. The results of the above mentioned methodology and emission factor are in good agreement with the statistical value.
Gas transport represents the highest proportion in the emissions. In Hungary, gas supply, as well as the total length of pipelines, has been growing significantly over the past 20 years. Annual data for pipeline lengths are indicated in *Table 3.17.*
Flaring was estimated – due to lack of information about emission – on the basis of detailed production data obtained from oil and gas companies and using default emission factors of the 2006 Guidelines (IPCC, 2006).
CH_4 and N_2O emissions from flaring (oil and gas) are included for the first time, in this submission.

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

Table 3.17. *Annual data for natural gas pipeline lengths in selected years (green and bold values are corrected by the data provider, MOL in 2009)*

3.6.4. CH_4 emission from thermal water

This category contains the emissions from thermal and other deep water drills. In Hungary, and especially in the Great Plain, subsurface waters and deep wells drilled for various purposes contain varying quantities of methane. Upon the abstraction of such waters (as drinking and/or as thermal water), methane is also abstracted and released into the atmosphere. According to a previous expert estimate, the annual quantity of methane released from wells is approx. 20 Gg. We believe that this item should also be included in the methane emissions for the sake of completeness. However, it does not have an appropriate "slot" in the inventory. Thus, such emissions were included among fugitive emissions from oil and natural gas *(1.B.2.D Other)* in the following way: the emissions are indicated in the CH_4 column but the box for activity data was left empty because emissions are not related to fuel consumption or fuel production.
It is planned that these emissions will be analysed in more details. So far, the capacities have been insufficient for the collection and evaluation (including retrospective collection and evaluation) of potentially available data from some ten thousands of wells.

3.6.5. Uncertainties and time-series consistency

The uncertainty of the majority of the activity data from recent years is favourable. These include main production data and pipeline lengths. The uncertainty of other values and specific emission factors is moderate; however, in the lack of other information, this cannot be quantified, only estimated. Naturally, the uncertainty of older data is higher due to the incomplete availability of the required information.
As a result of the accomplished concordant calculations, time-series data can be considered consistent.

3.6.6. QA/QC information

Analysing the activity data of fugitive emission from natural gas transmission it was found that the time-series had a peak in 2002 and the pipeline length decreased in some years after continous growth, therefore we asked MOL - the Hungarian Oil and Gas Plc. – to check the dataset. The company provided us after consulting with FGSZ Natural Gas Transmission Closed Company Limited (member of MOL Group) the checked and corrected activity data and information about the fluctuations. This resulted small correction of emissions in the category of natural gas transmission.

3.6.7. Recalculation

Only some minor changes have occurred in the category of natural gas transmission. More details are above in the QA/QC information of this sector.

3.6.8. Planned improvements

We will do more accurate calculations in some categories using data from EU ETS.
We would like to refine methods, input data and uncertainty, hopefully the government decree (see Ch. 1.3) allows us to establish database with help of the Mining and Geological Bureau of Hungary.
We have come to an agreement with MVM on compiling more precise inventory of coal mines, because the company has preserved long time-series about the quality of mined coal for power plants.

3.7. References

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

Energy Centre, 2008: Energy Statistics Yearbook, 2006 (In Hungarian: Energiagazdálkodási Statisztikai Évkönyv, 2006), Budapest.

Intergovernmental Panel on Climate Change (IPCC), 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, *Intergovernmental Panel on Climate Change, Organisation for Economic Cooperation and Development, and International Energy Agency*. *(IPCC/OECD/IEA),* UK Meteorological Office, Bracknell.
Available online at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm

Intergovernmental Panel on Climate Change (IPCC), 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, *Intergovernmental Panel on Climate Change National Greenhouse Gas Inventories Programme*, Institute for Global Environmental Strategies, Japan.
Available online at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/

Intergovernmental Panel on Climate Change (IPCC), Background Papers, 2002: IPCC Expert Meetings on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, p. 112., Japan.
(original source: CAPP, 1999: CH_4 and VOC Emissions from the Canadian Upstream Oil and Gas Industry, *Vols. 1 and 2, Prepared for the Canadian Association of Petroleum Producers by Clearstone Engineering,* Calgary, Alberta, Canada, Publication No. 1999-0010.)
Available online at: http://www.ipcc-nggip.iges.or.jp/public/gp/gpg-bgp.htm

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

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

Hungarian Central Statistical Office (HCSO), 2007: Statistical yearbook of Hungary (In Hungarian: Magyar statisztikai évkönyv, 2006), Budapest.

Hungarian Central Statistical Office (HCSO), 2008: Infrastructural supply of settlements, 2007 (In Hungarian: A települések infrastrukturális ellátottsága, 2007). Statisztikai tükör, II., No. 145.

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

Magyar Ásványolaj Szövetség (MÁSZ), 2005: Annual Report

Delta Informatika Zrt, 2008: Visualization system for data on national road transport at end of 2007, Budapest.

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

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

4. INDUSTRIAL PROCESSES (CRF sector 2.)

4.1. Sector Overview

Industrial Processes sector includes emissions generated by non-firing processes related to industrial production. Emissions from this category comprise the following sub categories: Mineral Products, Chemical Industry, Metal Production, Other Production and Consumption of Halocarbons and SF_6.

The major processes include cement, iron and steel, aluminium, ammonia and nitric acid production. In addition, technologies involving fluoride gases are considered here. The emission of Industry is the third following the Energy and Agriculture sectors. (See *Figure 2.7.* in Trends of GHG Emission Chapter).

The base year is the average value of the three years 1985–1987 for CO_2, CH_4 and N_2O, and 1995 for HFCs, PFCs and SF_6.

4.2. Emission Trends

Total emissions estimated from industrial processes were 5,236.43 Gg CO_2eq in 2007, or 6.9% of the total national emissions compared to 9.0% in the base year.

Greenhouse gas emissions from 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. Since then, emissions has been fluctuating again, maybe showing a decreasing tendency in the past years.
Figure 4.1. shows the trend of GHG emissions from this category for 1985-2007.

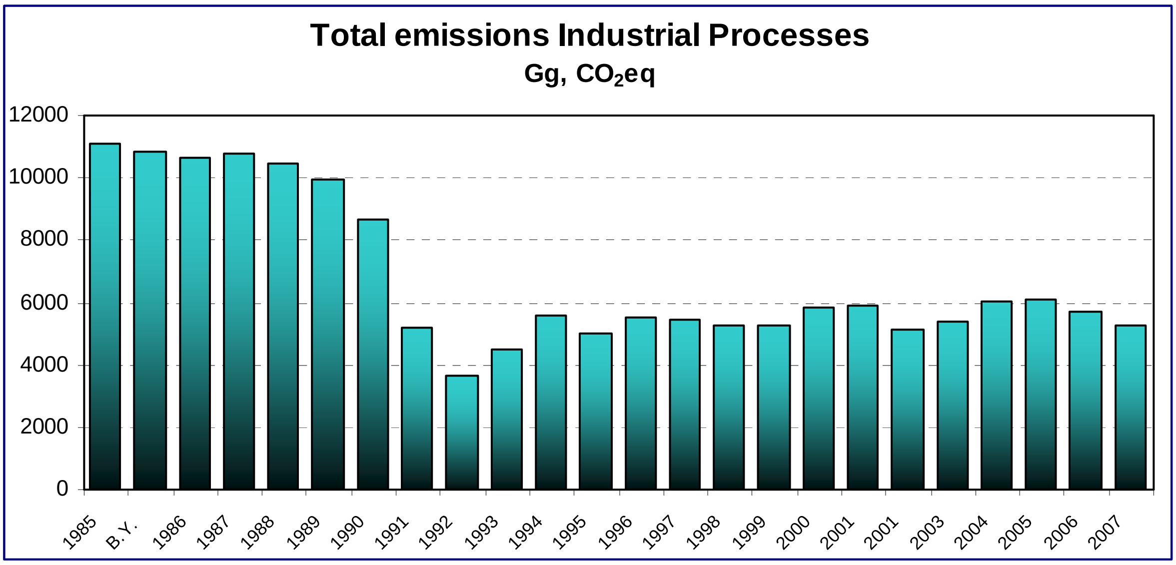


Figure 4.1. *GHG emissions from Industry sector, 1985-2007 (Gg CO_2eq)*

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

Some examples:

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

The privatisation 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. However, in some cases 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, the emission by industry has been showing a fluctuating trend reflecting the actual demands of production in the national economy. An example is the (relatively) significant increase of methane emission, which can be definitely connected to the increase of production in the chemical industry (see e.g. ethylene production: 2004: 374 kt, 2005: 594 kt, 2006:578 kt, 2007:648 kt).

4.2.1. Emission Trends by Gases

The most important GHG in Industrial Processes sector is carbon dioxide, contributing 67.33% to total GHG emissions in this sector in 2007, expressed in CO_2 equivalent, followed by N_2O (17.30%). Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) together contributed 15.07% to GHG emissions (*Figure 4.2*). Total sectoral emissions decreased by 50.88% between base year and 2007.

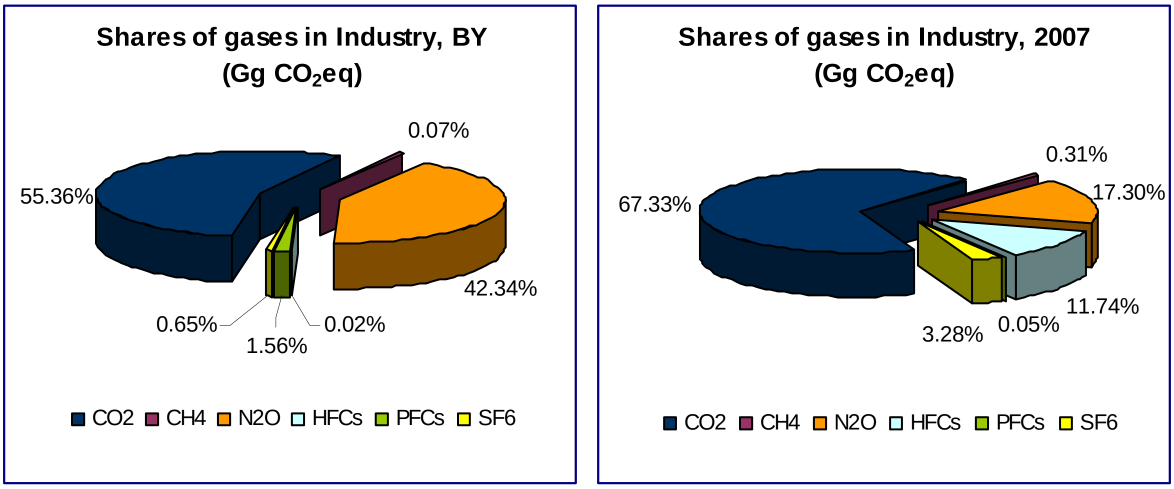


Figure 4.2. *Shares of gases in Industry secor, in base year and 2007 (Gg CO_2eq)*

The *Figure 4.3* below shows the emissions of this sector by gases:

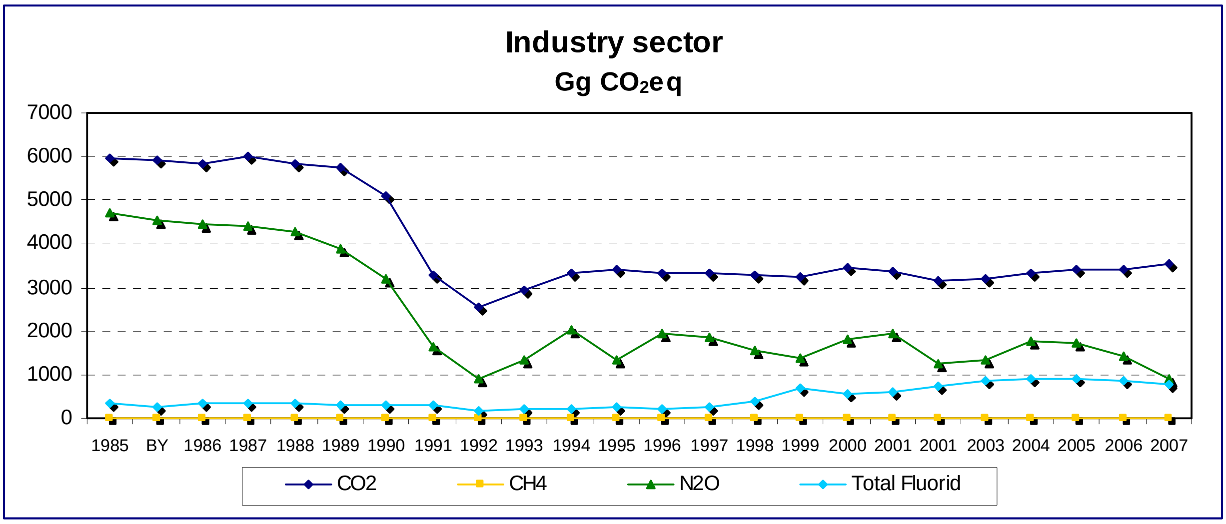


Figure 4.3. *The most significant greenhouse gases in Industry sector. In comparison with them, the quantity of fluoride gases and methane is negligible. Note: BY=average of 1985-87 but 1995 for F-gases*

It can be seen in *Figure 4.3* that in 2007 N_2O emission from Industrial Processes are 80.06% below the level of the base year and dropped by 36.65% from 2006 to 2007 which is due to the introduction of a new nitric acid plant.

4.2.2. Emission Trends by sources

In the base year, the chemical sub-sector accounted for 61.0% of total industrial GHG emissions, followed by mineral sub-sector 30.8%, metal sub-sector 7.5% and F-gases 0.7%. In 2007 mineral sub-sector accounted for 45.7%, followed by chemical sub-sector 33.7%, F-gases 15.1% and metal sub-sector 5.5% (see *Figure 4.4* and *Table 4.1*.).

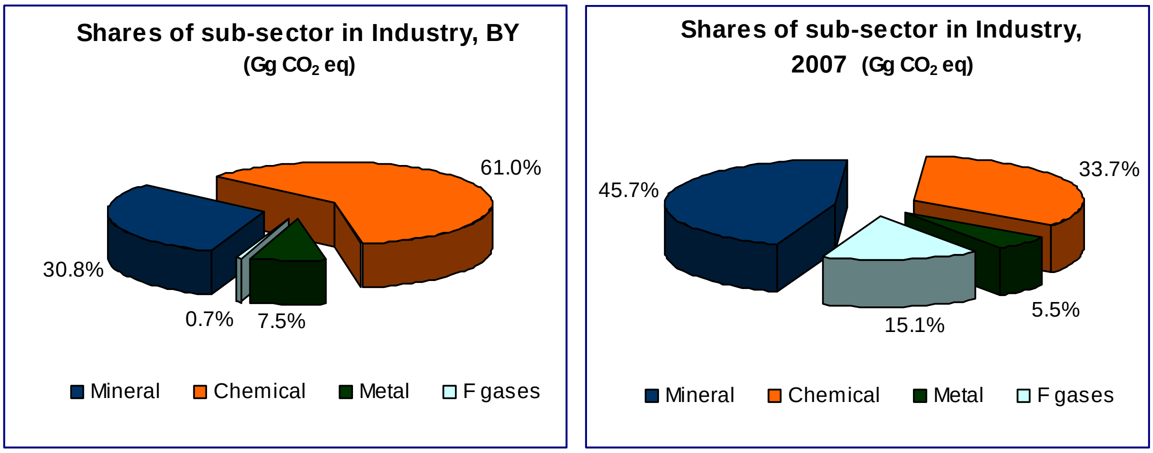


Figure 4.4. *Shares of sub-sectors in Industry sector, in base year and 2007 (Gg CO_2eq)*

Table 4.1. *Industrial processes sector CO_2eq emissions in 2007*

	GHG emissions in 2007 (Gg CO_2-eq)				
	CO_2	CH_4	N_2O	HFC/PFC/SF_6	Total
2. Industrial Processes	**3,525.77**	**16.46**	**905.67**	**788.54**	**5,236.43**
A. Mineral products	2391.17	0	0	0	2391.17
B. Chemical Industry	844.50	16.46	905.67	0	1,766.63
C. Metal Production	290.10	0	0	0	290.10
D. Other Production	0	0	0	0	0
E. Production of HFC/PFC/SF_6	0	0	0	0	0
F. Consumption of HFC/PFC/SF_6	0	0	0	788.54	788.54
G. Other	0	0	0	0	0

Figure 4.5. presents greenhouse gas emissions from Industrial Processes by sub-categories for the years 1985 to 2007. Chemical industry was the most important emitter in the beginning of the inventory period, especially N_2O emission from nitric acid production (for details see there). Nowadays the main source of greenhouse gases is Mineral Products while Consumption of Halocarbons and SF_6 is also showing a growing tendency.

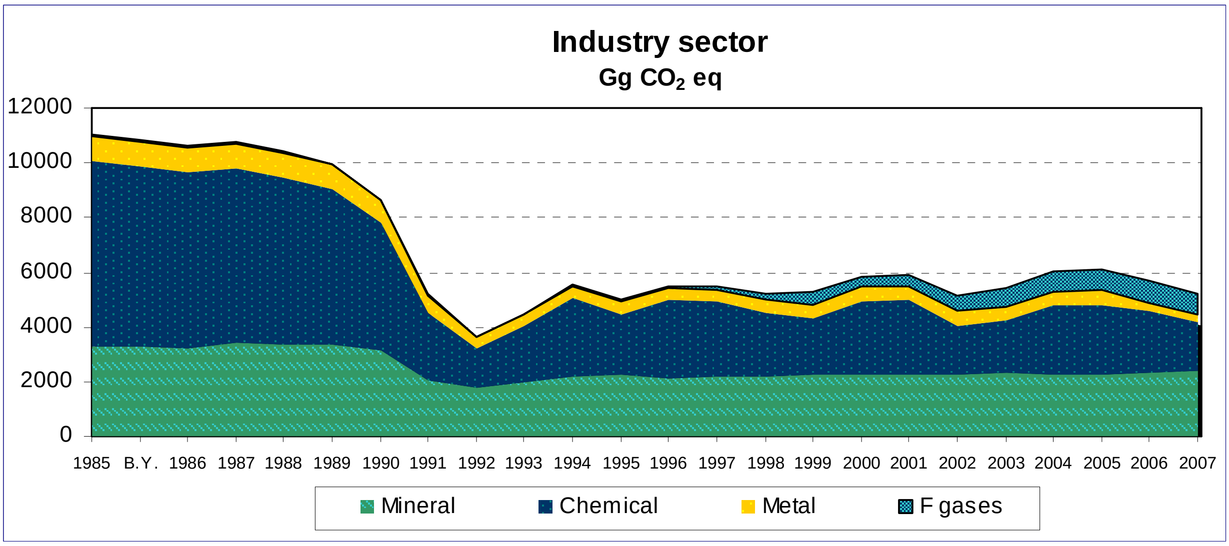


Figure. 4.5. *The emissions in Industry by sub-sectors*
Note: BY=average of 1985-87 but 1995 for F-gases.

4.3. Mineral Products (CRF sector 2.A)

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

Technology

Emitted gas: CO_2, SO_2
Key source: Level 1

CO_2 is generated during cement production in the clinker production phase:

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

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

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

Methodology

In this category, only emissions from the production processes are determined. Gases originating from fuels are included in Energy sub-sector 1.A.2.B.
Emissions were estimated using a country specific method similar to the IPPC Tier 2 methodology. In 2007 four factories were operated in Hungary. Production data for the whole time series were obtained directly from the factories and from Emission Trading System (ETS)

According to the ETS introduced by the European Union from 2005 on, the factories report their CO_2 emission. This value is calculated on the basis of the derivatographic analysis of carbonate, which contains also CO_2 generated from the $MgCO_3$ content of limestone. All these increase the accuracy of emission-determination. The quantities of CO_2 emitted in 2005, 2006 and 2007 are based on reports of the factories.

For the preceding years, raw material consumption was used for emission calculation instead of cement or clinker production. This is more accurate because cement factories measure the amount and composition of the raw flour. In 2000, production at one site was abandoned therefore previous production data of this factory was obtained directly from the Cement Industry Association which was able to supply only clinker data and ratio of calcium-oxide to clinker. The table below shows the time-series of production data.

Table 4.2. *Amount of raw flour used in process, clinker and cement production (kt) in Hungary (1985-2007)*

	B Y	1989	1990	1991	1992	1993	1994	1995	1996	1997
Raw flour, kt	4,739.7	5,081.4	4,825.7	2,942.4	2,453.4	2,910.1	3,276.8	3,398.2	3,211.1	3,392.2
Clinker, kt	3,173.2	3,242.7	3,210.4	1,987.6	1,598.3	1,905.7	2,154.0	2,233.2	2,079.0	2,193.8
Cement, kt	3,888.9	3,856.8	3,932.8	2,581.7	2,245.6	2,521.3	2,795.3	2,874.9	2,745.0	2,806.2

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Raw flour, kt	3,460.5	3,523.1	3,908.5	3,862.0	4,140.8	4,157.1	3,695.8	3,431.9	3,744.7	3,803.5
Clinker, kt	2,261.1	2,270.6	2,532.4	2,522.0	2,687.1	2,694.5	2,494.8	2,352.6	2,533.1	2,577.1
Cement, kt	3,003.4	2,985.8	3,344.7	3,452.4	3,504.2	3,564.9	3,266.7	3,363.5	3,722.9	3,485.1

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

Table 4.3. *CO_2 emissions in 2.A.1 Cement Production sub-sector (1985-2007)*

	B Y	1989	1990	1991	1992	1993	1994	1995	1996	1997
CO_2 from $CaCO_3$, Gg	1,713.5	1,749.7	1,630.0	1,000.8	833.9	992.3	1,117.9	1,158.9	1,105.1	1,168.1
CO_2 from $MgCO_3$, Gg	51.8	48.5	42.5	26.4	25.9	30.8	34.9	35.3	34.7	36.1
Total CO_2, Gg	1,765.3	1,798.2	1,672.6	1,027.2	859.8	1,023.1	1,152.8	1,194.2	1,139.8	1,204.2
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2 from $CaCO_3$, Gg	1,170.3	1,200.7	1,352.1	1,355.4	1,438.5	1,426.3	1,291.0	---	---	---
CO_2 from $MgCO_3$, Gg	36.2	37.1	41.0	42.6	42.9	48.1	49.6	---	---	---
Total CO_2, Gg	1,206.5	1,237.9	1,393.1	1,398.0	1,481.4	1,474.4	1,340.6	1,198.8	1,295.3	1,328.1

Due to the CO_2 generated from $MgCO_3$, which was calculated in 2007 for the first time for the whole time series, the earlier specific factors increased by nearly 5%. Upon the recommendation of ERT, we supplemented the emission calculation by carbon dioxide generated from $MgCO_3$. According to the information obtained from the Cement Industry Association, the limestone used in cement production contains very few, not more than 1-5% $MgCO_3$. The $MgCO_3$ content (in MgO) of raw flour was received for years 2002-2006 for each factory. The data of earlier years were calculated by averaging these data. Due to the recalculation, the emission of the sector changed from 1719.42 Gg to 1765.31 Gg in the base year.
Accordingly, average emission factors were obtained using CO_2 emissions calculated for the individual factories and production data. These are shown in the table below. In addition, the table demonstrates the time series of the annual emissions[1]:

Table 4.4. *Specific emission factors of clinker and cement in 2.A.1 Cement Production sub-sector (1985-2007).*

	BY	1989	1990	1991	1992	1993	1994	1995	1996	1997
CO_2/ klinker	0.5563	0.5545	0.5210	0.5168	0.5379	0.5369	0.5352	0.5348	0.5483	0.5489
CO_2/ cement	0.4539	0.4662	0.4253	0.3979	0.3829	0.4058	0.4124	0.4154	0.4152	0.4291

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

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2/ klinker	0.5336	0.5452	0.5501	0.5543	0.5513	0.5472	0.5374	0.5095	0.5114	0.5153
CO_2/ cement	0.4017	0.4146	0.4165	0.4050	0.4227	0.4136	0.4104	0.3564	0.3479	0.3811

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

Uncertainties and time-series consistency

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

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

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

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

The originally small uncertainty was further improved by using data of emission-trade.
Due to different measuring approaches before and after 2005, the consistency of the time-series shall be verified.

QA/QC information

The data used for emission calculations were obtained directly from the factories. Each factory has a quality assurance system in compliance with any of the ISO 9000 series. It should be noted that no such systems were operated in Hungary in the beginning of the 1990's.
The Cement Industry Association also verified the raw data and the calculation method. The data received from the Association and those published by KSH show a difference of a few thousand tons.
The resulting national emission factors were compared to the default values recommended by the Revised Guidelines (0.4985 t/t for cement). This showed that the Hungarian specific factors are by about 20 % lower than the default value. This difference is attributable to the use of high amounts of additives, as mentioned above.
In case of wet process, where part of the CKD is removed from the system, this was taken into consideration on the basis of the residual $CaCO_3$ content of the CKD.

Recalculation

Last year there was no recalculation.

Planned improvements

The consistency of the time-series needs to be analyzed further, especially the different

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

approaches used under the ETS (derivatographic analysis) and in the inventory for the years before 2005 (calculations based on carbonate content of the raw flour) should be compared in more details.

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

Technology

Emitted gas: CO_2
Key source: none

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

$$CaCO_3=CaO+CO_2$$

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

Methodology

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

Uncertainties and time-series consistency

According to the data provided in the Good Practice, the uncertainty of the emission calculations for the recent years is estimated to 5 %. The uncertainty of calculations for the initial years is higher than that. As a result of uniform calculation method, time-series consistency is ensured.

QA/QC information

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

Recalculation

Last year there was no recalculation.

Planned improvements

None.

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

Technology

Emitted gas: CO_2
Key source: none.

This sub-sector includes processes in which calcinations (CO_2 loss) occurs as a result of heating limestone and dolomite, but excluding their use in cement and lime production. Here, only CO_2 emissions generated by the degradation reaction are calculated while gases from fuel combustion are included in sub-sector 1.A.2.B.

Methodology

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

Uncertainties and time-series consistency

According to the information obtained directly from the factory, the reliability of the data is relatively high and the estimated uncertainty of the emissions is 2 %. For years when the default values were used, the uncertainty is higher.

QA/QC information

No sector-specific information is available.

Recalculation

Last year there was no recalculation.

Planned improvements

None.

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

Although glass production is mentioned in the Revised Guidelines as a source of NMVOC only, also CO_2 emission from glass production was determined based on the data from emission-trade database. CO_2 emission is generated by adding the carbonates (mainly soda ashes) of the alkali metals (Ba, Li, Na, etc.) to the melt in the course of glass melting.

Methodology

Considering the fact that all the glass factories take part in the emission-trade, the quantity of CO_2 reported by them was accepted as emissions in 2005, 2006 and 2007. The data of total produced quantity were provided by KSH. The CO_2 emission is only 76 Gg representing only 1 per thousand of the total CO_2 emission. In order to achieve time-series consistency, we supplemented the inventory with data of earlier years as well. A specific emission factor was created from the emission trading data of 2005, and emissions were calculated retrospectively using this EF with the known production data.
This method gives quite rough estimates for the earlier years as it does not consider the different carbonate content of the raw materials necessary for the various glass types. Nevertheless, due to its small rate, it has no demonstrable effect on the whole inventory.
The *Figure 4.6* below shows the complete CO_2 emission from this category:

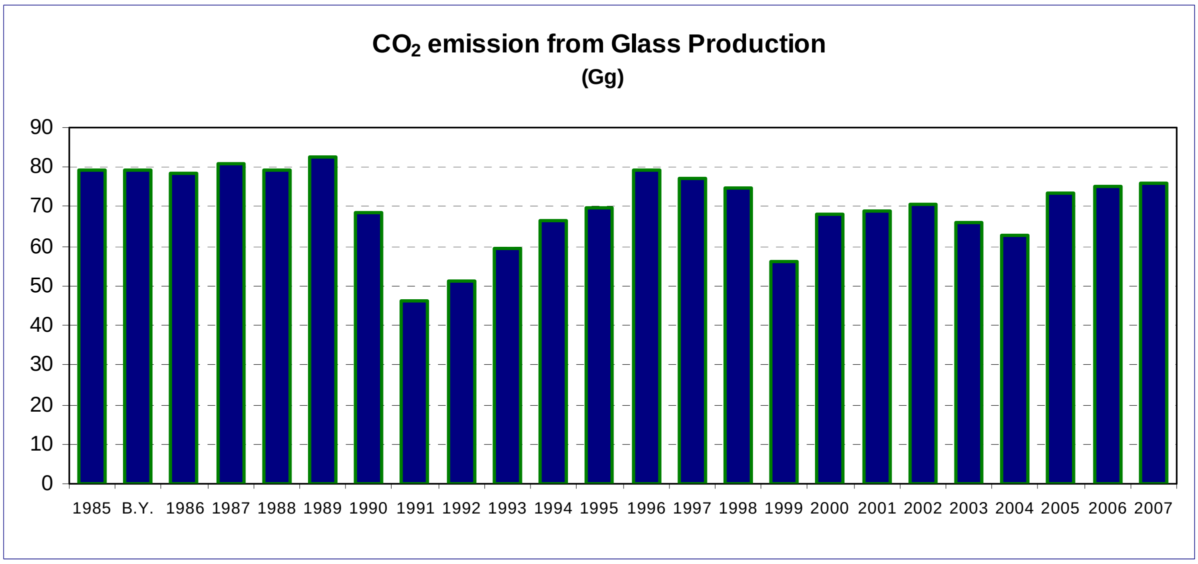


Figure 4.6. *CO_2 emission from Glass Production (1985-2007)*

Recalculation

Last year there was no recalculation.

Planned improvements

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

Table 4.5. *CO_2 emission comparison, Gg*

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

IEF CO_2 (2005)=

CO_2 emission from ETS was higher by 9.6% in 2006 and by 5.7% in 2007 which justifies the use of the more accurate ETS data.

4.3.5. Brick and ceramics

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

Methodology

The same method was used to determine emission as in case of glass production with the difference that not all the participants of the sector take part in emission-trade. Thus, the reported CO_2 emission does not cover the whole sector. Thus, we calculated a specific emission factor on the basis of the values given in the trade system and applied this to the total produced quantity known from statistical data. With the help of this factor, the emission of the earlier years was also calculated. The emission in 2007 determined this way was 357 Gg which is 0.5 % of the total CO_2 emission. The following table contains the data of production and emission:

Table 4.6. *Bricks and ceramics production and CO_2 emission in Industry sector (1985-2007)*

	BY	1989	1990	1991	1992	1993	1994	1995	1996	1997
Bricks and ceramics, kt	6,339.6	6,104.1	6,275.8	4,509.4	3,500.9	3,978.9	4,207.6	4,784.3	4,217.0	4,222.7
CO_2 , Gg	562.7	541.8	557.1	400.3	310.8	353.2	373.5	424.7	374.3	374.8
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Bricks and ceramics, kt	4,437.6	4,162.3	3,021.9	2,728.3	2,300.4	3,018.6	3,277.1	3,763.0	3,817.0	4,841.0
CO_2 , Gg	393.9	369.5	268.2	242.2	204.2	267.9	290.9	334.0	360.5	357.6

4.4. Chemical Industry (CRF sector 2.B)

The relevant processes operated in Hungary include:

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

Production of the chemical industry decreased in 2007 compared to 2006. This is demonstrated well by the time series of the production data in the tables shown later and in the next figure.

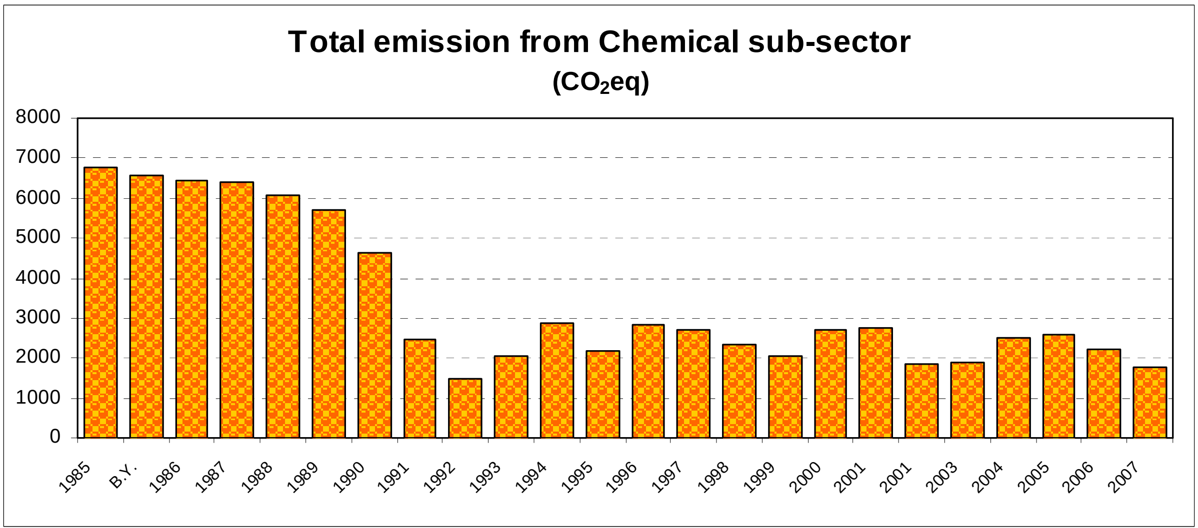


Figure 4.7. *Total emission from Chemical sub-sector (1985-2007)*

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

Technology

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

Traditional ammonia (NH_3) production uses natural gas, of which carbon content is released by the system in the form of carbon dioxide. Here, only emissions from the natural gas used as raw material is calculated and emissions from firing processes are taken into consideration under sub-sector 1.A.2.C. Among the factories operated in 1985, one was abandoned in 1987, another in 1991, and a third in 1992. As regards the existing factories, one uses obsolete technology and the other changed to a hydrogen/nitrogen-based technology in 2002. This technology does not generate technological CO_2. The share of the latter in the production is only about 5 %.

Methodology

Initially, production data published by KSH and default value recommended by the Revised Guidelines (1.5 to CO_2/t ammonia) were used for calculations. During ERT reviews (2002), it was repeatedly noted that calculation based on ammonia produced is not sufficiently accurate and natural gas-based calculations are more reliable, as also recommended in the first place by the Revised Guidelines. Therefore, we contacted the factories and the emissions were subsequently calculated using the natural gas consumption data obtained from them. According to the recommendation of ERT in 2007, we indicated the natural gas quantity instead of the previously used values containing the produced ammonia in the CRF Report. Since the input of the natural gas quantity in cubic metres was not possible. it was given in tons.

The table below shows the amount of the used natural gas and the resulting emission data:

Table 4.7. *Amount of natural gas used in the process, CO_2 emission and IEF tCO_2/tNH_3 in Chemical sub-sector (1985-2007)*

	BY	1989	1990	1991	1992	1993	1994	1995	1996	1997
Natural gas, kt	782.01	709.47	553.82	334.15	230.05	281.18	334.07	330.72	369.11	353.90
CO_2, Gg	1,995.97	1,812.73	1,415.53	838.06	562.28	687.24	816.50	808.32	902.16	864.98
IEF CO_2 (t/tNH_3)	2.1059	2.1203	2.2412	2.3645	2.4829	2.3597	2.2299	2.1487	2.1360	2.0996
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Natural gas, kt	313.51	279.67	361.59	326.22	232.75	231.52	297.96	336.40	316.36	345.52
CO_2, Gg	766.27	683.55	883.78	797.32	568.87	565.87	728.26	822.20	773.23	844.50
IEF CO_2 (t/tNH_3)	2.1872	2.1546	2.0660	2.0217	1.9657	2.0082	1.9719	2.0690	2.0872	2.0692

The *Table 4.6* above indicate that tCO_2/tNH_3 IEF value is around 1.97 to 2.48. It should be noted that the specific emission of the factory abandoned in 1992 was highly favourable (around 1.94). The effects of abandoning this factory are clearly reflected in the changes of the IEF: until 1992 this value shows a steady increase in line with the reduced production at the factories characterised by more favourable specific emissions.

Uncertainty and time-series consistency

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

QA/QC information

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

Recalculation

Last year there was no recalculation but we made smaller corrections due to some clerical errors.

Planned improvements

None.

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

Technology

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

Nitric acid (HNO_3) is produced by oxidising ammonia. The process end gas contains N_2O and NO. In order to control the emissions, the latter is reduced to nitrogen using natural gas and the carbon content of the natural gas is released in the form of carbon dioxide.
Among the old factories using obsolete technologies, one was abandoned in 1988, another in 1991, and a third in 1995. Until 2006 two production lines were operated in the country – the older one was established in 1975 and used GIAP technology which consists of four units with four different factors. These four units represented the major part (about 80%) of the production volume. Emissions from this process were measured from 2004. The other existing technology represented only 20% and had been operational since 1984 (combined acid factory producing diluted and concentrated nitric acid). Implementation of a new and more advanced production technology was started in 2005 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 reductions is reported in this inventory (see *Table 4.8*).

Methodology

Measured emission data were not available for a long time. Therefore, during the first phase of the recalculation project, the default specific emission factor recommended by IPCC (6 kg N_2O/t nitric acid) was used.
In 2004, an emission measurement system was installed at one of the factories and this has resulted in fundamental changes in the previously estimated values. Therefore, on the basis of almost one year of experience with measurements, the calculated emission factors of the factories using different technologies were between 10 to 19 kg/t. For calculation of emissions of the oldest factory (established in the 1950's), which was abandoned in 1988, the highest value recommended by the Good Practice was used (19 kg N_2O/t). 14.5 kg/t was used as specific emission factor for the three other abandoned factories including the one which was abandoned in September 2007. For the combined factory, a value of 10 kg/t was used.
End of 2004, selective catalytic reduction was introduced in tail-gas treatment which led to emission reductions in the following years. This modernization means furthermore that the EFs before and after 2004 cannot be the same. The emission data of 2005 and 2006 are based on measurements. In the second half of 2005 a new measuring instrument was installed which might partly explain the difference between IEFs. Thus, the weighted average ranges between 10.01 and 14.51 kg/t in the time series, depending on the production volume. In 2007 EF decreased to 6.15 kg/t. The new factory applies the EnviNOx technology, consequently a drastic reduction (about 95-99%) of emission has been reached.

The amount of carbon dioxide generated during the reduction reaction is so low (a few tens of tons: max. 93.29 in the whole period; and 63.84 in 2003) that it has no detectable effect on the inventory as a whole. Nevertheless, following the recommendation of ERT, we supplemented the database with these emissions. Since 2004 process tail gas has been treated with ammonia, so CO_2 emissions are no longer an issue.

Production data were obtained from the factories for each of the 23 years in the time series. These and the emission data are shown in the table below:

Table 4.8. *Nitric Acid production (kt) and N_2O emission in Chemical sub-sector (1985-2007)*

	BY	1989	1990	1991	1992	1993	1994	1995	1996	1997
Nitric Acid, kt	1,051.48	891.48	732.35	377.47	210.55	310.34	460.11	310.28	453.83	433.53
N_2O, Gg	15.26	12.57	10.37	5.24	2.87	4.34	6.56	4.35	6.21	5.98

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Nitric Acid, kt	354.44	309.50	415.99	454.27	294.80	306.21	415.01	484.41	460.83	474.91
N_2O, Gg	5.02	4.40	5.79	6.29	4.04	4.27	5.70	5.59	4.61	2.92

Uncertainty and time-series consistency

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

QA/QC information

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

Recalculation

Last year there was no recalculation.

Planned improvements

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

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

Emitted gas: CH_4
Key source: none.

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

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

Their contribution to the total emission is extremely low. Therefore, they are dealt with as one group. Earlier, the carbon black process was a confidential technology because only one such process was operated in Hungary. Therefore, we could not calculate the related emissions. In 2005 we contacted the manufacturer and obtained production data and the value of the emission factor characteristic of the technology. Accordingly, the factory established in 1993, is working with furnace black process with the thermal treatment of the generated gas. Thus, the emission of methane is quite minimal. The factory had the methane emission measured, and as a result the value of emission factor was 0.0037 kgCH_4/t product in contradiction to the default value of 0.06 recommended by GPG in 2006.
Using production data obtained form KSH and default values recommended by IPCC, methane emission was calculated for the other two processes. In 2006, this value was only 0.784 Gg (0.01 %). Comparing to the data of the previous years (0.4-0.6 Gg), the effect of production increase in 2007 can be observed here as well.

4.5. Metal Production (CRF sector 2.C)

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

Technology

Emitted gas: CO_2
Key source: none

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

Methodology

Partly for reasons related to the Hungarian traditions of energy statistics, the emissions of the sector from fuels are not included here but in sub-sector 1.A.2.A. The other reason justifying the use of this method is that no information is available as regards the distribution of fossil materials between use as a heat generator (i.e., energy production) and as a reducing agent (i.e., industrial process) during iron production. CO_2 released from limestone and/or dolomite is taken into account under sub-sector 2.A.3 (Limestone and dolomite use). Iron and steel production data were obtained from the reports of the International Iron and Steel Institute and the similar European agency (EUROFER). Initially, limestone consumption data were calculated on the basis of the default value in the Revised Guidelines. In recent years data received from the factories have been used.
In order to make emission calculations complete, carbon dioxide releases from raw iron and graphite electrode of the electric arc furnace (EAF) during steel production were also calculated here. For these calculations, the following default values were used: carbon content of iron: 4%; carbon content of steel: 0.5%; specific emission of electrode: 5 kg CO_2/t steel. The latter was obviously included only in case of electro steel production. Emissions were calculated using the following formula:

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

Uncertainty and time-series consistency

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

QA/QC information

There is no sector specific information.

Recalculation

There was no recalculation.

Planned improvements

None.

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

Technology

Emitted gas: CO_2
Key source: none.

Upon smelting alloying additive and iron. together with slag-forming additives. a reduction reaction occurs which results in release of CO_2.

Methodology

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

Uncertainty and time-series consistency

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

QA/QC information

No sector-specific information is available.

Recalculation

There was no recalculation.

Planned improvements

None.

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

Technology

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

During alumina electrolysis, CO_2 is released from carbon anode. At the same time, fluorinated hydrocarbons are produced from cryolite as a result of anode effect when aluminium oxide concentration is low in the electrolyte of the reduction cell. From the beginning of 2006 this technology is no longer in use.

Methodology

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

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

	BY	1989	1990	1991	1992	1993	1994	1995	1996	1997
Aluminium, t	73.75	74.64	75.19	75.16	62.88	26.82	27.88	29.65	31.91	33.47
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Aluminium, t	33.71	33.64	33.85	34.59	35.29	35.04	34.35	31.78	NO	NO

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

Table 4.10. *CF_4 emission in Aluminium Production 2.C.3 sub-sector (1985-2007)*

	BY	1989	1990	1991	1992	1993	1994	1995	1996	1997
CF_4, Gg	36.18	38.42	36.50	31.50	18.17	19.64	21.42	22.48	21.48	21.41
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CF_4, Gg	23.05	23.60	28.40	26.75	27.19	25.38	26.96	28.01	NO	NO

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

Uncertainties and time-series consistency

The total quantity of produced crude metal is in the order of 10.000 tons and the accuracy of the obtained values is 0.1 t. The resulting uncertainty is below 1%. Whereas the effect numbers are recorded in the factory records, the effect time can be easily measured but is an average value. These are associated with a highly favourable level of uncertainty. According to the Good Practice, the uncertainty of the Slope value is about max. 1%. In summary, the uncertainty of emission values is around 1% to 2 %. Data consistency was ensured by using the same calculation method for the whole time series.

QA/QC information

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

Recalculation

Last year there was no recalculation.

Planned improvements

None.

4.6. Other Production (CRF sector 2.D)

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

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

Halocarbons and SF_6 are not produced in Hungary.

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

4.8.1. Technology

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

HFCs (partially fluorinated hydrocarbons) are used in household and commercial cooling equipments, medical sprays (propellant gas), during production of foams used in construction/insulation industry, and as fire extinguishing agents. On the other hand, PFCs (fully fluorinated hydrocarbons) are used as solvents or as an ingredient of cooling mixes, but they are rare. No HFCs or PFCs are produced in Hungary and such substances are imported. HFCs may be released to the atmosphere during the following work phases: filling, refilling, repairing, technical failure, direct use (spray, fire extinguishing).

PFCs were started to be used as an ingredient of cooling mixes in 1997. In 1998 and 1999, significant quantities were also used for adhesive tape production.

SF_6 is also imported and is mainly used as an insulation gas in electrical switchboards. It is further used as intermediate gas in double-glass heat insulation windows and production of optical bodies, etc. In Hungary SF_6 is not used as a cover gas in coloured metal foundries.

4.8.2. Methodology

In cooling industry, the imported HFCs are either filled into new equipment or are used to refill the cooling medium of installed equipments. It is assumed that the quantities previously released into the atmosphere are replenished and these amounts are taken as the emissions. Naturally, the refilling/handling loss should be added to this. In case of sprays, the entire quantities of propellant used in Hungary are taken as emissions.

In the beginning. the emissions were calculated on the basis of a preliminary study prepared by László Gáspár, Institute of Environmental Management in 1998, later the calculations were improved.

Activity data

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

On the basis of the latest available information. HFCs emitted during foam material production were also included. According to data obtained from the factory, the mixture (HFC 227ea/365mfc) is used for the production of both soft and hard foam. HFC-134a is also used in foam material production, and so was HFC-152a in 2006.
In calculating the emission of HFCs used in foam blowing for the year 2005, we changed to the method and the specific factors recommended by GPG. The data of 2004 were recalculated with the help of this method. The HFC-365mfc values were taken out of the database.
In order to calculate domestic consumption, the quantity filled into equipment intended for export was subtracted from the total quantity of HFCs imported.

Emission factors
As regards household refrigerators. emission data were received directly from the manufacturer. In case of commercial and industrial equipment, the data required for determination of quantities used for filling new refrigerators and for refilling existing ones were received from trading companies. The latter value was taken as emission. For certain operators, the above ratio was determined by estimation in the light of the activities. In such cases, the emissions were calculated without the use of emission factors.
As regards production of foam materials. the recommendations of GPG were taken into consideration in calculating emission. The CRF program and the IPCC GWP Table of 2005 do not include GWP for HFC 365mfc, therefore it is not included in the database.
In case of SF_6, consumption and (sometimes) emission data were obtained directly from the users. However, only one company could provide data for the initial years and those for the others years were determined by estimation, taking due account of the general trends of industrial production. When a company could not provide data for a given year, this was determined again by estimation.

4.8.3. Uncertainties and time-series consistency

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

4.8.4. QA/QC information

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

4.8.5. Recalculation

Last year there was no recalculation.

4.8.6. Planned improvements

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

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

5.1. Overview of the sector

Emitted gases: N_2O, CO_2, NMVOC
Key sources: none

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

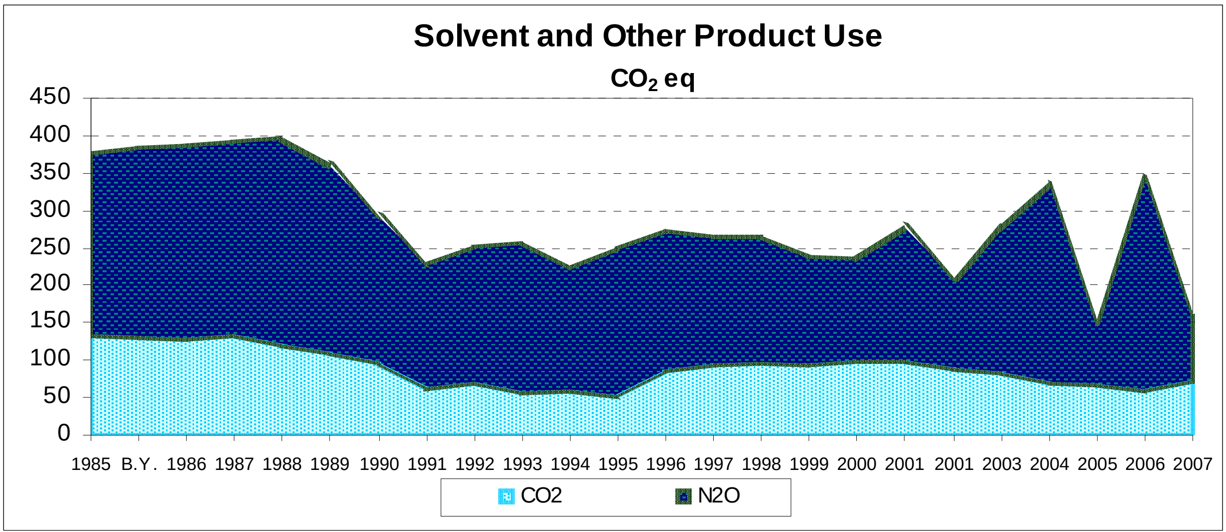


Figure 5.1. *CO_2 and N_2O emissions in Solvent and Other Product Use sector (1985-2007)*

In 2007 this category had a contribution of 0.2% (excluding LULUCF) to total greenhouse gas emissions (158.091 Gg CO_2 equivalents). There has been a decrease of 58.85 % in greenhouse gas emissions for this sector from base year to 2007 and decrease of 54.02% between 2006 and 2007. This significant decrease is due to decreased N_2O uses in anaesthesia.

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

5.2.1. Technology

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

5.2.2. Methodology

Data on paint and solvent uses were obtained from the data supplies of the Hungarian Central Statistical Office (KSH) or from Statistical Yearbooks. In 1996, KSH altered the type of data collection, and this is the cause of increase in that year in the diagram above. Compositions and solvent contents were discussed with the Paint Industry. Paints, lacquers, kits etc. were classified into several groups according to the average solvent content. The Revised Guidelines provide little help for calculation of specific values. NMVOC emissions were taken to be equal to the amount with solvent. You can find detailed description in

ANNEX 3.
Specific emission factors show in the next table (t emission/t paint):

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

	BY	1989	1990	1991	1992	1993	1994	1995	1996	1997
IEF NMVOC, t/t	0.196	0.305	0.267	0.278	0.290	0.255	0.241	0.224	0.371	0.394
IEF CO_2 t/t	0.575	0.896	0.779	0.810	0.845	0.737	0.693	0.641	1.084	1.154
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
IEF NMVOC, t/t	0.375	0.312	0.274	0.268	0.245	0.220	0.181	0.219	0.226	0.236
IEF CO_2 t/t	1.095	0.898	0.781	0.762	0.689	0.613	0.492	0.616	0.637	0.668

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

5.2.3. Uncertainties and time series consistency

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

5.2.4. QA/QC information

No sector specific information is available.

5.2.5. Recalculation

Emissions from this sector were not calculated in the years between 1985 and 1997. This was made up for during the two phases of recalculation, but the available data on the uses from the previous period are less detailed. We have since improved the calculation of emissions related to degreasing and dry cleaning technologies and applied QA/QC check.

5.2.6. Planned improvements

None.

5.3. Use of N_2O (CRF sector 3.D)

5.3.1. Technology

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

5.3.2. Methodology

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

Table 5.2. *N_2O emission (1985-2007, t)*

N_2O (t)	BY	1989	1990	1991	1992	1993	1994	1995	1996	1997
Anaesthesia	497.33	512.00	422.00	377.00	426.00	476.00	389.00	499.00	470.00	430.00
Cartridge	321.29	304.19	206.65	162.74	164.63	167.16	137.00	145.02	136.97	131.05
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Anaesthesia	441.00	371.00	375.00	520.00	331.00	578.00	827.50	228.32	894.04	255.62
Cartridge	112.84	95.92	70.55	60.69	55.78	44.98	37.81	38.60	29.59	23.48

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

5.3.3. Uncertainties and time series consistency

Production data are highly reliable because they are obtained directly from manufacturers. Provided that the information on the unaltered form is correct,the emitted amounts are also highly reliable. The time series data are also considered highly reliable and consistent.

5.3.4. QA/QC information

No sector specific information is available.

5.3.5. Recalculation

Last year there was no recalculation.

5.3.6. Planned improvements

None.

6. AGRICULTURE (CRF sector 4.)

6.1. Overview of the sector

Between 1985 and 2007 agriculture production contributed to the greenhouse gas emission at national level through the following processes:

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

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

The main characteristics of the Hungarian agricultural sector were the following:
From the 1990s continuous and significant economic and social changes have been occurring in the agricultural sector. As the result of the political and economic processes after the change of regime, between 1990 and 2000, the number of agricultural farms was reduced by more than 30%, the number of employees by more than 50%, the volume index of the gross agricultural production by more than 30% and the livestock by about 50%.

The structure of the Hungarian agricultural sector is summarised on the basis of the assessment conducted by the HCSO published in 2008 (Agriculture in Hungary, 2007 – Farm Structure Survey).
Two forms of farming exist in the Hungarian agricultural sector: private farms and agricultural enterprises. The preliminary outcome of the survey showed that about 7400 agricultural enterprises pursued agricultural activities in 2007. The number of private farms pursuing agricultural activities amounted about 619,000 in 2007 – agricultural activities around the house and in the gardens belonging to holiday houses should also be mentioned above these ones. The number of agricultural enterprises and of private farms has decreased by 6% and 12.5%, respectively since 2005.
In 2007 76.5% of the agricultural enterprises used land for agricultural purposes, their average agricultural area was 386 hectares. The private farms using land for agricultural purposes (91.5%) cultivated an area of 3.6 hectares on average. The average area of agricultural enterprises has decreased by 3%, the average area of private farms has increased by 13% since 2005. In the case of agricultural enterprises the farm size above 300 hectares was prevailing. Farms of the size between 10 and 300 hectares (6% of the farms) possessed 73% of the agricultural area of private farms. In 2007 29% of agricultural enterprises and 55% of private farms pursued animal keeping.
For detailed agricultural area (land-use) data see Chapter 7.

6.1.1. Emission trends

In 2007, 12.5% of the GHG emissions expressed in CO_2 equivalents of the Hungarian economy can be linked to the agricultural sector.
The trend between 1985 and 2007 is summarised in Figure 6.1 (all emissions in CO_2 equivalents). As a result of the production decrease between 1990 and 1995, greenhouse gas emission from agriculture activities reduced significantly. In the period between 1996 and 2006, the level of production was essentially stagnating or slightly decreasing, particularly in animal production. In a few years (e.g. 2004, 2005), in some sectors of plant production (e.g. wheat and maize) the production increased due to the significantly high yield owing to the

friendly weather conditions. The greenhouse gas emission of agricultural activities was changing essentially in accordance with the activity data: it slightly increased between 1995 and 2000 and stagnated between 2000 and 2006.

In 2007 the greenhouse gas emission from the agricultural sector was 44.8% of the average of 1985-1987. Figure 6.2 shows the trend between 1985 and 2007.

The constant decrease in methane emissions (Figure 6.3) in the period is the result of the constant reduction of the number of animals. Nitrous oxide emissions show similar trends (Figure 6.4) until 1995, and there were a slight increase between 1996 and 2007. The main reason is the increase in fertilizer use. (Nevertheless, fertiliser use of the Hungarian agriculture sector is still only slightly higher than half of the amount between 1980 and 1985.)

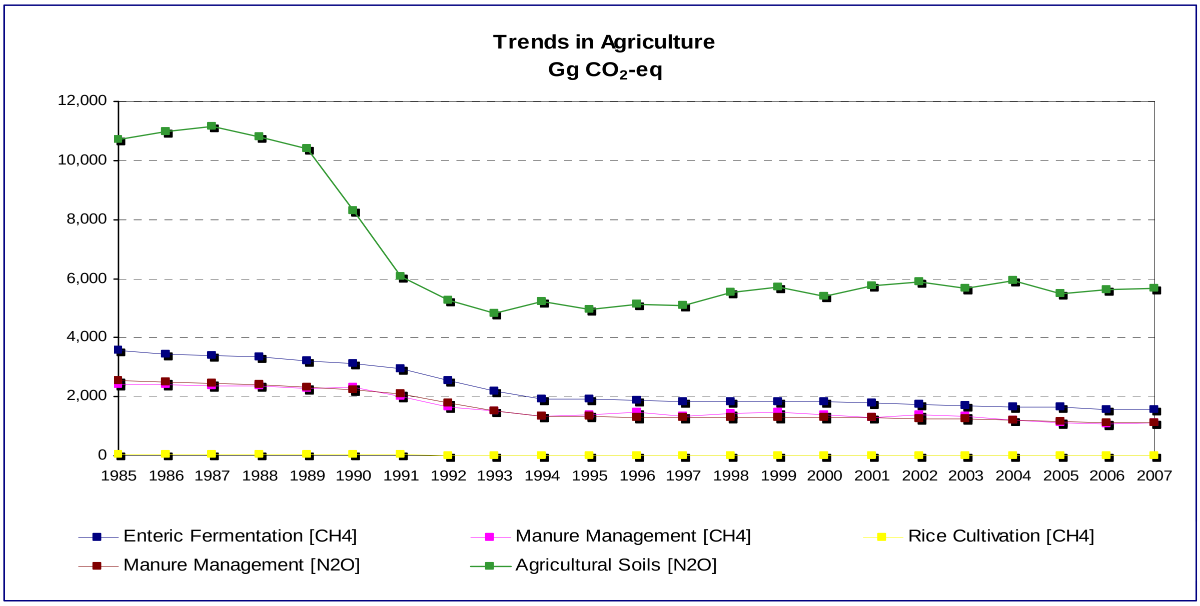


Figure 6.1. *GHG emissions from Agriculture in CO_2-eq*

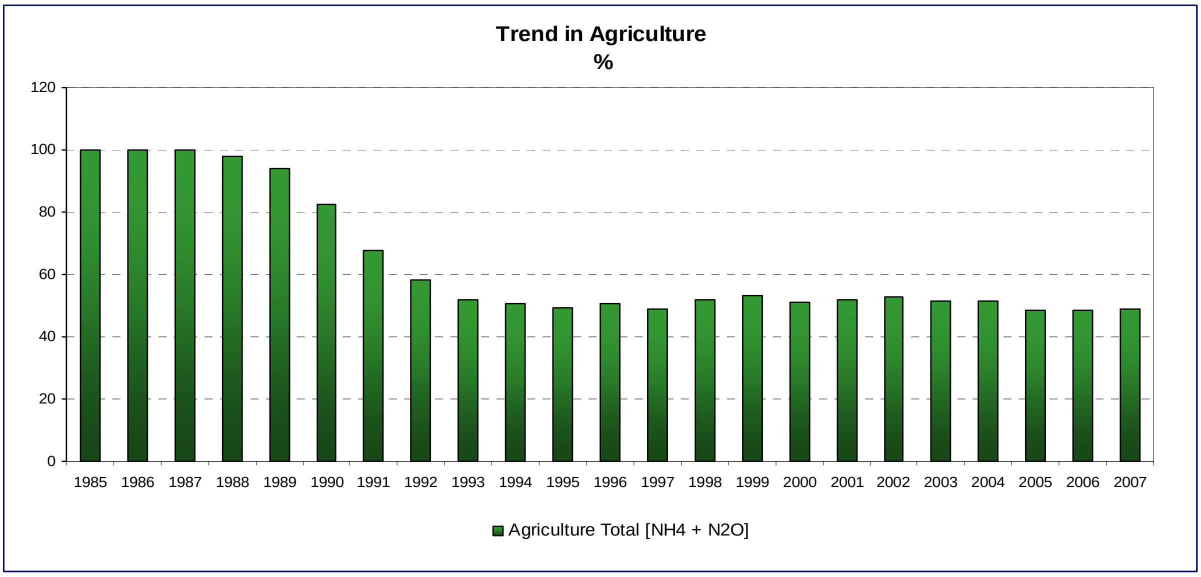


***Figure 6.2**. GHG emissions from Agriculture in % of base years*

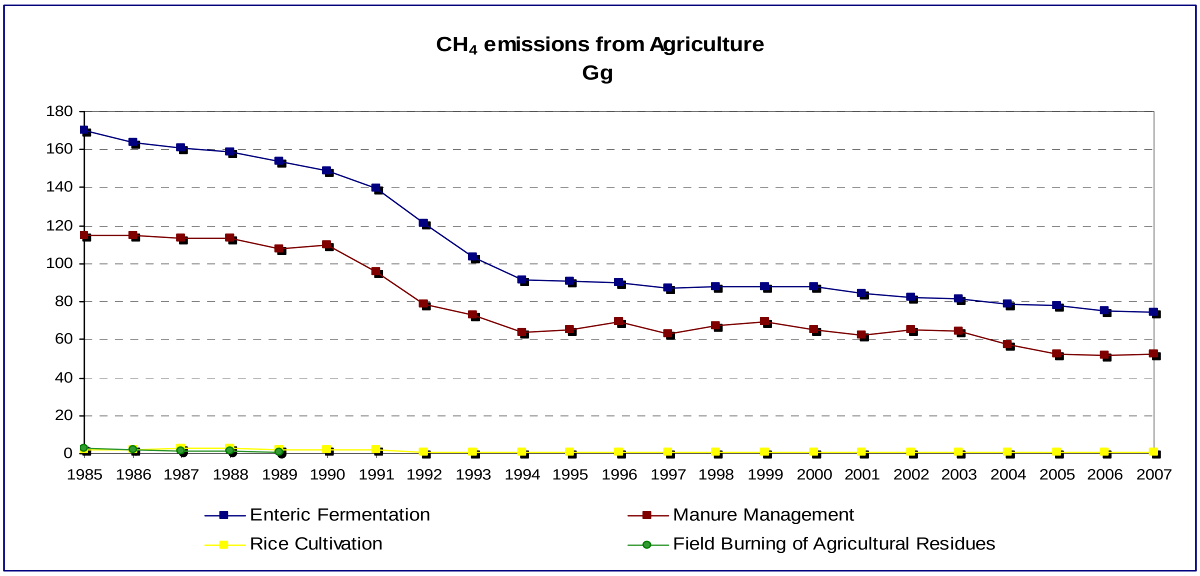


Figure 6.3. *CH_4 emissions from Agriculture*

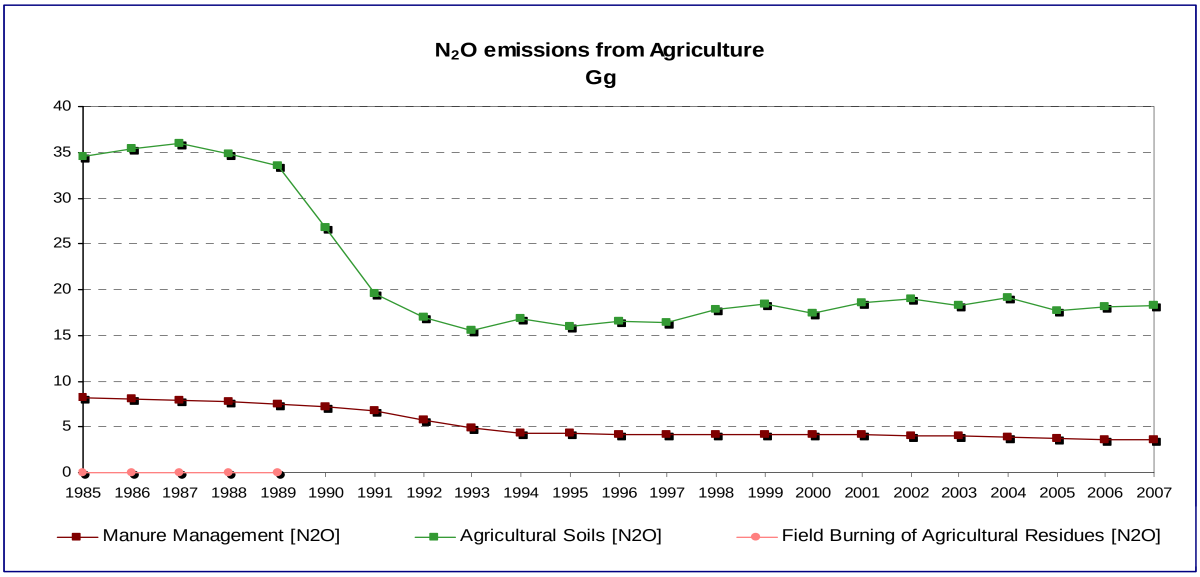


Figure 6.4. *N_2O emissions from Agriculture*

6.1.2. Key Categories

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

6.1.3. Methodology

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

6.1.4. Quality Assurance and Quality Control

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

In the course of the compilation of the inventory the calculation documentation (data, calculation files, CRF) done by the external expert is checked by a member of the GHG division on the basis of the general QC measures summarized in Table 8.1 GPG2000 as well as of the QA/QC measures listed at the individual source categories.

The documentation is archived by the Hungarian Meteorological Service Greenhouse Gas Division and the Institute for Animal Breeding and Nutrition independently from each other. External co-expert opinion was prepared on the entire inventory, so also on the Agriculture chapter in 2007 (Systemexpert 2007).

6.1.5. Uncertainty Assessment

At the moment there are few country-specific data in the field of uncertainty assessment, so GPG2000 Tier 1 method was applied for uncertainty calculations.

The uncertainty of the activity data was calculated on the basis of the available data of the HCSO and of expert judgement; the uncertainty of the emission factors was calculated on the basis of the GPG 2000 recommendations. Uncertainties were combined in accordance with GPG 2000 Equation 6.3 and Equation 6.4, and Table 6.1 contains the results.

Out of the key categories the uncertainty of the Direct Soil Emissions and the Indirect Soil Emissions categories have the highest value. These high values derive from the uncertainty of the activity data (to a smaller extent) and of the emission factors (to a greater extent).

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

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

6.1.6. Recalculations

In the framework of the conversion into IPCC Tier 2 method the entire time series were recalculated by Tier 2 method in the categories Enteric Fermentation Dairy Cattle and Enteric Fermentation Non-Dairy Cattle.

In the Manure Management category CH_4 and N_2O emissions, while in the Agricultural Soils

category N_2O emissions were recalculated for the entire time series. The recalculation basis in the case of CH_4 emissions is the conversion to Tier 2 method, while in the case of N_2O emissions is to correct the faulty data (poultry population, 1985-1999), and to revise the data of HCSO (Fertilizer use 2006) as well as to include guinea fowl and rabbit population into the inventory (1985-2007).
In the frame of NIR/CRF 2007 no recalculation occurred in "Rice Cultivation" and in "Field burning of agricultural residues" category.
Recalculations resulted in values higher by 12.0% on average in the case of the entire emissions (in CO_2-equivalents) of the agricultural sector (Range: 10.8% - 14.8%). The increase by individual gases is 44.8% on average for CH_4 emissions (Range: 39.8% - 50.6%), and 1.4% on average for N_2O emissions (Range: 0.7% - 3.0%).

6.1.7. Planned improvements

A multistage, methodological development program, jointly with the Research Institute for Animal Breeding and Nutrition, titled "Development and regular review of country-specific emission factors for the agricultural greenhouse gas (methane, nitrous oxide) inventory" is in progress. In accordance with the recommendation of the Centralized Review currently the following problems are to be solved:

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

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

6.2.1. Source Category Description

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

Enteric fermentation in animals is considered as significant source of CH_4 all over the world. The most important process of generation is anaerobic cellulose degradation in the rumen of ruminants. Some CH_4 is generated in the colon of horses and rabbits, and in the caecum of poultry. In Hungary the leading CH_4 emitters are cattle and sheep, with the most important category being dairy cattle. In addition to the number of animals, the level of production and feeding practices are the factors primarily influencing the amount of CH_4 from enteric fermentation. In 2007 58.5% of the entire CH_4 emissions from agriculture derived from this source category.

6.2.2. Methodology

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

6.2.3. Livestock Population

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

$$NoA_{2007} = (0.5*NoA_{Dec2006}+NoA_{Apr2007}++NoA_{Aug2007}+0.5*NoA_{Dec2007})/3$$

(Equation 6.1.)

Where:

NoA_{2007} = average annual population in the given livestock category in 2007. [1’000 head]
$NoA_{Dec2006}$ = population in the given livestock category on 1 December 2006. [1’000 head]
$NoA_{Apr2007}$ = population in the given livestock category on 1 April 2007. [1’000 head]
$NoA_{Aug2007}$ = population in the given livestock category on 1 August 2007. [1’000 head]
$NoA_{Dec2007}$ = population in the given livestock category on 1 December 2007. [1’000 head]

Table 6.2. *Domestic livestock population and its trend 1985-2007 (I)*

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

Source: HCSO (2007)

Table 6.3. *Domestic livestock population and its trend 1985-2007 (II)*

Year	Population size (1'000 heads)				
	Animal category				
	Horses	Asses and Mules	Swine	Total poultry	Other animals (Rabbits)
1985	103	5.0	8,931	82,030	2,238
1986	100	5.1	8,955	83,502	2,319
1987	93	5.0	8,876	82,914	2,400
1988	80	4.8	8,902	79,079	2,481
1989	79	4.6	8,457	74,591	2,562
1990	80	4.5	8,751	69,846	2,644
1991	84	4.3	7,558	57,540	2,978
1992	79	4.3	6,159	52,746	2,755
1993	75	4.3	5,760	44,013	2,096
1994	85	4.3	4,926	46,264	1,271
1995	75	4.3	5,089	45,092	1,378
1996	74	4.3	5,536	38,873	1,041
1997	76	4.3	4,953	45,874	933
1998	77	4.3	5,338	46,620	1,005
1999	78	4.3	5,585	40,722	912
2000	78	4.1	5,063	49,385	919
2001	65	4.1	4,821	52,050	1,138
2002	64	4.1	5,093	50,940	1,157
2003	62	4.1	5,049	53,541	1,148
2004	65	4.1	4,385	50,496	999
2005	67	4.1	4,022	46,415	1,003
2006	65	4.1	3,944	44,668	1,084
2007	59	4.1	4,037	43,211	1,055

Source: HCSO (2007)

6.2.4. Emission Factors

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

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

(Equation 6.2)

Where:

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

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

In the case of Non-Dairy Cattle category the default values of Rev. 1996 IPCC Guidelines Ref. Manual (Table B-1, Page 4.40) were used for the Tier 2 calculations.

Table 6.4 and 6.5 summarises the emission factors used for the calculations. In the case of Buffalo, Sheep, Goats, Horses, Asses & Mules, Swine, Poultry and Rabbits categories GPG Tier1 and IPCC default emission factors were used.

Table 6.4. *Annual milk yield, gross energy intake, methane conversion rate and emission factors for Dairy Cattle 1985-2007*

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

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

Animal category	CH_4-emission factor [kg head^{-1} yr-^{1}]	Comments
Dairy Cattle	see Table 6.4	*country specific value, Tier 2*
Non-dairy Cattle	53	*country specific value, Tier 2, Basis Rev. 1996 Guidelines, Ref. Man., Table B-1, p. 4.40*
Buffalo	55	*IPCC default value for developed countries*
Sheep	8	*IPCC default value for developed countries*
Goats	5	*IPCC default value for developed countries*
Horses	18	*IPCC default value for developed countries*
Asses & Mules	10	*IPCC default value for developed countries*
Swine	1.5	*IPCC default value for developed countries*
Poultry	0.015	*expert judgement, according to Minonzio et al. (1998)*
Rabbits	0.08	*expert judgement, according to NIR Italy*

6.2.5. QA/QC Information

See 6.1.4.

6.2.6. Uncertainty Assessment

See 6.1.5. and Table 6.1.

6.2.7. Recalculation

See 6.1.6.

6.2.8. Planned improvements

See 6.1.7.

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

6.3.1. Source Category Description

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

Animal manure is an important source of CH_4 and N_2O. The amount of CH_4 and N_2O emitted from the manure to the atmosphere depends on the conditions of manure management and use as well as on the composition of released excrements. In 2007 41.1% (CH_4) and 16.4% (N_2O) of the entire emissions from agriculture derived from this source category.

6.3.2. Methodology

See chapter 6.2.2 and Table 6.2 and 6.3 regarding activity data.
CH_4 emissions generated from manure management (excluding Rabbits category) were estimated by using of GPG2000 Tier 2 method, emission factors were calculated in accordance with the GPG2000 (Equation 4.17):

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

(Equation 6.3)

Where
EF_i emission factor for livestock population i [kg $head^{-1}$ yr^{-1}]
VS_i volatile solids excretion for livestock population i [kg $head^{-1}$ day^{-1}]
365 Factor-1 [day yr^{-1}]
B_{oi} maximum CH_4 producing capacity for manure produced by animals in livestock population i [m^3 kg^{-1} VS]
0.64 Factor-1 [kg m^{-3}]
MCF_{jk} CH_4 conversion factors for each manure management system j by climate region k [kg kg^{-1}]
MS_{ijk} fraction of animal species/category i's manure handled using manure system j in climate region k

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

Table 6.6. Volatile solids excretion rates and CH_4-emission factors for Manure Management for Dairy Cattle 1985-2007

Year	VS (Volatile Solid Excretion Rate)	CH_4-Emission Factor
	[kg DM day^{-1}]	[kg head^{-1} yr^{-1}]
1985	0.05950	6.71
1986	0.05943	6.75
1987	0.05935	6.78
1988	0.05928	6.82
1989	0.05920	6.85
1990	0.05913	6.89
1991	0.05905	6.92
1992	0.05898	6.96
1993	0.05890	7.00
1994	0.05883	7.03
1995	0.05875	7.07
1996	0.05868	7.10
1997	0.05860	7.14
1998	0.05853	7.17
1999	0.05845	7.21
2000	0.05838	7.24
2001	0.05830	7.28
2002	0.05823	7.31
2003	0.05815	7.35
2004	0.05808	7.38
2005	0.05800	7.42
2006	0.05793	7.45
2007	0.05785	7.49

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Regards to the N excretion of livestock, the amount of excreted N in various manure management systems and the emission factors, the following further pieces of information are considered important:
As regards manure management, Hungarian conditions were analysed on the basis of expert consultations (Mészáros, 2000) and a paper by Ráki (2003). This paper includes the processing of three databases:

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

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

6.3.3. QA/QC Information

See 6.1.4.

6.3.4. Uncertainty Assessment

See 6.1.5. and Table 6.1.

6.3.5. Recalculation

See 6.1.6.

6.3.6. Planned improvements

See 6.1.7.

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

6.4.1. Source Category Description

Emitted gas: CH_4
Key source: none

Since the production volume is very low in Hungary, the contribution of rice cultivation to the greenhouse gas emissions is minimal, only 0.4% of the entire CH_4 emissions from agriculture sector.

6.4.2. Methodology

Methane emissions from rice cultivation were calculated by using the default factors recommended by the GPG 2000 Guidelines (Ef_c= 20 g m^{-2}; SF_w=0.5; SF_0= 1). The total size of the production area was calculated on the basis of the official HCSO data.

6.4.3. QA/QC Information

See 6.1.4.

6.4.4. Uncertainty Assessment

See 6.1.5. and Table 6.1.

6.4.5. Recalculation

See 6.1.6.

6.4.6. Planned improvements

See 6.1.7.

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

6.5.1. Source Category Description

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

In 2007 agricultural soils emitted 83.6% of the N_2O emissions of agriculture.
N_2O emitted by soils is generated as an intermediary product of denitrification and a by-product of nitrification. The nitrogen released to the soil via anthropogenic sources may participate in the nitrification/denitrification processes in the recipient soil (direct N_2O emission), or after having been transferred to other soils and water reserves (indirect N_2O emission) via various indirect pathways (leaching, runoff, ammonia and NO_x volatilisation and deposition). The most important factor affecting the N_2O emissions from agricultural soils is the amount of nitrogen released into the soils via animal manure, synthetic fertilizers, crop residues through deposition and N-fixing. Small changes in the environmental conditions may have a significant effect on the amount of generated N_2O.
[Note: for a detailed review on N_2O generation processes in soils, see also Granli et al. (1994), Bremner (1997) és Schmid et al., (2000).]

6.5.2. Methodology

The estimation of direct and indirect N_2O emissions was carried out on the basis of the GPG 2000, using the Tier 1b method. A certain part of the activity data for the sector were obtained directly from the database of the HCSO (livestock for calculating N excretion, total harvested production of plants, synthetic N-fertilizer use).

N_2O emissions from the categories of Direct Soil Emissions (from synthetic N-fertilizers, manure, N-fixing, crop residues and histosols), Emissions from Pasture, Range and Paddock Manure and Indirect Soil Emissions were calculated with the parameters summarized in Table 6.12. In order to calculate the amount of N in the frame of manure use and on pastures the data of Table 6.7, 6.8 and 6.10. (see also chapter 6.3.2) were also used beside Table 6.12. Trends of synthetic N-fertilizer use, N-excretion and total harvested production of plants are shown in Figure 6.5, 6.6 and 6.7.

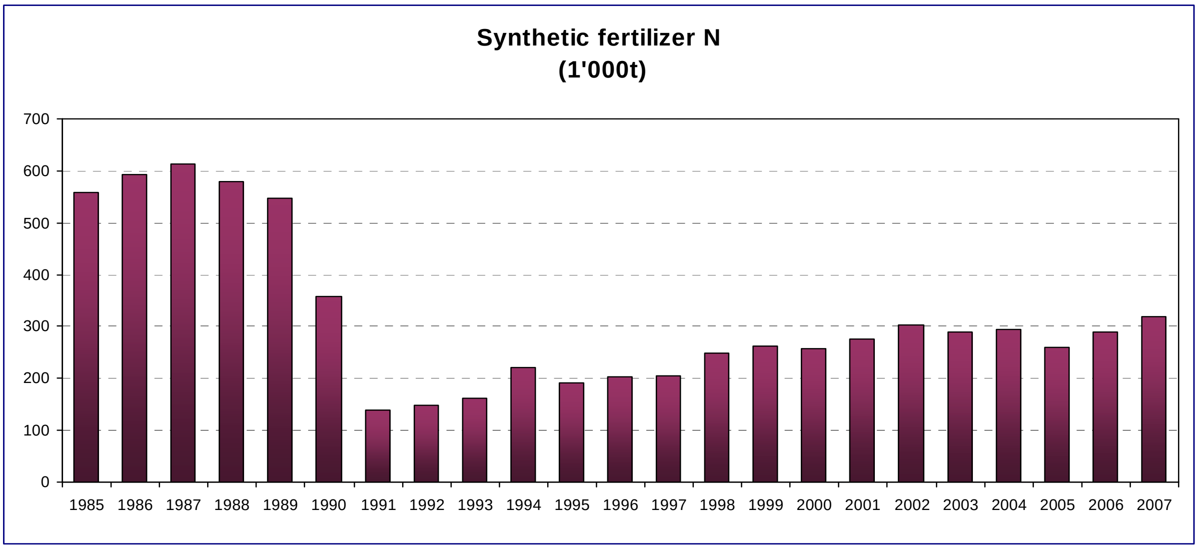


Figure 6.5. *Synthetic fertilizer nitrogen applied to soils*

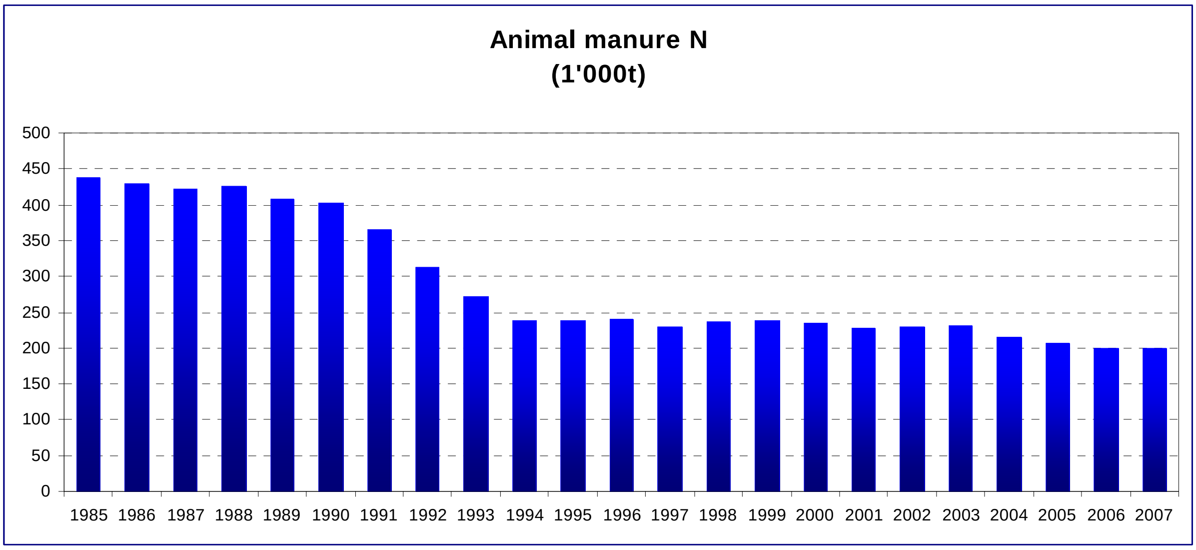


Figure 6.6. *Animal manure nitrogen excreted by livestock*

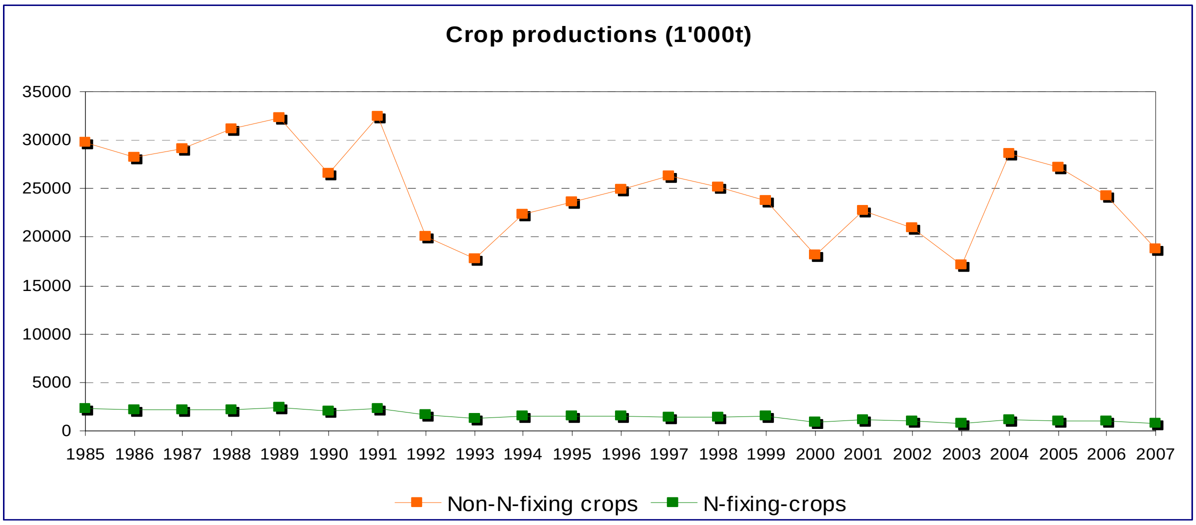


***Figure 6.7**. Production of N-fixing and non-N fixing crops in 2007*

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

Parameter	Dimension	Value
Direct Soil Emissions – Fertilizer		
$Frac_{GASFS}$	kg kg^{-1}	0.1
F_{SN}	kg yr^{-1}	GPG Eq-4.22
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Animal manure		
$Frac_{GASM}$	kg kg^{-1}	0.2
$Frac_{FUEL-AM}$	kg kg^{-1}	0
$Frac_{PRP}$ (2007)		0.096073
Average (1985-2007)	kg kg^{-1}	0.089131
Min (1996) - Max (2005)		(0.077602-0.099962)
$Frac_{FEED-AM}$	kg kg^{-1}	0
$Frac_{CNST-AM}$	kg kg^{-1}	0
F_{AM}	kg yr^{-1}	GPG Eq-4.24
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – N-Fixing		
$Res_{BF}/Crop_{BF}$		
Non-Forage Crops	kg kg^{-1}	1.50-2.10
Forage Crops		0
$Frac_{DM}$, N-fixing-crops	kg kg^{-1}	0.850-0.870
$Frac_{NCRBF}$	kg kg^{-1}	0.0142-0.0230
F_{BN}		
Non-forage Crops	kg yr^{-1}	GPG Eq-4.26
Forage Crops		GPG Eq-4.27
EF_1	kg kg^{-1}	0.0125

Parameter	Dimension	Value
Direct Soil Emissions – Fertilizer		
$Frac_{GASFS}$	kg kg^{-1}	0.1
F_{SN}	kg yr^{-1}	GPG Eq-4.22
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Animal manure		
$Frac_{GASM}$	kg kg^{-1}	0.2
$Frac_{FUEL-AM}$	kg kg^{-1}	0
$Frac_{PRP}$ (2007)		0.096073
Average (1985-2007)	kg kg^{-1}	0.089131
Min (1996) - Max (2005)		(0.077602-0.099962)
$Frac_{FEED-AM}$	kg kg^{-1}	0
$Frac_{CNST-AM}$	kg kg^{-1}	0
F_{AM}	kg yr^{-1}	GPG Eq-4.24
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – N-Fixing		
$Res_{BF}/Crop_{BF}$		
Non-Forage Crops	kg kg^{-1}	1.50-2.10
Forage Crops		0
$Frac_{DM}$, N-fixing-crops	kg kg^{-1}	0.850-0.870
$Frac_{NRCBF}$	kg kg^{-1}	0.0142-0.0230
F_{BN}		
Non-forage Crops	kg yr^{-1}	GPG Eq-4.26
Forage Crops		GPG Eq-4.27
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Crop Residues		
$Res_O/Crop_O$		
Non-Forage Crops	kg kg^{-1}	0.3000-1.600
Forage Crops		0
$Frac_{DM}$, Non- N-fixing-crops	kg kg^{-1}	0.78-0.92
$Frac_{NCRO}$	kg kg^{-1}	0.0028-0.0228
$Res_{BF}/Crop_{BF}$		
Non-Forage Crops	kg kg^{-1}	1.50-2.10
Forage Crops		0
$Frac_{DM}$, N-fixing-crops	kg kg^{-1}	0.850-0.870
$Frac_{NCRBF}$	kg kg^{-1}	0.0142-0.0230
$Frac_{BURN}$	kg kg^{-1}	0
$Frac_{BURN}$ for Cereals 1985-1989		0.1103-0.0220
$Frac_{FUEL-CR}$	kg kg^{-1}	0

$Frac_{CNST-CR}$	kg kg^{-1}	0
$Frac_{FOD}$	kg kg^{-1}	0
F_{CR}	kg yr^{-1}	GPG Eq-4.26
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Pasture, Range and Paddock Manure		
$Frac_{PRP}$ (2007)		0.096073
Average (1985-2007)	kg kg^{-1}	0.089131
Min (1996) - Max (2005)		(0.077602-0.099962)
EF_3	kg kg^{-1}	0.02
Indirect Soil Emissions – Atmospheric deposition		
$Frac_{GASFS}$	kg kg^{-1}	0.1
$Frac_{GASM}$	kg kg^{-1}	0.2
EF_4	kg kg^{-1}	0.01
Direct Soil Emissions – Leaching and Run-Off		
$Frac_{LEACH}$	kg kg^{-1}	0.3
EF_5	kg kg^{-1}	0.025

6.5.3. QA/QC Information
See 6.1.4.

6.5.4. Uncertainty Assessment
See 6.1.5. and Table 6.1.

6.5.5. Recalculation
See 6.1.6.

6.5.6. Planned improvements
See 6.1.7.

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

6.6.1. Source Category Description
Emitted gases: CH_4, N_2O
Key source: none

In Hungary field burning of agricultural residues has been bound to permit by the Regulation No. 21/1986. (VI. 2.) of the Council of Ministers being in force between 1986 and 2001. The condition for a permit was the case of plant health emergency. The Decree of Government No. 21/2001. (II. 14.) came into force in 2001 explicitly bans field burning of agricultural residues (the new regulation still keeps the possibility of field burning in the case of plant health emergency by a permit). So according to the abovementioned facts it was thought that there is no legal field burning in Hungary since the Regulation No. 21/1986. (VI. 2.) of the Council of Ministers has come to force. According to the estimation of the regional inspectors of the Central (Budapest) Soil and Plant Protection Service, less than 1% of the area sown by crops (i.e., not the entire arable area) is affected by illegal burning (Sári 2003, verbal communication), therefore it was taken into account only between 1985 and 1989, and it was considered as negligible in the period after 1990.

6.6.2. Methodology

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

6.6.3. QA/QC Information

See 6.1.4.

6.6.4. Uncertainty Assessment

See 6.1.5. and Table 6.1.

6.6.5. Recalculation

See 6.1.6.

6.6.6. Planned improvements

See 6.1.7.

6.7. References

Babinszky, L. et al. (2002). Magyarország fehérjegazdálkodásának helyzete és fejlesztési stratégiája *[Situation and development strategy of protein management in Hungary]*. MTA Agrártudományok Osztálya *[Hungarian Academy of Sciences, Division Agricultural Sciences]*, Budapest. 207 p. (in Hungarian)

Borka, G. (1998): Modelluntersuchungen zur Bestimmung der Ammoniakemissionen aus Rinderexkrementen im Stallbereich. Dissertation ETH Zürich Nr. 12830, 126 p. (in German)

Borka G. (2002): A haszonállat-tartásból származó metánemisszió meghatározására szolgáló differenciált módszer kidolgozása a magyar mezőgazdaság sajátosságainak figyelembe vételével *[Elaboration of a differentiated methodology for the determination of the methane emission from livestock keeping, by taking into account the characteristics of the Hungarian agriculture]*. Beszámoló jelentés, FVM K+F 120-e/2000 kutatási program *[Final report Project FVM K+F 120-e/2000]*, 16 p. (unpublished, in Hungarian).

Borka G. (2003): Ammónia, nitrogén-oxid és metánemissziók a magyar mezőgazdaságból: emissziós trendek, az emissziócsökkentés lehetőségei, ajánlások *[Ammonia, nitrous oxide and methane emissions from the Hungarian agriculture: emission trends, emission reduction options, recommendations]*. Beszámoló jelentés, FVM K+F 89-d/2002 kutatási program, 2003. december 20. *[statement report FVM K+F 89-d/2002, 20 December, 2003]*. 11 p. (unpublished, in Hungarian).

Borka, G. (2007): Az állati termék előállítás hatása az atmoszférára: a nitrogén- és üvegházgázemissziók jelentősége és csökkentési lehetőségei *[The effects of animal production on the atmosphere: nitrogen and greenhouse gas emissions and reduction possibilities]*. Állattenyésztés és Takarmányozás. 2007. 56:469-487. (in Hungarian)

FAO (1985-2002). FAO Fertilizer Yearbook, Vol. 35-Vol. 52.

FAO (1985-2002). FAO Production Yearbook, Vol. 39 – Vol. 56.

FAO (2008). FAOSTAT Fertilizers, http://faostat.fao.org/

FAO (2008). FAOSTAT Livestock, http://faostat.fao.org/

Fébel, H.Ms., Department of Physiology of Nutrition, Research Institute for Animal Breeding and Nutrition (2007). Expert consultation, verbal communication.

Fébel, H.Ms. – Gundel, J.: A takarmányozás és a környezetvédelem kapcsolata. *[Connection between nutriton and environmental protection]*. Állattenyésztés és Takarmányozás. 2007. 56:427-456.

Gundel, J., Department of Swine Nutrition, Research Institute for Animal Breeding and Nutrition (2004): Expert consultation, verbal communication.

HCSO [Hungarian Central Statistical Office] (1985-1989, 1997-2005): Statistical Yearbook of Agriculture. Budapest

HCSO [Hungarian Central Statistical Office] (1990-1996): Statistical Pocket-book of

Agriculture. Budapest

HCSO [Hungarian Central Statistical Office] (2000a): Agriculture in Hungary, 2000. Regional data. Budapest, 581 p.

HCSO [Hungarian Central Statistical Office] (2000b): Hungarian Agriculture 1851-2000. CD-ROM, Budapest.

HCSO [Hungarian Central Statistical Office] (2001): A mezőgazdaság gép- és épületállománya 1991-2000 [Machinery and building stock of agriculture sector, 1991-2000]. Budapest.

HCSO [Hungarian Central Statistical Office] (2004): Livestock 1851-2003. (internal report)

HCSO [Hungarian Central Statistical Office] (2008a): Stadat-tables – Times series of annual data 4. Economic sectors. 4.1. Agriculture. http://portal.ksh.hu/

HCSO [Hungarian Central Statistical Office] (2008b): Statistical Reflections, Livestock, 1 December, 2006, 1 April 2007, 1 August 2007, 1 December, 2007

IPCC (1996): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual.

IPCC (2000): Good Practice Guidance and Uncertainty Management in Greenhouse Gas Inventories.

Magyar Takarmánykódex Bizottság [Hungarian Nutrition Codex Commision] (2004): Magyar Takarmánykódex II. [Hungarian Nutrition Codex II.] 535 p. (in Hungarian)

Mészáros György, Ministry of Agriculture and Rural Development (2000): Expert consultation, verbal communication.

Minonzio, G. et al. (1998): Methan-Emissionen der schweizerischen Landwirtschaft. Schriftenreihe Umwelt Nr. 298, BUWAL, 130 p. (in German)

Pazsiczki I., Department for Mechanization of Animal Husbandry and Fodder Processing, Hungarian Institute of Agricultural Engineering (2005): Expert consultation, verbal communication.

Pazsiczki I., MGI and Borka G., ÁTK (2005): Expert consultation, verbal communication.

Pazsiczky, I.: Trágyatárolás, -kezelés és hasznosítás. *[Manure storage, management and utilization]*. Állattenyésztés és Takarmányozás. 2007. 56:457-468. (in Hungarian)

Ráki, Z. (2003): Az állattartás épületkapacitása, kapacitáskihasználása és a nagyobb telepek műszaki állapota *[Building capacity, capacity utilization of animal management and the technical status of larger farms]*. Budapest. (unpublished, in Hungarian)

Sári, D. (2003) Expert consultation, verbal communication.

Schmid, M. et al. (2000): Lachgasemissionen aus der Schweizer Landwirtschaft. Schriftenreihe der FAL, 33, 129 p. (in German)

Schmidt, J. et al. (2000): A kérődzők takarmányainak energia- és fehérjeértékelése *[Energy and protein assessment of ruminants' food]*. Mezőgazda Kiadó, Budapest, 185 p. (in

Hungarian)

Systemexpert Tanácsadó Kft. [Systemexpert Consulting LTD] (2007): A 2007-es magyarországi üvegházgáz-leltár IPCC és UNFCCC követelmények szerinti felülvizsgálata és a felhasznált módszertan áttekintése. *[Review of the 2007 greenhouse gas inventory of Hungary according to the requirements of the IPPC and UNFCC and of the applied methodology]* Budapest. 27 p. (unpublished, in Hungarian)

Széles Gy.. (szerk.) (1987-1988): Mezőgazdaság számokban. III. Állattenyésztés *[Agriculture in numbers. III. Animal breeding]*. Agroinform – STAGEK, Budapest. 463 p. (in Hungarian)

Tóth P., HCSO (2004). Expert consultation, verbal communication.

Várhegyi Józsefné et al. (1999). A kérődzők új fehérjeértékelési rendszerének alkalmazása gyakorlati takarmányozásban *[Application of the new protein assessment system of ruminants in the practice of feeding]*. ÁTK Herceghalom, PATE Mosonmagyaróvár. 68 p.

Várhegyi J., Department of Ruminant Nutrition, Research Institute for Animal Breeding and Nutrition (2004). Expert consultation, verbal communication.

Walther et al. (1994). Grundlagen für die Düngung im Acker- und Futterbau. FAP Zürich, RAC Nyon, FAC Liebefeld-Bern. Agrarforschung 1 (7), 40 p. (in German)

7. Land-Use, Land-Use Change and Forestry (CRF sector 5.)

7.1. Overview of the sector

7.1.1. Introduction

The estimates of the 2008 inventory submission are based on the methodology suggested by the *GPG for LULUCF (IPCC, 2003)* and the *IPCC 2006 Guidelines (IPCC, 2006)*. The complete coverage of the six top-level categories and the relevant gases, fulfilling the requirements arising from the Kyoto Protocol made us initiate a comprehensive revision of the sector in 2007.
In accordance with the GPG for LULUCF (IPCC, 2003) emissions and removals should be reported separately for land remaining in the same category and land converted to another land-use category, but sufficient information on land-use conversion is not yet available in Hungary. Research projects on investigation of historical land-use conversions are underway, to enable Hungary to meet the reporting requirements.
It is necessary to emphasize that this submission is built on our preliminary results. The data collection, data processing and the methodological developments are continuing and our estimates will undergo further refinement.

7.1.2. Completeness

In the 2008 inventory submission Hungary reports carbon stock changes, as well as greenhouse gas emissions and removals from Forest Land (CRF 5.A), Cropland (CRF 5.B) and Grassland (CRF 5.C). In category 5.A Forest Land carbon stock change in living biomass is reported. In category 5.B Cropland carbon stock changes in living biomass and mineral soils are reported. In category 5.C Grassland carbon stock change in mineral soils are reported. Carbon stock change in mineral soils for the whole LULUCF system thus carbon stock change in mineral soils for Cropland as well as Grassland and afforested cropland and grassland areas is reported combined in the CRF table 5.B.1 Cropland remaining Cropland (see Chapter 7.3 Cropland and Chapter 7.4 Grassland). N_2O emissions from agricultural soils and fertilization (CRF 5(I)) are reported under the Agriculture sector (CRF 4). In addition, CO_2 emission from liming is reported in CRF table 5(IV) and CO, CH_4, N_2O and NO_x emissions from biomass burning (burning of slash in forests) are reported in CRF table 5(V).

Emissions and removals from LULUCF are not yet reported separately for land use categories remaining in the same land use category and land converted to another land use category (excluding carbon stock change in living biomass from category Land converted to Forest Land). Hungary has aggregate land-use statistics, which are appropriate for the implementation of the area representation method Approach 1. Higher-approach method for area representation is under development by the Central Agricultural Office Forest Directorate and Institute of Geodesy, Cartography and Remote Sensing.

The LULUCF sector report does not include emission estimates from Wetlands (CRF 5.D), Settlements (CRF 5.E) and Other Land (CRF 5.F). In these categories only aggregate area data in the land remaining in the same land-use categories are reported. Non-CO_2 emissions from drainage of soils and Wetlands (CRF 5(II)) are not reported as drainage is a very rare activity in Hungary. N_2O emission from disturbance associated with land-use conversion to Cropland (CRF 5(III)) has not yet been reported due to lack of available data. In Hungary, organic soils are not in use for agricultural purposes, so emissions from organic soils are not reported. Controlled biomass burning is not reported, except for burning of slash in Forest

Land category, because the biomass burning on site is strictly limited activity by law in Hungary. The wildfires are not reported under any subcategories due to the lack of an appropriate database.

7.1.3. Quantitative overview

The LULUCF sector in 2007 was a net sink of 4,137.55 Gg CO_2–eq, because the total emissions arising from the sector are smaller than the total removals (Table 7.1, Figure 7.1). The LULUCF sector is a net sink of CO_2 in Hungary. Figures of previous NIR submission differs from the figures in this report due to recalculations. The large sink is mainly due to fact that the total increment of the growing stock in forest lands has been higher then the annual harvest. In 2007 the net sink in living biomass in forests was 4,215.21 Gg CO_2.
The living woody biomass in croplands was a source of 61.23 Gg CO_2 due to the higher removal than plantation in vineyards. On the contrary the mineral soils in Hungary are a minor sink of CO_2 (24.58 Gg). Mineral soils in Hungary were sometimes minor sinks sometimes minor sources during the last few years. The sink is due mainly to the afforestation on Cropland. The liming in agricultural soils added up to 13.96 Gg CO_2 emissions in 2007. In addition, the non-CO_2 emission from biomass burning in forests (burning of slash) was 16.02 Gg CO_2-eq. The estimates of emissions and removals from LULUCF over the period 1985-2007 are presented in Table 7.1.

Table 7.1. *Emissions and removals from LULUCF 1985-2007 (Gg)*

	1985	BY	1986	1987	1988	1989	1990	1991
CO_2	-1,525.12	-3,628.98	-4,555.67	-4,806.15	-5,963.27	-5,063.25	-4,238.94	-4,771.48
CH_4	1.44	1.43	1.46	1.40	1.36	1.36	1.25	1.22
N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NO_x	0.36	0.36	0.36	0.35	0.34	0.34	0.31	0.30
CO	12.60	12.55	12.76	12.29	11.91	11.87	10.93	10.66
	1992	1993	1994	1995	1996	1997	1998	1999
CO_2	-5,751.68	-8,522.21	-8,961.44	-8,642.73	-3,494.62	-3,535.01	-5,771.97	-2,505.68
CH_4	1.12	0.98	1.00	1.05	1.14	1.16	1.13	1.19
N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NO_x	0.28	0.24	0.25	0.26	0.28	0.29	0.28	0.30
CO	9.77	8.61	8.79	9.18	9.98	10.18	9.91	10.4
	2000	2001	2002	2003	2004	2005	2006	2007
CO_2	-856.96	-2,587.94	-1,782.53	-4,517.63	-4,229.25	-4,645.36	-4,137.85	-4,164.60
CH_4	1.27	1.22	1.22	1.23	1.24	1.28	1.24	1.17
N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NO_x	0.32	0.30	0.30	0.31	0.31	0.32	0.31	0.29
CO	11.14	10.63	10.71	10.80	10.89	11.16	10.88	10.23

In 2007 removals from LULUCF correspond to approximately 5 percent of the total GHG emissions in Hungary (without LULUCF), compared to its 3% in the base year. The removals are 14.8% higher than in the base year. Removals from LULUCF are fluctuating over the period 1985-2007 (Figure 7.1).

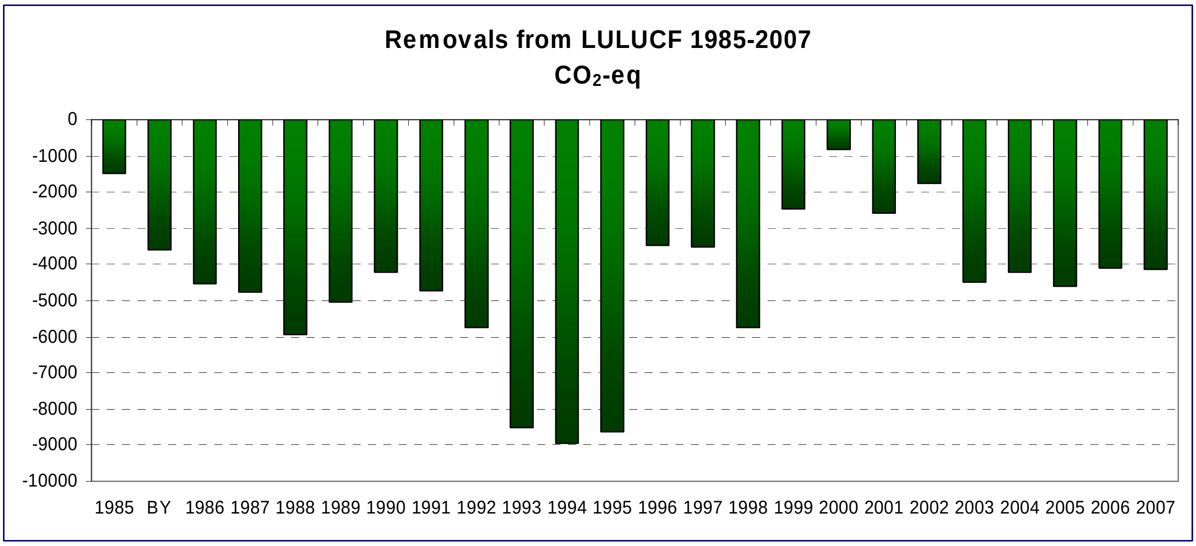


Figure 7.1. *Trend from LULUCF 1985-2007*

7.1.4. Land area representation used in the Hungarian inventory

Coverage of the IPCC land-use categories required the compilation of different activity data obtained from different statistical surveys in Hungary.
The main sources of activity data were the National Forest Inventory (Central Agricultural Office Forest Directorate), the land-use statistics of the Hungarian Central Statistical Office (HCSO) and the CORINE database.

Forest inventory (National Forestry Database, NFD) provides the data of our estimates for Forest land. NFD comprises data on the whole forested area of the country regardless of proprietary relations. The survey is continuous; approximately 10 percent of the whole forested area is renewed annually, and the whole forested area is surveyed in a 10-year-long cycle. The inventory is stand-based, the average size of a forest compartment is about 4 ha, and the spatial resolution of mapping of forests is 0.1 ha. NFD until 2007 did not provide information on land-use categories before afforestation and after deforestation. The initial and final land-use data have been collected since 2008, and a research project on the investigation of lacking historical land-use data is in progress.

For Cropland and Grassland the main data source is the HCSO agricultural surveys. The HCSO publishes the land-use data for land under agricultural management via the internet, annually on the website of the HCSO (http://portal.ksh.hu/pls/ksh/docs/eng/agrar/html/tabl1_3_1.html). The estimation of emissions from mineral soils according to the IPCC methods needs activity data for the last 20 years. The base year in Hungary is the average of the years of 1985, 1986 and 1987; it means that Hungary needs a consistent area database from 1965 to 2007.
The HCSO's data set is available since 1853, although there have been changes in the methodology since the beginning of the data collection (Kecskés, 1997). To ensure the consistency, the data set was adjusted according to the methodological changes.

The IPCC Settlements category matches the HCSO built-up area statistics (HCSO, 2006).

The areas of Wetlands were determined by the CORINE land cover databases (in reference to 1990 and 2000). This category contains all the wetlands in Hungary. For separation of peat lands and flooded lands as managed wetlands by GPG for LULUCF (IPCC, 2003), further data are needed. (The most peat land areas are protected in Hungary, thus the peat extraction has been rolled back over the recent decades. The peat extraction is negligible in Hungary.)

To ensure the consistency regarding the Hungarian area the Other land sub-category comprises the remaining land areas, which do not fall into any of the other five categories.

National application of IPCC land use categories in the Hungarian inventory

Forest

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

Regarding the data sources, the activity data was taken from the National Forestry Database of the Central Agricultural Office Forest Directorate (the former National Forest Service).

Cropland

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

Grassland

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

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

Pasture: land area under grass (artificial planting included) utilised for grazing irrespective of whether it is used for cutting sometimes. Land areas under grass with trees utilised for grazing are included.

Wetlands
Wetland area matches to the wetlands and water body categories of the CORINE land cover database. It contains the inland marshes (low-lying land usually flooded in winter, and more or less saturated by water all year round), peat bogs (peat land consisting mainly decomposed moss and vegetable matter. May or may not be exploited), water courses (natural or artificial water-courses including those serving as water drainage), water bodies (natural or artificial lakes, ponds etc.).

Settlements
The built-up area definition of the EUROSTAT is applied: residential- and industrial lands, quarries, pits and mines, commercial land, land used by public services, land used for infrastructure and for recreation.

Other Land
The Other Land category contains the uncultivated (abandoned) agricultural lands and other unmanaged lands in Hungary, which do not fall into any of the other five categories. The Other Land area is the residual land area of the country after the other land-use categories have been accounted.

Table 7.2. *Areas of IPCC land-use classes for the years 1985-2007 (1,000 ha)*

	Forest Land	Cropland	Grassland	Wetland	Settlements	Otherland	Total
1985	1541.482	5096.329	1246.400	270.873	496.083	652.092	9303.260
BY	1547.772	5088.776	1234.133	271.305	499.817	661.456	9303.260
1986	1547.203	5087.876	1233.700	271.305	499.714	663.461	9303.260
1987	1554.630	5082.124	1222.300	271.738	503.654	668.814	9303.260
1988	1554.668	5075.371	1209.900	272.170	507.384	683.767	9303.260
1989	1552.596	5068.418	1197.300	272.603	510.848	701.495	9303.260
1990	1573.959	5062.365	1185.600	273.035	514.444	693.858	9303.260
1991	1584.015	5032.812	1173.100	273.467	517.572	722.294	9303.260
1992	1591.705	5005.359	1164.000	273.900	521.000	747.296	9303.260
1993	1602.070	4974.106	1156.600	274.332	523.681	772.470	9303.260
1994	1612.103	4947.553	1148.000	274.765	526.467	794.372	9303.260
1995	1625.181	4921.700	1148.000	275.197	529.400	803.781	9303.260
1996	1637.414	4908.400	1148.300	275.629	534.313	799.203	9303.260
1997	1651.345	4899.400	1148.100	276.062	539.722	788.630	9303.260
1998	1663.733	4877.800	1147.800	276.494	545.081	792.351	9303.260
1999	1679.669	4852.200	1147.100	276.927	550.200	797.164	9303.260
2000	1672.690	4802.700	1051.200	277.359	557.200	942.110	9303.260
2001	1703.250	4804.200	1061.200	277.792	565.100	891.718	9303.260
2002	1714.620	4804.200	1063.100	278.224	569.700	873.415	9303.260
2003	1740.256	4803.100	1061.600	278.656	576.700	842.947	9303.260
2004	1770.288	4804.200	1059.600	279.089	583.300	806.782	9303.260
2005	1789.639	4797.800	1056.900	279.521	589.400	789.999	9303.260
2006	1805.802	4794.400	1014.500	279.954	596.655	811.950	9303.260
2007	1825.953	4790.100	1016.900	280.386	601.241	788.680	9303.260

The next figure (Figure 7.2) shows the distribution of the six, broad IPCC land-use categories in Hungary, in 2007.

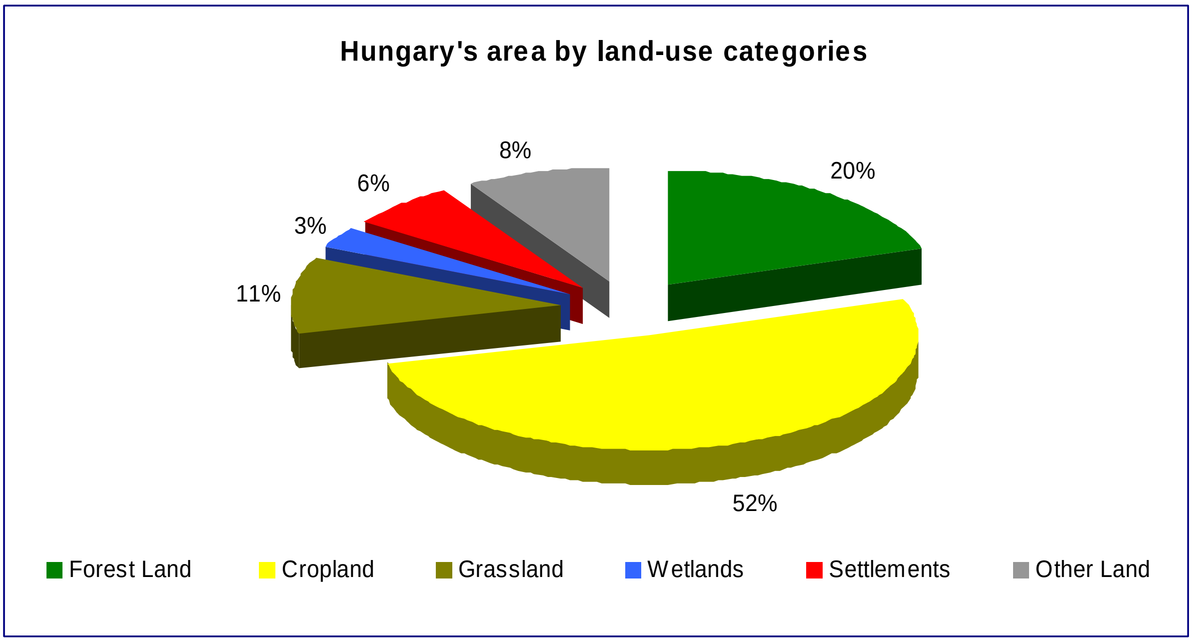


Figure 7.2. *Distribution of IPCC land-use categories in Hungary in 2007*

7.1.5. Estimation of emission from mineral soils

The main drivers of carbon stock change in mineral soils in Hungary are the extensification and afforestation of agricultural areas. Thus, our estimation on emission from mineral soils is based principally on the land-use change of Cropland, Grassland and afforested agricultural areas in this submission.

As Hungary only has aggregate area statistics, only the net changes in the area of any land-use category can be estimated (i.e., the Approach 1 area representation method can be used). Thus, all emissions/removals from managed soils in the different land-use categories (Forest Land, Cropland and Grassland) have to be calculated combined, in the same way as is delineated in the Box 2.2 of the 2006 IPCC Guidelines. Therefore, only the total carbon stock change of all managed soils is applicable, because the total land area is used to estimate the carbon stock there is constant. In Hungary, the sum of the areas of Forest Land, Cropland and managed Grassland in 1965 is the maximum area of land in the time-series, thus this area is used as the basis for emission and removal estimation throughout the inventory time-series, in accordance with the Guidelines (IPCC, 2006). Carbon stocks on unmanaged lands is assumed to remains constant until the year in which land is classified as managed in accordance with the Guidelines (IPCC, 2006).

The annual change of carbon stock in the different subcategories are not comparable, because we can not separate the carbon stock change arising from changes in area from carbon stock change due to the overall management of the soil. So, all emissions/removals from managed mineral soils in Hungary are reported without reference to individual land-use subcategories. If the carbon stock changes would be reported separately by land-use categories in this case the land area changing from/to unmanaged to/from managed status would incorrectly appear as a carbon stock increase/decrease. This could wrongly be inferred as a removal/emission from/to atmosphere, whereas in reality it is only an increase/decrease due to the expanded/decreased land-use area over the inventory time-series. Thus the total carbon stock change of the Forest Land, Cropland and Grassland mineral soils is reported aggregated in the Cropland remaining cropland category. Thus the reported emissions/removals in the Cropland remaining Cropland (CRF 5.B.1), mineral soils category refers to the all managed soils in Hungary.

Following recommendations of the 2008 centralized review the method used for estimation of aggregate emission/removal of all managed land have been delineated in Annex 3. The stratification of Cropland and Grassland by climate zone, soil type and land-use practices are detailed in Chapter 7.3 and Chapter 7.4

7.2. Forest Land (CRF sector 5.A)

A general description of the Hungarian forests and forestry in English can be found at http://www.aesz.hu/index.php?option=content&task=view&id=295&Itemid=558. Further data, mainly in Hungarian, can also be found on the website of the Central Agricultural Office Forest Directorate at http://www.aesz.hu. The summary below contains references to relevant pages. Further data and information were used that is not at the website, but that are in documents that are found in the documentation of the inventory.

Forests cover some one fifth of the terrestrial area of the country. The total forest (FL-FL+L-FL, stocked plus unstocked) area by the end of 2007 was 2,019.2 thousand ha, while the forest area covered by tree stands or earmarked for plantation was 1,890.9 thousand ha. The area actually covered by trees (i.e. the stocked area) was 1 825 953 ha. Both in the graphs in this reports, as well as in the CRF tables, the area of the stocked forests is reported, as this is the area where carbon stock changes take place.

Of all the forests, more than 700 thousand ha were established since 1930. After periods of slow increase of forest area, afforestations have been intensified recently (Figure 7.3. Forest management has also a long history in the country, and most forests are more or less intensively managed. Therefore, and because there are practically no unmanaged forests in the country (unmanaged forests called forest reserves occupy only a few thousand ha, i.e. 0.5% of all forests), all forests are considered as managed.

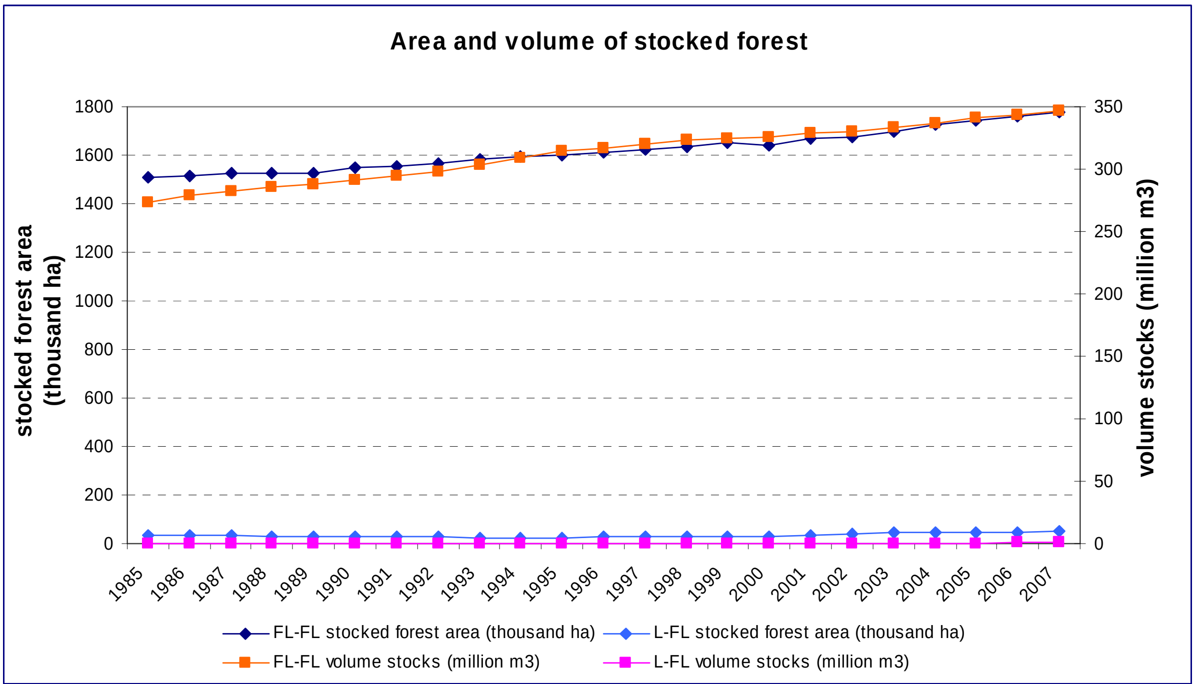


Figure 7.3. *Area and volume of stocked forest on land remaining forest land (FL-FL) and land in the transition category land converted to forest land (L-FL). Note that values of L-FL are small, but not zero.*

Forest management planning, as well as forest inspection are quite intensive in the country. In addition, there is a *continuous forest inventory* in the country. The units of the planning, as well as the inventory are stands of about four ha on average. During planning, practically all *forest stands are surveyed once in every 10 years*, which makes it possible to track the fate of all stands, and thus that of all forest land. The survey produces detailed maps and a detailed description of the forest stands (e.g. species, mean breast height diameter, mean height, stock volume, number of trees, basal area etc.).

Due to the intensive forest monitoring as described above, *all forest stands are accounted for*, and all changes in the biomass carbon stocks of the forests, due to any causes from growth through harvests, natural disturbances and deforestation (see below), are captured by the forestry statistics of each stand at least on a decade scale, and those of the whole forest area even on an annual basis. However, because the total forest cover has been growing for decades, there have not been any major deforestation, their total annual area being around five hundred ha. However, until now, there have not been separate statistics for conversions from forest to other land use. Nevertheless, the forest inventory statistics include all losses of volume stocks due to deforestations. *Carbon stock changes due to deforestations are thus included in the inventory, however, they are not reported separately.*

Note also that, in most cases when forest had to be cleared and land use type had to be changed, a new forest was established for replacement. Finally, abandonment of forest land is also regarded very rare, although it must have grown recently due to privatization of some 40% of all forests in the 1990's, but any increase or reduction of volume stocks on possibly abandoned land are included in the statistics of total volume stock change of all forests. Because of the above, and because statistics are only available at highly aggregate levels, land conversions to forest land could be accounted for separately. However, because separate statistics on land converted to forests were not previously needed, carbon stock changes of land conversions cannot at the moment be consistently estimated. Currently, there is a project under development to produce consistent land conversion statistics. (See further details in the methodological sections).

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

"Forest" (the area actually or potentially covered by trees) is defined in Hungary as a land spanning more than 0.5 hectares with trees higher than five meters and a canopy cover of more than 30 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. On the other hand, „forest land" includes both forests, as well as roads and other areas that are under forest management, but that are not covered by trees.

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

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

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

7.2.1. Forest Land remaining Forest Land (CRF sector 5.A.1)

Due to the nature of the Hungarian forestry statistics, estimates of total volume of all forests in the country are available annually. Concerning land use changes, as mentioned above, only conversions to forest can be distinguished, because of the associated subsidies.

Therefore, carbon stock changes in lands converted to forests (i.e. afforestations and reforestations) can be estimated and reported separately, but those in lands converted from forest to other land uses (i.e. deforestations) cannot. However, as mentioned above, emissions from carbon stock changes in the biomass pools in deforestations are included in the emissions from biomass carbon stock changes in "forest land remaining forest land".

Category description

Estimated main characteristics of the category can be found in Table 7.3.

Table 7.3. *Emissions and removals in the sub-category by gas and inventory year*

inventory year	area (ha)	CO_2 (Gg)	CH_4 (Gg)	CO (Gg)	N_2O (Gg)	NO_x (Gg)
1985	1,507,870	-1,770	1.44	12.60	0.0099	0.36
1986	1,514,547	-4,054	1.46	12.76	0.0100	0.36
1987	1,522,931	-4,356	1.40	12.29	0.0097	0.35
1988	1,524,883	-4,670	1.36	11.91	0.0094	0.34
1989	1,524,725	-3,288	1.36	11.87	0.0093	0.34
1990	1,546,279	-3,942	1.25	10.93	0.0086	0.31
1991	1,556,718	-4,407	1.22	10.66	0.0084	0.30
1992	1,563,643	-5,209	1.12	9.77	0.0077	0.28
1993	1,581,471	-7,280	0.98	8.61	0.0068	0.24
1994	1,592,078	-7,943	1.00	8.79	0.0069	0.25
1995	1,602,669	-7,944	1.05	9.18	0.0072	0.26
1996	1,610,309	-3,312	1.14	9.98	0.0078	0.28
1997	1,620,986	-3,358	1.16	10.18	0.0080	0.29
1998	1,633,565	-5,211	1.13	9.91	0.0078	0.28
1999	1,648,983	-2,000	1.19	10.40	0.0082	0.30
2000	1,641,480	-1,214	1.27	11.14	0.0088	0.32
2001	1,667,081	-3,057	1.22	10.63	0.0084	0.30
2002	1,672,599	-2,623	1.22	10.71	0.0084	0.30
2003	1,696,202	-4,771	1.23	10.80	0.0085	0.31
2004	1,726,313	-4,059	1.24	10.89	0.0086	0.31
2005	1,745,228	-5,323	1.28	11.16	0.0088	0.32
2006	1,759,646	-4,465	1.24	10.88	0.0085	0.31
2007	1,777,157	-4,094	1.17	10.23	0.0080	0.29

Methodological issues – CO_2 emissions and removals

The general approach to estimate emissions and removals in the forestry sector is based on the IPCC methodology (*GPG for LULUCF, IPCC 2006 Guidelines*). However, wherever it was possible, country specific data was used (Tier 2), and IPCC default values (Tier 1) were only used in a few cases. Emissions and removals leading to changes in the biomass carbon pools are accounted for, however, due to lack of data, assumptions are applied with respect to other pools to comply with requirements to completeness.

Changes in carbon stocks in the biomass pools

Changes in carbon stocks in the biomass pools are estimated using the stock-change method. This method is applied in the national greenhouse gas inventory since 2006. Previously, the changes had been calculated, following the early advice of the IPCC 1996

Guidelines, using the “IPCC default method” (better termed as a process-based method or growth and loss method) where data on changes due to growth, harvests and disturbances was used. However, as it was noted several times in earlier NIRs, relatively high uncertainties are inherent in these data due to different reasons, therefore, we changed for the stock-change method.

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

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

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

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

where

- ΔC_B = carbon stock changes of biomass (tonnes C)
- C_t = carbon stocks at time t (tonnes C)
- V_t = volume stocks at time t (m^3)
- D = wood density, tonnes m^{-3}
- R = root-to-shoot ratio (dimensionless)
- CF = carbon fraction of biomass (tonnes C tonnes $biomass^{-1}$).

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

Each stand is surveyed once in every 10 years. During the survey, the main stand measures (such as height, diameter, basal area, and density) are estimated by various measurement methods. These depend on species, age and site, and more accurate methods are usually used for stands of higher volume stocks. In years between surveys, yield functions are used to update volume stocks. As a result, (aggregated) volume carbon stocks are available for each inventory year.

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

Concerning wood density, data by main species and species groups are available from literature (Table 7.2). Note that, for the last several submissions, the same density values have been used across all inventory years for the sake of consistency. However, a research study is under way to revise the wood density values, and to replace some of them with basic density values.

Table 7.4. *Wood density values for the main species and species groups in Hungary. (The source of the oven-dry wood density values is Babos, K., Filló, Z., Somkuti, E. 1979. Haszonfák. Műszaki könyvkiadó, Budapest. In Hungarian; Kovács, I. 1979. Faanyagismerettan. Mezőgazdasági Kiadó, Budapest. In Hungarian).*

Species or species group	Wood density ($t\ m^{-3}$)
Oak	0.665
Turkey oak	0.770
Beech	0.680
Hornbeam	0.790
Black locust	0.740
Other hardwood	0.593
Hybrid poplar	0.370
Indigenous poplar	0.395
White willow	0.330
Other softwood	0.560
Conifers	0.530

A research project had been carried out to refine the wood-density values of the Hungarian tree species (see Somogyi Z. (2008): A hazai erdők üvegház hatású gáz leltára. Erdészeti kutatások 2007-2008. vol. 92. 154.). The introduction of the new densities in the GHG inventory is anticipated in the next reporting year (2010).

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

With respect to the below-ground biomass, a general root-to-shoot ratio (R) is applied. Until a few years ago, carbon stock changes in the below-ground biomass carbon pool were not accounted for. Since 2006, in lack of proper data, IPCC default values are used in connection with expert judgement (Tier 1 methodology). Considering that the majority of the forests in Hungary are young, that the average volume stocks are 189 $m^3\ ha^{-1}$ (in 1990) and 219 $m^3\ ha^{-1}$ (in 2004), corresponding to an average aboveground biomass of 122 $t\ ha^{-1}$ (in 1990) and 140 $t\ ha^{-1}$ (in 2004), and that the IPCC default values have relatively high uncertainty, a conservative value of R of 0.25 is used for all species.

Concerning the carbon fraction of dry wood, the IPCC default value, i.e. 0.5 tonnes C tonnes $biomass^{-1}$ is used.

<u>Changes in the carbon stocks of the dead wood, litter, soils and harvested wood products pools</u>

In Hungary, data has not been collected systematically even in the main ecosystem types for dead wood, litter or soil. However, it seems justified to state that these pools continue to sequester carbon in the medium-term, rather than to lose carbon. This is mainly due to two reasons: one is the sustained way of managing existing forests, which means that less wood is harvested than what is grown, and the other is that about one-third of all forests are afforestations since 1930, and most of these forests are still in their intensive growing phase.

The effect can be easily seen from Figure 7.4, which shows the amount of estimated current annual increment and harvest statistics.

The difference of increment and harvests is large enough to claim sustained yield, which is also obvious from the growing trend of total volume stocks for the last two decades.

Given (1) the increase of the growing stock of the Hungarian forests, we can assume (2) the increase of the amount of deadwood, too. The relationship is not linear, of course. In the last decades (3) the close-to-nature forest management was favoured and came to the front, and clearcuts were pushed into the background, so we can suppose the accumulation of both deadwood and litter in the Hungarian forests (which in turn increase the carbon stocks of the soils). Additionally, no major disturbances or other processes are known that could result in substantial emissions from these pools. Therefore, although no quantitative estimates can be made on the increase, the Tier 1 assumption can safely be made that these pools are not sources, and their carbon stock changes are zero. (See also a recent presentation by Somogyi (2006) at
http://afoludata.jrc.it/events/Kyoto_technical_workshop/presentations/Z_Somogyi.pdf.)

Concerning harvested wood products, changes in the carbon stocks in this pool are not reported, either. The reason for this, in addition to lack of proper data and proper methodology adopted, is the likely relatively small size of changes in this pool.

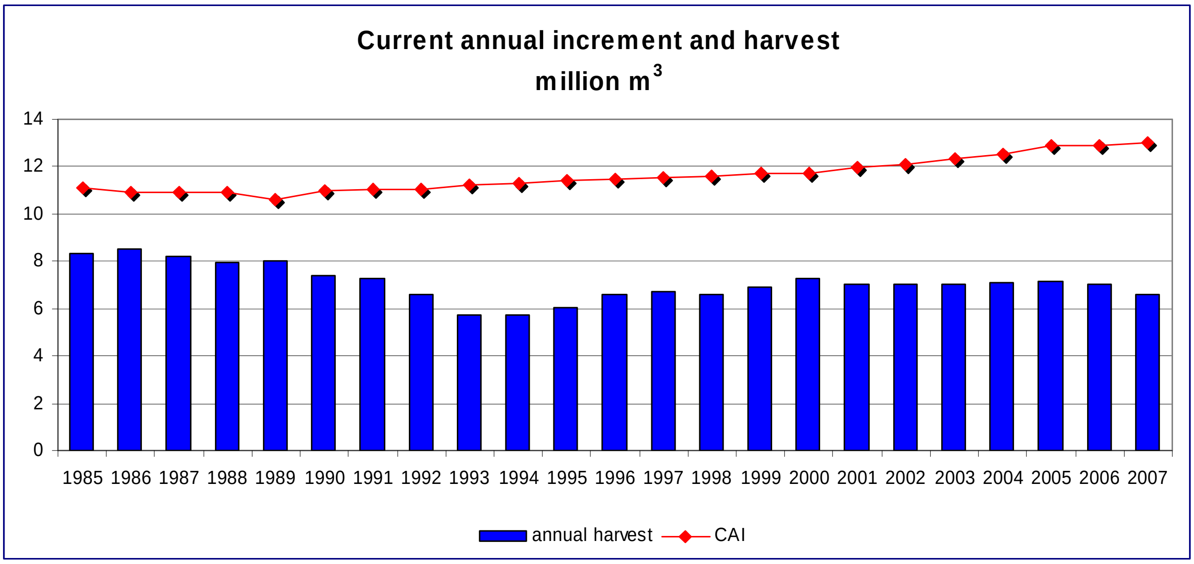


Figure 7.4. *Current annual increment and annual harvest in Hungary in the last decades Data source: National Forest Database.*

CO_2 emissions from liming

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

Methodological issues – non-CO_2 emissions

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

The estimation methodology is based on the method suggested by the *IPCC 1996 Guidelines*, as well as equation 3.2.19 of the *GPG for LULUCF (IPCC, 2003)*. Carbon released is estimated using harvest statistics (m^3 of wood removed from forest, see the graph above, from which the amount of slash was calculated using average values by species, see Table 7.5 below) which were developed in former country-wide specific project for statistical purposes). In addition, expert judgement was applied with respect to the fraction of slash burnt on site (0.2), and to the fraction that oxidised on site (0.9). Finally, the IPCC default value was used for the carbon fraction of harvested wood (0.5). The product of these values is first multiplied by default emission ratios by gas: 0.012 for CH_4, 0.06 for CO, 0.007 for N_2O, and 0.121 for NO_x. Then, for the nitrogen compounds, a general default value of 0.01 are applied to yield the total amount of nitrogen (N) released. Finally, the products obtained are multiplied by the appropriate molecular weight ratios, which are the following: 16/12 for CH_4, 28/12 for CO, 44/28 for N_2O, and 46/14 for NO_x.

Table 7.5. *Harvest statistics for the inventory years*

reporting year	harvested volume (m^3)	slash (from data by species) (t)
1985	8,345,562	999,660
1986	8,500,991	1,012,554
1987	8,193,145	975,181
1988	7,960,397	945,002
1989	8,031,779	941,890
1990	7,415,162	867,795
1991	7,255,202	846,173
1992	6,588,569	775,646
1993	5,723,745	683,589
1994	5,717,468	697,710
1995	6,049,151	728,540
1996	6,603,733	791,934
1997	6,713,101	807,859
1998	6,578,931	786,791
1999	6,900,612	825,188
2000	7,287,456	883,913
2001	7,010,979	843,752
2002	7,013,167	850,311
2003	7,053,960	857,268
2004	7,094,753	864,225
2005	7,167,426	885,614
2006	7,005,190	863,594
2007	6,609,099	812,238

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

Category description

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

contribution to greenhouse gas emissions and removals, only carbon stock changes in the biomass pools are accounted for. (We note here that, according to recent estimates, converting land from croplands does not entail any emissions from soil. See Somogyi, 2005: Guidelines and improved standards for monitoring and verification of carbon removals in afforestation/reforestation joint implementation projects. Results of the monitoring case study in the test site in Hungary. CarboInvent, WP8.5 report, http://www.joanneum.at/carboinvent/D_8_5.pdf
Somogyi, Z. – Horváth, B. 2006. Az 1930 óta telepített erdők szénlekötéséről. Erdészeti Lapok CLI.9:257-259.; and Somogyi, Z. – Horvath, B. 2006. Detecting C-stock changes in soils of afforested areas in Hungary. Presentation at the workshop Development of Models and Forest Soil Surveys for Monitoring of Soil Carbon. April 5-8, 2006 at Koli, Finland, www.metla.fi/tapahtumat/2006/soil2006.) However, there are some indications that converting grassland to forest may lead to some emissions – see Horvath, B. 2006. Kohlenstoff-Akkumulation im Boden nach Neuaufforstungen: Beitrag zur Reduzierung der C-Emission in Ungarn? (C-accumulation in the soil after afforestation: contribution to C-mitigation in Hungary?) Forstarchiv v. 77(2) p. 63-68. However, the fact is that there are huge marginal lands or former croplands in the country, and, also because of biodiversity concerns, the overwhelming majority of all conversions occur on croplands, so no major emissions from soils are suspected during conversion.)

The estimated area of, and CO_2 emissions from this category are summarized in Table 7.6 below.

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

Hungary has long, very succesful and internationally recognised tradition of afforestation. About 30% of the current forests were planted since 1930. The afforestation efforts are still continous, and decisively subsidy-driven. The subsidies are granted to each forest-subcompartment in three steps: (1) at initial planting, (2) in the second year, (3) at finishing of the afforestation. The compartments under afforestation are annually surveyed on site by the national forest authority, and the 3rd portion of the subsidy is only granted if the juvenile stand is in good condition and has overgrown the competing herbs and shrubs. This is the time when the forest authority declares the stand as forest, and after this time the compartment is included it in the FL area. However, this stage of forest development is stand-specific due to many factors: site conditions, wheather, the forest manager's efforts etc. The afforestated stands are recorded in the National Forestry Database annualy and can be tracked year-by-year. This method of administration is based on individually stand-surveyes (Tier 3) and very successful in ensuring the success of the afforestations.

Table 7.6. *CO_2 emissions and removals on land converted to forest*

inventory year	area (ha)	CO_2 (Gg)
1985	33,613	-213
1986	32,656	-106
1987	31,699	-106
1988	29,785	-213
1989	27,871	-213
1990	27,680	-21
1991	27,297	-43
1992	28,063	85
1993	20,599	-390
1994	20,025	-275
1995	22,513	48
1996	27,106	510
1997	30,359	362
1998	30,168	-28
1999	30,686	-100
2000	31,210	507
2001	36,169	363
2002	42,021	546
2003	44,054	23
2004	43,976	-237
2005	44,411	473
2006	46,156	196
2007	48,797	-121

Methodological issues – CO_2 emissions and removals

Concerning biomass, methodologies used in this category are the same as used in the forest land remaining forest land category.

We note here again, that due to the nature of the stock change method, because different lands move into and out from this category, and because the time that the various land areas are accounted for in this category significantly varies by species and site, the reported carbon stock changes are not due to, and cannot be interpreted as driven by natural processes like tree growth etc. Alone, rather, they are artifacts. Therefore, implied emission factors and other indices, that are in other cases useful for error checking or verification, cannot be interpreted for any single year, rather, only statistics for longer periods can be regarded as meaningful. Also, these data will be revised later (see below) and should be regarded as temporary.

With respect to deadwood and litter, the assumption is made that the stock change is zero. This is a justified assumption, because both the litter and deadwood pools are zero before the conversion, and usually increase after the conversion.

It is to be noted that soil carbon stock changes due to conversion of land to forest land are indirectly estimated and reported in section 7.3.2 where total carbon stock changes due to all land conversions are simultaneously covered for all land categories.

7.2.3. Category-specific uncertainties and time-series consistency

The main objective of this uncertainty analysis, complying with that of the IPCC Guidelines, is to identify possible major sources of errors, and to indicate where efforts on development should concentrate in future inventories. We note here that uncertainties were assessed for the first time for the 2000 inventory. In 2003, Hungary applied quantitative sensitivity analysis to her LULUCF GHG balance, based on expert judgment.

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

With respect to accuracy, the estimated values are generally accurate as far as practicable, or are conservative estimates (i.e., overestimate emissions, and underestimate removals), or conservative assumptions are used (e.g. in the case of carbon stock changes in soils, litter and deadwood. The only difference could be that the wood density values may be too high, which may yield overestimations of removals of a few percent. Finally, accuracy cannot always be quantified, partly because the error distributions are unknown due to lack of measured data, partly because calculation errors, or because assumptions cannot be quantified. However, calculation errors are highly unlikely, due to the double-checking of the data processing.

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

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

The uncertainty of the *annual* CO_2 emissions, as estimated based on the annual volume stock *changes*, can be quite high due to unknown uncertainty of annual estimates. Concerning the individual inventory years, actual values may deviate more from estimated values, as the stock volume inventory for the whole country is not able to capture all inter-annual variability of timber growth and harvests. However, a more detailed uncertainty analysis of the activity data (area and volume of forests) cannot be performed as the current forest inventory system has not been designed to yield uncertainty information.

Finally, it can be concluded that many sources of error have been removed by switching from the process-based method to the stock-change method. Thus, it is expected that current estimates better reflect emissions and removals associated with forest land than earlier estimates. The uncertainties that are related to the application of the wood densities will be at least partly removed when new density values will be developed.

7.2.4. Category-specific QA/QC and verification

Almost all calculations are based on the activity data taken from the National Forest Database. This database is the most accurate database in the country on the forests. The first complete and country-wide inventory was accomplished in 1976 and has applied modern informatiion technologies since the early '80-s. It is updated annually, and the data is checked by many people at subsequent procedures from field assessment to data processing. The constant development of field methods and informatics, improvement of checks, and increasing requirements on quality of work resulted in growing accuracy of the Database.

This year the GHG is completed by the Central Agricultural Office Forestry Directorate (CAOFD, formal National Forest Service), the attendant of the National Forest Database.

Apart from double-checking of the data processing and correct application of IPCC assumptions and methodologies by the CAOFD (QC), QA was performed at the national level by the hungarian Forest Reaserch Institute. The sepatation of the two roles (to prepare and to check the GHG inventory) had very beneficial effect on data quality.

However, data verification was, and is continuously, conducted concerning activity data (see the comparison of volume stock changes with trends of wood volume increment and harvest, see also previous NIRs of Hungary). The applicability of background data and correctness of the arithmetic used was double-checked. All background information is archived by the expert in addition to the inventory agency. Thus, the correctness of the estimation methodology is in principle verifiable.

7.2.5. Category-specific recalculations

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

Recalculation took place this year because of a misunderstanding of the sign-convention of emissions and removals. The error affected only the L-FL areas, 1985-2006.

In category 5.A.1 Forest Land remaining Forest Land minor transcription errors caused rounding decimals between calculation sheet and CRF Reporter were corrected in the period 2004-2006.

7.2.6. Category-specific planned improvements

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

In 2006 Hungary joined to the European Forest Fire Information System (EFFIS), and data of forest fires have been collected since the year 2007.

In April, 2008 a new method was designed and introduced into the National Forest Database to identify the deforested areas. The test-operation of this data collection (the introductory year) was conducted in 2008, and in the moment of completing the NIR (march of 2009) we are in the evaluation phase. The results are promising to describe the exact location and lost woody volume of losses - including demages caused by forest fires.

7.3. CROPLAND (CRF sector 5.B)

7.3.1. Cropland areas

Though a significant decrease of the area of croplands was characteristic for the last four decades - roughly 800,000 hectares were transferred to another category of land use – cropland still represents the main land use category in Hungary. The proportion of this land-use category was 52 percent in 2007 (Figure 7.2). All the lands with annual crops, as well as orchards and vineyards with perennial woody crops are classified here, as shown on Table 7.7. (Kitchen garden are assumed to be annual crops, perennial woody biomass in this subcategory is neglected.)

Table 7.7. *Cropland in Hungary (1985-2007)*

Year	Cropland (1,000 ha)				
	Perennial crops		Annual crops		Total
	Vineyard	Orchard	Arable lands	Kitchen garden	
1985	154	104	4,698	142	5,096
1986	147	99	4,705	137	5,088
1987	145	97	4,709	131	5,082
1988	142	95	4,712	126	5,075
1989	140	94	4,713	121	5,068
1990	139	95	4,713	116	5,062
1991	136	94	4,692	111	5,033
1992	135	95	4,670	106	5,005
1993	132	93	4,649	101	4,974
1994	132	93	4,628	95	4,948
1995	131	94	4,606	90	4,922
1996	131	94	4,585	98	4,908
1997	131	96	4,564	109	4,899
1998	130	96	4,542	109	4,878
1999	127	96	4,521	108	4,852
2000	106	95	4,500	102	4,803
2001	93	98	4,516	98	4,804
2002	93	97	4,516	99	4,804
2003	93	98	4,516	96	4,803
2004	95	103	4,510	97	4,804
2005	86	103	4,513	96	4,798
2006	86	103	4,510	96	4,794
2007	86	102	4,506	96	4,790

Activity data are based on the HCSO's annual statistics for arable lands, kitchen garden, orchard and vineyard categories revised by the HCSO's and the inventory agency's experts to account for inconsistencies. The revisions are as follows.
There was a change in the methodology of data collection of kitchen gardens in 1992, which caused time series inconsistencies. Up to 1991 the kitchen gardens in settlements were included in this category, but after 1992 these gardens were included in the uncultivated land category. According to the methodological changes, the garden data were adjusted

retrospectively. (Gardens in built-up areas were shifted into the uncultivated lands category in the whole time-series. This methodological change matches the IPCC definitions, where the gardens in built-up areas are included separately from the arable lands, i.e. in the Settlements category.)
Another adjustment was executed in the arable land category because in the years of census the data set was derived from the census while in other years from land-owner questionnaires. The more detailed results in the years of census can cause a big difference between the year of the census and the subsequent and preceding years. These outliers were eliminated as well.

The CO_2 removals in living biomass, as well as emissions from cultivated mineral soils and agricultural lime application are reported under the category of CO_2 emissions from cropland remaining cropland. Hungary has aggregate land-use statistics, but no detailed land use change statistics; therefore, all removals and emissions of cropland are reported under the Cropland remaining Cropland category.

7.3.2. Carbon stock change in living biomass

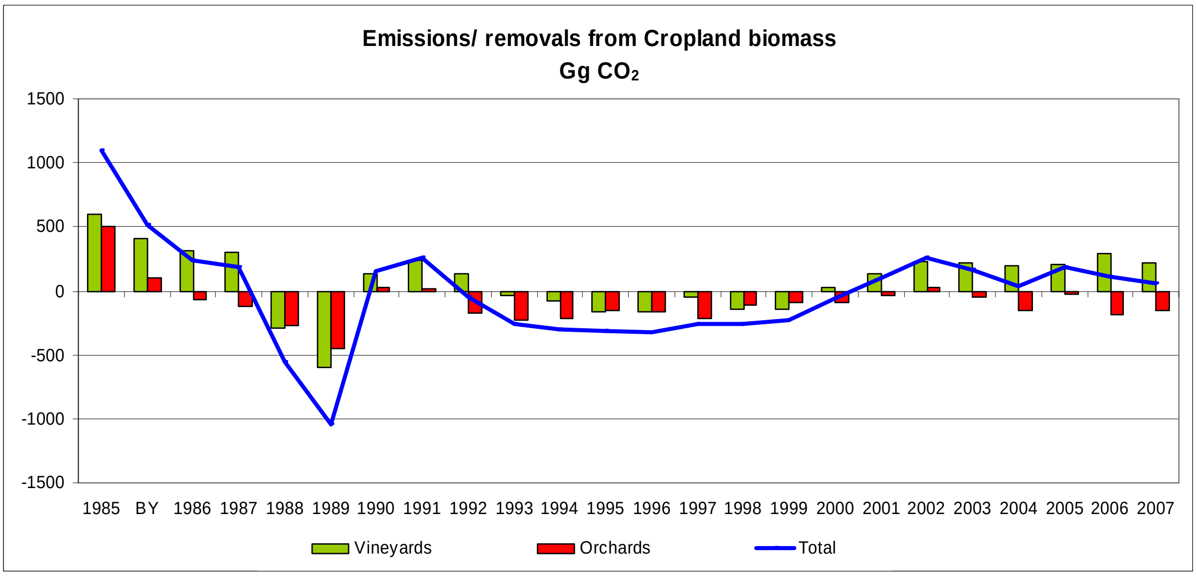


Figure 7.5. *Trends in emissions/removals from Cropland living biomass 1985-2007*

In 2007 Cropland living (woody) biomass was a source of 61.23 Gg CO_2 in Hungary, due to vineyard removals. There is a permanent vineyard abandonment system in the EU, therefore vineyard removal is subsidised in Hungary similar to other EU member states. Orchards were a sink of 42,369.18 tonnes carbon in 2007, the decrease of orchard area was not significant and the plantations exceeded the removals.
The trend in emission from Cropland woody biomass is changeable over the time series as shown in Figure 7.5. This trend differs from that of in our former submission, because following the recommendations of the centralized review the time-series was recalculated by using additional removal statistics.

Methodology

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

Equation 3.2.2 of the GPG for LULUCF (IPCC, 2003) the following formulas were applied:

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

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

$\Delta C_G = A_G \cdot G$

$\Delta C_L = A_L \cdot L$

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

Activity data

Activity data to estimate land areas (A_G, A_L) of growing stock and removals in perennial woody crops are derived from the statistics of HCSO. In our previous submission, the loss of carbon stock in living biomass of cropland was calculated from the net decrease of the vineyard and orchard area, due to the lack of statistics for the removed lands of vineyards and orchards for the whole legal forms. In this submission this source category was recalculated by using additional HCSO statistics, and process was elaborated to estimate the missing activity data, as it is shown in Annex 3. The methodology for the estimation of the missing activity data is considered to provide a relatively conservative approach to the calculation of emissions and removals.

Uncertainty assessment

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

7.3.3. Carbon stock change in mineral soils

In Hungary the organic soils are not in use for agricultural purposes, so emissions from organic soils are not reported.

The carbon stock of mineral soils in Hungary has been changing especially for the last decade due to increasing changes in the principles of soil cultivation. The need for environmentally friendly and energy saving soil tillage systems is increasing as the consequences of improper soil cultivation practice that characterised the last decades are manifested in unfavourable soil properties (Birkás, 2002, Birkás et al., 2007). In accordance with the efforts to reduce soil degradation due to the improper soil use, the conventional soil cultivation methods are prospectively replaced by conservation tillage, including different versions of reduced till, mulch-till, crop residue management etc. (Forgács et al., 2005). These new soil tillage methods aim at the decrease of the depth of the regularly cultivated soil layer and the formation of a topsoil rich in organic matter, hence, they considerably affect soil C stocks in croplands. Though there are no extensive measured data yet in Hungary, there are already some results concerning the effect of reduced tillage systems on the CO_2-emission from the soil that provide valuable information with respect to soil utilisation (Gyuricza et al., 2005; Tóth and Koós, 2006; Zsembeli et al, 2005, 2006; Zsembeli and Kovács, 2007).

Methodology

The estimation used is based on the Tier 1 methodology of GPG for LULUCF (IPCC, 2003), using Equation 3.3.4 (B) for the all managed land (Cropland, Grassland and Afforested lands), simultaneously. Hungary has aggregate land-use statistics thus the carbon stock change of all managed land is estimated combined in according to the Box 2.2 of the Guidelines (IPCC, 2006). The method is generally described in Annex 3.4 and the stratification of Cropland is detailed in this chapter.
The categorisation of croplands is partly based on expert judgement due to the lack of sufficient statistics of the recent Hungarian land use practice mainly on the management and input. Nevertheless, the input factors can be judged well on the base of the actual composition of annual crops, while the change in the management practice can be followed by the number of the tools and machines used in reduced tillage, as described below.

Activity data

In accordance with the GPG for LULUCF (IPCC, 2003) the area of Croplands was stratified by soil type, climate, management and input types. For the stratification the HCSO's area data were harmonised with CORINE land cover data (1990, 2000) and the HMS's climate data. Though land use data are not available for the periods before 1990 and after 2000, so the stratification was estimated by the interpolation and extrapolation of the available data. The procedures for stratification of Cropland by climate zone, soil type and management practices may be followed from the description below.

Soil type
The soil types were determined on the base of AGROTOPO (digital soil map of Hungary) database. This database were harmonised with the land use types of CLC to determine the rate of land use types on different soil types (GIS Lab of the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences). The Hungarian national soil classification system classifies soils by genetic types, and these types are not comparable with the types identified by the WRB or the USDA systems. Therefore, a project titled "Modernization and international correspondence of Hungarian soil classification", was conducted to harmonize the two systems, founded by the Hungarian Scientific Research Fund, managed by Erika Michéli. This study was the base of the classification of the soils of Hungary into the soil type groups needed for the calculations. As a result of the classification the croplands in Hungary were classified into four soil types from among the types that are determined in the *GPG for LULUCF (IPCC, 2003)* with following proportions of the total land in 2006 (Table 7.7).

Table 7.8. *Classification the croplands in Hungary by soil type in proportion to the total land*

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

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

Climate

The climatic classification and the determination of the spatial distribution of climate zones was made by the Hungarian Meteorological Service. Two categories were determined: i.e., Cold Temperate Dry (CTED) where the mean annual temperature (MAT) is just below 10℃ and the annual precipitation is less than the evapotranspiration, and Warm Temperate Dry (WTED) MAT is above 10℃ and the annual precipitati on is less than the evapotranspiration. After determining the climate zones, they were harmonised with the soil classing: the four soil types were grouped into the two climate categories (made by the GIS Lab of the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences) according to their spatial distribution in Hungary. As a result, the proportions indicated Table 7.8 were gained.

Table 7.9. *Classification of croplands in Hungary by climate in proportion of the total land*

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

Management

In Hungary full tillage of croplands was the only applied cultivation system until the end of 1990ies and it is still dominant, although the area cultivated with reduced tillage methods is increasing year by year. As the management of croplands considerably modifies soil C stocks, reduced tillage has been the most characteristic in Hungary recently. To account for changes in soil C stocks of croplands we estimated the areas of the two main cultivation types at the beginning and at the end of the inventory time period. There are no sufficient data available to estimate the correct actual area of reduced tillage, hence, the calculation is based on expert judgement. The principle of the calculation is that the total area of cereals (winter wheat, barley, maize) can be considered stable (approximately 2.6 million ha), the fluctuation is not considerable. The newly introduced soil protective cultivation methods are used mainly in the case of cereal production. We took into account the cumulative number of sold machines and tools that are suitable for reduced tillage since 1998 (source: KITE Ltd., the biggest company in agricultural service and commerce in Hungary), and calculated the extent of the area, where these machines and tools can be applied (one fourth of the actual area of cereals). According to our judgement, the area cultivated by applying one of these alternative methods was extended approximately to 1,850,000 hectares in Hungary in 2006.
According to export judgement, the area cultivated by applying one of these alternative methods was extended approximately to 207,200 hectares in Hungary in 2007.

Input

To select the appropriate input factors that represent the agricultural practice in Hungary, the characteristics of crop rotations were taken into consideration. According to the *GPG for LULUCF (IPCC, 2003)*, the input factors represent the effect of changing carbon input to the soil, as a function of crop residue yield, bare-fallow frequency, cropping intensity, or applying amendments. Therefore, the four soil types representing the Hungarian croplands were divided further into three input categories (Table 7.9).

***Table 7.10**. Classififcation of croplands in Hungary by input in proportion of the total land*

Input category	Proportion of total Cropland area (%)
Low	55
Medium	40
High with no manure	5

Low residue return is due to removal of most residues, which is very characteristic to the growing technology of cereals (wheat, rye, barley) and a certain fraction of maize in Hungary. As the total are of cereals - except for maize - is approximately 1.4 million hectares, the proportion of the low input category is significant. We also have to take into consideration that crop residues are typically removed from a certain amount of the area of the crops listed under *medium* input.

Medium input cropping systems represent annual cropping with crops where crop residues are returned to the field. This way of growing is characteristic – besides some other less important crops - to maize, sunflower and sugar beet production. These three crops occupy approximately 1.8 million hectares annually. But as it was mentioned earlier, not the total area of these crops can be calculated in the *medium* input category.

High input (without manure) rotations are not widely used in Hungary, practically limited to the use of green manures and cover crops.

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

On the base of the methodology of classification and data sources described above, the area of the different sub-categories representing the Hungarian croplands was estimated by soil type, climate, management and input. The data are shown in Tables A3-4-A3-9 in Annex 3.4.

Stock change and emission factors

According to the estimation method, described in the GPG for LULUCF (IPCC, 2003) Equation 3.3.3. the soil organic C stocks (SOC) were estimated using the relevant default reference carbon stocks (SOC_{ref}) taken from GPG for LULUCF (IPCC, 2003) Table 3.3.3 and the relevant stock change factors (F_{LU}, F_{MG}, F_I). The values for applied SOC_{ref} and stock change factors are presented in Table 7.11.

Table 7.11. *Reference soil organic carbon stocks and stock change factors for croplands in Hungary*

sub-categories				SOC_{ref}	F_{LU}	F_{MG}	F_I
Climate	Soil	Management	Input				
cold dry	HAC	full till	low	50	0.8	1.00	0.92
cold dry	HAC	full till	medium	50	0.8	1.00	1.00
cold dry	HAC	full till	high with no manure	50	0.8	1.00	1.07
cold dry	HAC	reduced till	medium	50	0.8	1.03	1.00
warm dry	HAC	full till	low	38	0.8	1.00	0.92
warm dry	HAC	full till	medium	38	0.8	1.00	1.00
warm dry	HAC	full till	high with no manure	38	0.8	1.00	1.07
warm dry	HAC	reduced till	medium	38	0.8	1.03	1.00
cold dry	LAC	full till	low	33	0.8	1.00	0.92
cold dry	LAC	full till	medium	33	0.8	1.00	1.00
cold dry	LAC	full till	high with no manure	33	0.8	1.00	1.07
warm dry	LAC	full till	low	24	0.8	1.00	0.92
warm dry	LAC	full till	medium	24	0.8	1.00	1.00
warm dry	LAC	full till	high with no manure	24	0.8	1.00	1.07
cold dry	sandy	full till	low	34	0.8	1.00	0.92
cold dry	sandy	full till	medium	34	0.8	1.00	1.00
cold dry	sandy	full till	high with no manure	34	0.8	1.00	1.07
warm dry	sandy	full till	low	19	0.8	1.00	0.92
warm dry	sandy	full till	medium	19	0.8	1.00	1.00
warm dry	sandy	full till	high with no manure	19	0.8	1.00	1.07
cold dry	aquic	full till	low	87	0.8	1.00	0.92
cold dry	aquic	full till	medium	87	0.8	1.00	1.00
cold dry	aquic	full till	high with no manure	87	0.8	1.00	1.07
warm dry	aquic	full till	low	88	0.8	1.00	0.92
warm dry	aquic	full till	medium	88	0.8	1.00	1.00
warm dry	aquic	full till	high with no manure	88	0.8	1.00	1.07

7.3.4. Liming

Liming shows a decreasing tendency in Hungary in the last decade. There is no reliable data on the amount of lime applied in Hungary. Therefore, the estimated amount is based on expert judgement by the extent of reclaimed areas for which data is available.

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

Unfortunately data gathering for reclaimed soils ceased after 2006, hence other sources had to be used to estimate the total area of reclaimed soils.
Application of lime for amelioration, require permission from Agricultural Office of the county.
(Agricultural Offices of the counties belong to the Directorate of Plant Protection, Soil Conservation and Agri-environment of Central Agricultural Office.)
The reclaimed area data were gathered from the 19 offices for the year 2007, and these areas were the basis of the expert judgement in the last inventory year.

The carbonate containing chemical amendments used for the reclamation of acidic soils are the followings: grinded limestone, grinded dolomite, beet potash, and other by-product potashes of different origin. In certain cases (in alkaline soils) gypsum is the proper chemical amendment to reclaim salt affected soils, but carbonate containing chemical amendments are also used.

The following assumptions were made:

- Two third of the acidic soils are reclaimed with limestone containing amendments while 27% with dolomite.
- In the case of salt affected soils half of them were estimated to be reclaimed with limestone or other carbonate containing material.
- The usual dosage of lime and dolomite application for soil reclamation, and the average quantity of $CaCO_3$ as agent is 8 t h^{-1} and 7 t h^{-1} $CaMg(CO_3)_2$ in the case of dolomite were applied.

The Tier 1 method of GPG for LULUCF (IPCC, 2003) was applied for the estimation of CO_2 emission. The default emission factor of 0.12 was used for carbonate containing lime, and 0.122 for dolomite.

7.3.5. Uncertainty assessment

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

Table 7.12. *Uncertainties of emissions from Cropland category*

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

7.3.6. Source specific recalculations

Following the recommendation of the 2008 centralized review the revision of the estimation 5.B.Cropland remaining Cropland/Carbon stock change/ living biomass for the whole time series was done. The recalculation has been carried out in accordance with the GPG for LULUCF (IPCC, 2003) Tier 1 methodology, by the HCSO's statistics and estimated activity data, partially. The methodology of emission estimation is described above the new activity data and the estimation procedure for unavailable activity data is presented in Annex 3.4.
In the previous submission the estimation was based on the Vineyard and Orchard area reported by the HCSO, annually, and the removal was considered to be the net decrease of the vineyard and orchard area due to the lack of removal and plantation data. Emissions/removals reported in this submission were calculated using detailed plantation and removal statistics and estimations taking them into account as well. These changes had a significant impact on figures of the amount of CO_2 emissions/ removals of 5.B Cropland subcategory. As the conservative approach was applied in the course of the recalculation the annual increment in carbon stock is lower than in the previous submission, consequently the carbon removals are lower as well. The problem of data collection for private farms resulted in outlier emission for the year of 2000 in the previous submission. As an effect of the recalculation the outlier disappeared from the time-series.

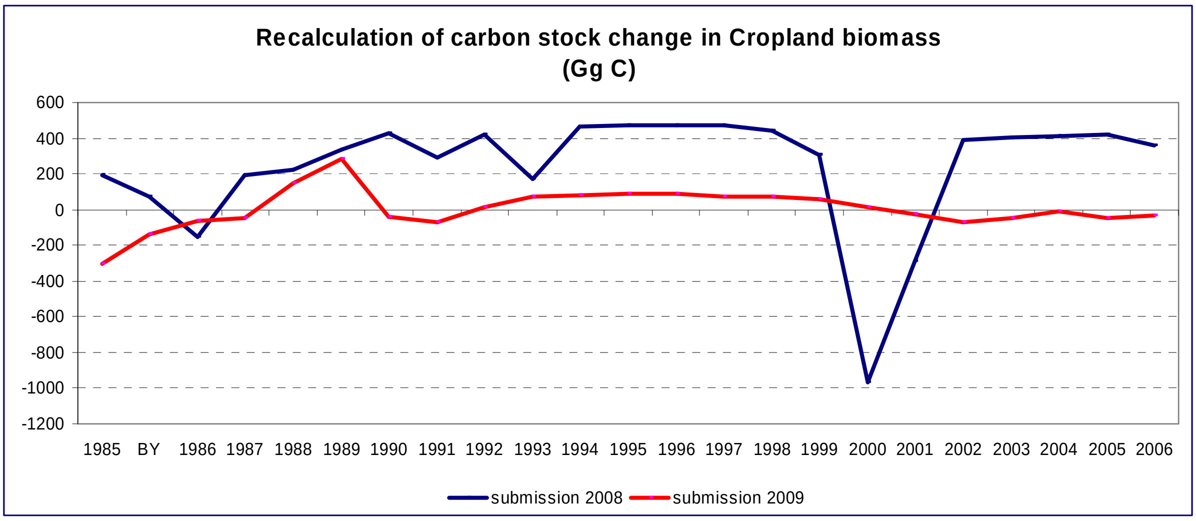


Figure 7.6. *Effects of the recalculation in carbon stock change of living biomass of Cropland*

In 5.B.Cropland remaining Cropland/ Carbon stock change/ in mineral soils recalculation was needed as the activity data changed. In 2008 the Hungarian Central Statistical Office revised the data previously provided for the year 2005 and 2006 on Vineyard area. These changes resulted in a minor decrease of the area of Cropland compared to the previous submission (0.2% both in 2005 and 2006) and consequently had an impact on the emission/ removal of the amount of CO_2 of subcategory 5.B. As a result of this recalculation the mineral soils became a minor sink of carbon both in 2005 and 2006 instead of being a minor source, as it was estimated in the previous submission. The Table 7.13 records the results of this recalculation. The losses in the carbon stock are presented as negative quantities.

Table 7.13. *Effect of recalculation of carbon stock change in mineral soils*

submissions	carbon stock change in the inventory years (Gg C)	
	2005	2006
2008	-0.850	-0.005
2009	2.334	2.865

7.4. GRASSLAND (CRF sector 5.C)

7.4.1. Grassland areas

The total area of grasslands in Hungary was considerably decreasing during the last three decades; while approximately 1,300,000 ha were occupied by grasslands in 1975, only 1,050,000 ha remained by 2005. Taking 1985 as a base year, the decrease of grassland areas in Hungary was 16%. Contrary to this trend, the change in the number of livestock of grazing animals (mainly cattle, sheep and geese as the livestock of horses, water buffalos and goats were not so considerable from the 1970ies) was different. In 1975 more than 2 million cattle, 700 thousand geese and 2 million sheep were in Hungary, and these numbers just slightly changed till 1985: 2 million cattle, 1 million geese and 3 million sheep. These numbers show that the decade of the 1980ies was the peak period concerning animal husbandry based on grazing, which was also the period of the highest natural expenditures regarding the utilisation of the Hungarian grasslands: the highest fertiliser doses and the largest irrigated areas characterised this period. Taking the peak year of 1985 as a base year, it can be concluded that the number of grazing animals and the intensity of grassland both started to decrease from that time and reached its bottom in the middle of the 1990ies.

The area of Grassland category is based on HCSO annual land-use statistics (for more details see Chapter 7.1.4).
Hungary has aggregate land-use statistics, therefore all removals and emissions from mineral soils in Grassland are reported under Cropland remaining Cropland category (for more details see Chapter 7.3).

7.4.2. Carbon stock change in living biomass

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

7.4.3. Carbon stock change in mineral soils

In Hungary no organic soils are under agricultural grassland management, thus organic soils are not reported.

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

Method

Since extended country-specific stock change factors are not available in Hungary at the moment, the estimation method we used is based on default factors given in Tier 1 methodology of GPG for LULUCF (IPCC, 2003), using Equation 3.3.4 (B) for the all managed land (Cropland, Grassland and Afforested lands), simultaneously. Hungary has aggregate land-use statistics thus the carbon stock change of all managed land is estimated combined in according to the Box 2.2 of the Guidelines (IPCC, 2006). The method is generally described in Annex 3.4 and the stratification of Grassland is detailed below.

Activity data

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

Soil type

The method of the classification of the Hungarian grasslands according to soil types is based on GIS analysis. The same procedure was applied that is described in the Chapter 7.3. The grasslands in Hungary occupied four soil types from among the types that are determined in the *IPCC Good Practice Guidance for LULUCF (2003)* with following proportions of the total land.

Table 7.14. *Classififcation of grasslands in Hungary by soil type in proportion of the total land*

Soil type by IPCC	Proportion (%)
High Activity Clay Mineral	74.01
Low Activity Clay Mineral	4.25
Sandy	4.1
Aquic	17.64

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

Climate

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

Management

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

Input

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

Table 7.15. *Classification of grasslands in Hungary by management in proportion of the total land*

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

On the base of the methodology of classification described above, the areas of the different sub-categories representing the Hungarian grasslands by climate, soil type, management and input are shown in Table A3-10-A3-15 in Annex 3.4.

Stock change and emission factors

According to the estimation method described in the *GPG for LULUCF (IPCC, 2003)*, first the soil organic C stocks (SOC) were estimated for the beginning and end of the inventory time period using the relevant default reference carbon stocks (SOC_{ref}) and the default stock change factors (F_{LU}, F_{MG}, F_I). The change in soil organic C stocks in mineral soils was calculated by subtracting the C stock in the last year of an inventory time period (SOC_0) from the C stock at the beginning of the inventory time period ($SOC_{(0-T)}$) and dividing by 20, the time dependence of the stock change factors.

Table 7.16*.* *Reference soil organic carbon stocks and stock change factors for croplands in Hungary*

Sub-categories				SOC_{ref}	F_{LU}	F_{MG}
Climate	Soil	Management	Input			
cold dry	HAC	non-degraded	-	50	1	1
cold dry	HAC	improved	medium	50	1	1.14
warm dry	HAC	non-degraded	-	38	1	1
warm dry	HAC	improved	medium	38	1	1.14
cold dry	LAC	non-degraded	-	33	1	1
cold dry	LAC	improved	medium	33	1	1.14
warm dry	LAC	non-degraded	-	24	1	1
warm dry	LAC	improved	medium	24	1	1.14
cold dry	sandy	non-degraded	-	34	1	1
cold dry	sandy	improved	medium	34	1	1.14
warm dry	sandy	non-degraded	-	19	1	1
warm dry	sandy	improved	medium	19	1	1.14
cold dry	aquic	non-degraded	-	87	1	1
cold dry	aquic	improved	medium	87	1	1.14
warm dry	aquic	non-degraded	-	88	1	1
warm dry	aquic	improved	medium	88	1	1.14

7.4.4. Liming

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

7.4.5. Uncertainty assessment

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

Table 7.17*. Uncertainties of emissions from Grassland category*

AREAS	
Input data	**Uncertainty %**
Determination of total area of grasslands	2.7
Area stratified by soil type	25
Area stratified by climate	25
Area stratified by management	25
Area stratified by input	25
FACTORS	
Input data	**Uncertainty %**
Land use as grassland	NA
Nominally managed (non-degraded)	NA
Improved management	10
Medium input	NA

7.4.6. Source specific recalculations

No recalculations have been made for this inventory submission.

7.5. Wetlands (CRF sector 5.D)

Areas of Wetland, according to the national definition comprise the inland marshes, peat bogs, water courses and water bodies. The Wetland area (280,386 ha, 3% of the total Hungary's area) was determined by extrapolation from the CORINE databases in reference to 1990 and 2000. CORINE is a land cover database therefore managed and unmanaged lands can not be separated by it. The result of our area estimation (interpolation and extrapolation) does not provide information about the area data of the conversion to Wetlands categories. To determine the area of flooded lands and peat lands, which is the managed area of Wetlands in terms of the *GPG for LULUCF (IPCC, 2003)*, additional information would be applied, which is currently not available. Therefore in the Wetland remaining Wetland category only the whole Wetland area is reported. (Parties do not have to prepare estimates for categories contained in Appendix 3a.3.) The emission of the converted to Wetlands categories are not estimated due to the lack of detailed area data and developed methodology. Whereas, these emissions could not be significant because the total Wetland area does not change remarkably in Hungary, while the area of protected Wetlands increases. Hungary is among the signatories of the Ramsar Convention, therefore the preservation and the sustainable uses of Wetlands are emphasized. In 2007 altogether 26 wetlands (204,876 ha) in Hungary had been included in the Ramsar List of Wetlands of International Importance.

7.6. Settlements (CRF sector 5.E)

Areas of Settlements, in terms of the national definition, comprise the areas residential and industrial lands, quarries, pits and mines, commercial land, land used by public services, land used for infrastructure and for recreation.

The Settlements area (601,241ha, 6.5% of the total area of the country) data derives from the HCSO built-up area statistics (HCSO, 2008). In Settlements remaining Settlements category only area data are reported. (Parties do not have to prepare estimates for categories contained in Appendix 3a.4.) The emission of converted to Settlements categories are not estimated due to lack of detailed area data and developed methodology. (Distinguishing the converted to Settlements categories is not possible by our current data base.)

7.7. Other Land (CRF sector 5.F)

The Other Land category contains the uncultivated (abandoned) agricultural lands and other unmanaged lands in Hungary, which do not fall into any of the other five categories.

The Other Land area is the residual land area of the country after the other land-use categories have been accounted.

The area of the Other Land category is 788,680 ha, which accounted for 8.5 percent of the total area of the country.

Under the Other Land category only the total area of the category is reported.

7.8. Non-CO_2 emissions

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

Hungary has aggregate fertilization database, which derives from sales statistics. We can not distinguish the fertilization by land-use categories. The total nitrogen content of the used fertilizer is taken into account under the Agriculture sector.

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

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

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

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

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

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

Emissions from wildfires have not been included yet, due to lack of suitable database. The data collection is in progress.

7.9. Sector specific QA/QC and verification

Emissions/removals from LULUCF are estimated by external experts and the GHG division of HMS is responsible for the QC procedures. The division of tasks makes possible that different persons make the estimates of emissions and the QC procedures. In addition, the new institutional arrangements for LULUCF inventory preparation mean that institutes instead of individuals have became responsible for the inventory preparation. Thus the human capacity for inventory preparation has increased since 2007, ensuring the implementation of a far wider range of QC procedure. The report on Forest Land category was reviewed externally by an internationally recognized expert on LULUCF as an important element of our QA/QC for the 2009 submission. The review report is available in Annex 3.4.

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

The main topics of our QC activity in LULUCF sector:

- Check and verification of the activity (area) data, cross checks of national and international land-use datasets (HCSO’s land-use database, CORINE land cover databases and FAO land-use dataset).
- Check the applied methodology
- Check of conversion factors and units through the calculation process
- Data, calculation system and methodology archiving
- Consistency check (time series are calculated consistently)
- The overlapping with other sources has been taken into consideration and reported

7.10. Sector specific planned improvements

Our main goal is to improve the sector coverage and area representation and to fulfil the reporting requirements arising from the Kyoto Protocol.

7.11. Sources - references

Babos, K., Filló, Z., Somkuti, E., (1979): Haszonfák. Műszaki könyvkiadó, Budapest

Birkás M. (2002): in Környezetkímélő és energiatakarékos talajművelés – Emvironment conservation and energy saving tillage.

Birkás M., Kalmár, T., Fenyvesi, L. and Földesi, P. (2007): Realities and beliefs in sustainable soil tillage. Cereal Research Comm. 35. 2. 257-260.

Central Agricultural Office, Forestry Directorate web page: www.aesz.hu

CORINE Land Cover (CLC) map displays (1990, 2000)

Environmental Report of Hungary (HCSO, 2006)

Forgács, L., Zsembeli, J., and Tuba G. (2005): Examination of a soil protective cultivation method in the Research Institute of Karcag. Realizáciou poznatkov vedy a vyskumu k trvalo udrzatel'nému pol'nohospodárstvu. Michalovce, Slovakia. 64-68.

Genetic soil types of Hungary (Agrotopo 2000)

Gyuricza, Cs., Földesi, P., Mikó, P., Ujj, A. (2005): Carbon Dioxide Emission from Arable Lands. Cereal Res. Com., 33. 1. 89-92.

Kecskés Csaba (1997): Methodological changes in land-use statistics. Statisztikai szemle. Vol 75. No. 12. 1047-1061 (in Hungarian, with English summary).

Király L. (1978): Új eljárások a hosszú lejáratú erdőgazdasági üzemtervek készítésében. Kandidátusi értekezés, Budapest

Kovács, I. 1979. Faanyagismerettan. Mezőgazdasági Kiadó, Budapest

Z. Nagy, K. Pintér, Sz. Czóbel, J. Balogh, L. Horváth, Sz. Fóti, Z. Barcza, T. Weidinger, Zs. Csintalan, N.Q. Dinh, B. Grosz and Z. Tuba, (2007). The carbon budget of semi-arid grassland in a wet and a dry year in Hungary. Agriculture, Ecosystems and Environment 121 (2007) 21–29.

Short description of the hungarian forest management web page in English: www.aesz.hu/index.php?option=content&task=view&id=295&Itemid=558

Statistical Yearbooks for Agriculture (1965-2006)

Somogyi Z. (2006): How to demonstrate if a pool is not a source? – case study: forest soils is Hungary, Detached National Expert Forest Research Institute, Budapest (http://afoludata.jrc.it/events/Kyoto_technical_workshop/presentations/Z_Somogyi.pdf)

Somogyi, Z., Horváth, B. (2006): Az 1930 óta telepített erdők szénlekötéséről. Erdészeti Lapok CLI. 9. 257-259.

Somogyi, Z., Horvath, B., (2006): Detecting C-stock changes in soils of afforested areas in Hungary. Presentation at the workshop Development of Models and Forest Soil Surveys for Monitoring of Soil Carbon. April 5-8, 2006 at Koli, Finland (www.metla.fi/tapahtumat/2006/soil2006.)

Somogyi Z. (2008): A hazai erdők üvegház hatású gáz leltára. Erdészeti kutatások 2007-

2008. Vol. 92. 154.
(http://www.erti.hu/ek.php?id=1&fn=vol92)

Somogyi Z., J. Merganic, J. Merganicova, Illés G. (2005): CarniInvent WP 8 Final Report – D8.5 Guidelines and improved standards for monitoring and verification of carbon removals in afforestation/reforestation joint implementation projects. Result of the monitoring case study int he test site in Hungary
(www.joanneum.at/carboinvent/D_8_5.pdf)

Sopp L. (1974): Fatömegszámítási táblázatok. Mezőgazdasági Kiadó, Budapest

Temperature zone maps (1971-2000)

Tóth, E. and Koós, S.: 2006. Carbon dioxide emission measurements in a tillage experiment on chernozem soil. Cereal Research Communications. Vol. 34. No. 1. 331-334.

www.akii.hu

www.ksh.hu

Zsembeli, J. and Kovács Gy. (2007): Dynamics of CO_2-emission of the Soil in Conventional and Reduced Tillage Systems. Cereal Research Communications. Vol. 35. No. 2. 1337-1340.

Zsembeli, J., Tuba G. and Kovács Gy. (2006): Development and extension of CO_2-emission measurements for different soil surfaces. Cereal Research Communications. Vol. 34. No. 1. 359-362.

Zsembeli, J., Tuba, G. and Forgács, L. (2005): CO_2-emission of soil in an energy saving soil cultivation system. Realizáciou poznatkov vedy a vyskumu k trvalo udrzatel'nému pol'nohospodárstvu. Michalovce, Slovakia. 59-63.

8. Waste (CRF sector 6.)

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

The major part of municipal solid wastes is treated by managed disposal and a smaller part by reuse, incineration or other means. The average specific municipal household waste generation rate is 1.0 to 1.3 kg/capita/day.

Since the last inventory, some minor changes have been made in the emission calculations of the waste sector. Emissions from solid waste disposal sites were recalculated following a revision of activity data. Although in the last submission, emissions from sludge treatment have been estimated separately for the year 2006, this time we turned back to the formerly used calculation method for the sake of consistency.

8.1. Overview of the sector

The waste sector with 4135.89 Gg CO_2 equivalent represents 5.5% of total national GHG emissions. In the base year (which is 1985-1987) the total GHG emissions from the waste sector amounted to 3073.3 Gg CO_2 equivalent which accounted for 2.6% of total national GHG emissions. Consequently, in contrast with other sectors, the emissions of waste sector show significant increase. However, the growth in emissions has been slowed down in recent years.

In all the years, the largest category is Solid Waste Disposal on Land, representing 72% in 2007, followed by Wastewater Handling (18%) and Waste Incineration (10%). Solid Waste Disposal on Land and Waste Incineration categories are showing an increasing tendency whereas the emissions from Wastewater Handling are decreasing as shown in Figure 8.1.

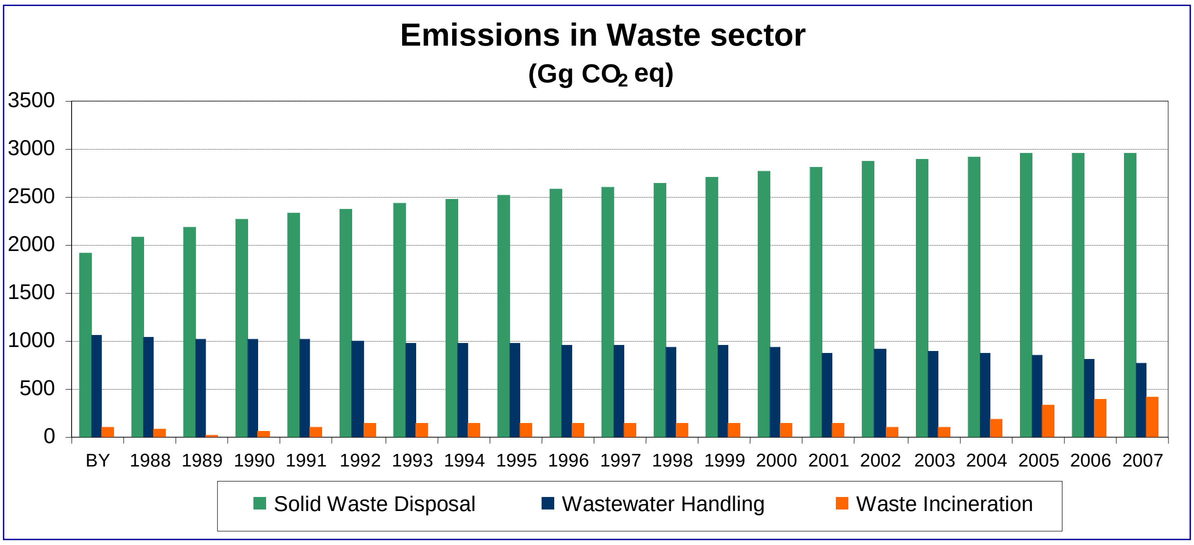


Figure 8.1. *The trend of emissions of the different categories in waste sector*

8.2. Solid waste disposal in landfills (CRF sector 6.A.)

Emitted gas: CH_4
Key source category: Level 1, 2; Trend 1, 2

8.2.1. Source category description

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

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

The available data relate to the annual quantities of municipal waste that are regularly removed and disposed. Some 2/3 of this originates from households, while the remaining 1/3 comes from institutions, services and the industry. This latter is similar to household waste and can be treated together with municipal waste.

8.2.2. Methodological issues

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 has been used. The FOD method produces a time-dependent emission profile which may better reflect the true pattern of the degradation process as it is claimed by the IPCC GPG.

Former inventories were based on a national method which can be described as follows. First, the fraction of organic compound was estimated based on official waste composition data. As the amount of the organic part of the waste, the quantities of the categories “paper”, “decomposing organic” and the half of the amount of “textile” were taken into account. It was assumed that 250 l of biogas is emitted for every kg of organic waste. It was further assumed that half of the emitted biogas is methane and the other half is CO_2 where the latter has not to be taken into account. Knowing the density of methane the emission could be easily calculated. Recovery was subtracted. The national method is in a way similar to the IPCC Tier1 method based on the same assumption that all potential methane is released in the same year when the waste is disposed of. In 2007, for the purpose of comparison, the methane emissions were calculated with all these three methods (national method, IPCC Tier1 and FOD) for the entire times series, using the same background data. The IPCC Tier1 and our national method lead to similar results, the average difference was around 5%. At the same time, the FOD method gave significantly different estimates: in the base year, the calculated emission is only half of the value given by Tier1, and also for the last few years, the FOD estimates are around 15% less than the Tier1 estimates.

8.2.3. Used activity data and parameters

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

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

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

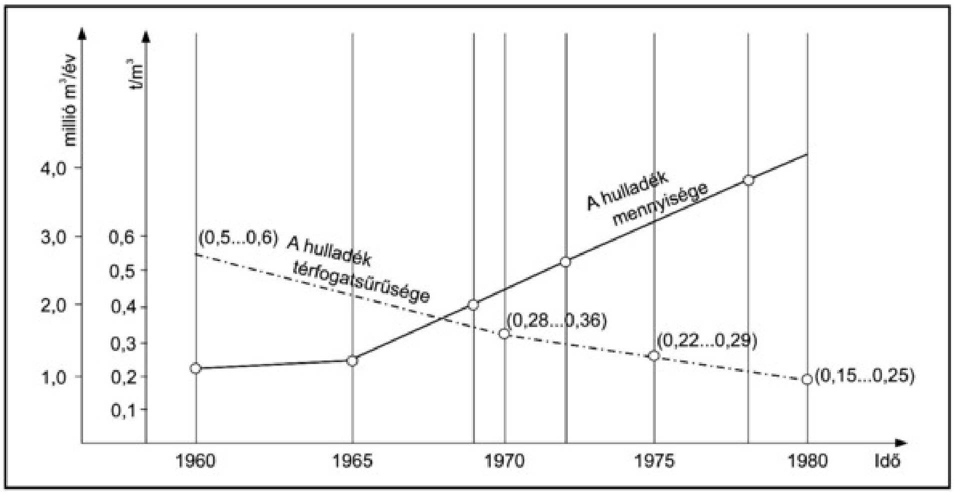


Figure 8.2. *The loosening trend of municipal solid waste in Budapest. The solid line denotes the amount of waste while the dotted line shows the decrease of volume-density. Source:* (http://www.hik.hu/tankonyvtar/site/books/b108/).

Before 2001, the amount of removed solid waste was reported in volume units (m^3), therefore these data had to be converted to mass unit using the gravimetric density (t/m^3) as an important physical characteristic of the waste. Between 1975 and 2000, the value of this parameter decreased from 0.3 t/m^3 to 0.2 t/m^3 based on the data of the Statistical Office. Both international and national studies suggested that the mass of municipal solid waste increased hardly while waste volumes increased drastically all over the world, which is reflected in decrease of the gravimetric density. These changes are attributable to the increasing amounts of paper and plastic in the packaging sector. In other words, this is the so-called loosening trend in MSW which can be seen clearly in Fig. 8.2.

To summarize the above, the following densities were used for conversion from volume to waste units:

Table 8.1. *Waste densities used for conversion*

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

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

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

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

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

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

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

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

	Disposed MSW [Gg]	Paper [%]	Textile [%]	Decomp. Organic [%]	Hyg.	Recovered methane [Gg]	Emitted methane FOD [Gg]	Emitted methane Tier1 [Gg]
1950	1800	22%	5%	30%			**0**	
1975	1872	19%	6%	30%			**58.9**	
Base year	**4018**	**19%**	**6%**	**28%**			**91.3**	**178.9**
1990	3518	20%	7%	32%			**107.8**	171.7
1991	3287	18%	3%	38%			**111.0**	153.8
1992	3367	19%	4%	39%			**113.5**	164.5
1993	3288	17%	7%	35%			**116.3**	152.7
1994	3436	18%	5%	33%			**118.3**	159.1
1995	3481	17%	4%	35%			**120.5**	156.0
1996	3294	19%	3%	32%			**122.6**	149.3
1997	3486	19%	6%	28%	4%		**124.2**	164.7
1998	3575	18%	6%	31%	3%		**126.5**	171.1
1999	3688	20%	5%	31%	3%		**129.0**	180.6
2000	3799	14%	4%	41%	1%		**131.7**	165.1
2001	3696	16%	3%	41%	2%		**134.1**	170.0
2002	3717	16%	3%	31%	2%		**136.4**	155.1
2003	3966	16%	3%	30%	3%		**137.7**	160.1
2004	3978	15%	3%	31%	2%		**139.2**	166.7
2005	4072	15%	3%	29%	2%	0.0	**140.5**	165.1
2006	3902	16%	4%	24%	3%	0.9	**140.8**	152.0
2007	3477	11%	4%	25%	3%	1.7	**140.7**	111.4
Trend	**-13%**						**54%**	**-8%**

8.2.4. Uncertainties and time-series consistency

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

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

The time series can be regarded as consistent.

8.2.5. QA/QC information

It was revealed by the QC procedures that the formerly used recovery data are unfounded. We have revised also the waste composition data, and hygienic waste was added. The calculations in the IPCC Waste Spreadsheet Model have been saved and archived for future reviews. It can be expected that by having better and more detailed data from the Waste Management Information System, the uncertainty of our calculations will decrease.

8.2.6. Recalculation

Emissions were recalculated for the last few years, because hygienic waste was formerly not taken into accout among degradable wastes. This recalculation resulted in a small (1-3 Gg) increase of methane emissions.

8.2.7. Planned improvements

More accurate and more detailed data surveys started in 2001 because Act No. XLIII laid down a new system of rules for Hungary, which has resulted in the amendment of several existing legal systems and the development of new ones since then. In the following years, the range of available data will increase and their accuracy will be significantly improved after the entry into force of a new regulation in compliance with the EU requirements.

We expect more complete recovery data in the future, and we will have waste composition data representative not only for the capital but the whole country.

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

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

8.3.1. Overview of the sector

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

8.3.2. Methodology

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

For domestic wastewater, the activity data - the quantity of Total Organic Waste (TOW) - was calculated by multiplying the population of the country by the IPCC default value of

Biochemical Oxygen Demand that is BOD_5 = 60 g/person/day (Table 6.4 in Volume 5 Chapter 6 of the 2006 IPCC Guidelines). This BOD value was confirmed by Hungarian experts of the Ministry of Environment and Water as well and was used uniformly for the entire times series and for the whole country.

The activity data for industrial wastewater were the total output of wastewater [1000m^3/year] and the Total Organic Wastewater [kg COD/year] which were collected by the regional inspectorates and further processed by the Research Institute for Environmental and Water Management (VITUKI). However, no precise data were available on the industrial wastewater generation in individual sectors, especially for the initial years of the calculation period. Therefore a few years ago, inter- and extrapolation were carried out using also the ratio of the total organic industrial wastewater [kg COD/year]) and the total quantity of wastewater which is known for 2000 (0.008976) and for 1987 (0.005555).

However, our recently used activity data for industrial wastewater seemed not to be correct, especially if they were compared with the data of similar countries or data from the literature. Therefore in 2008 we started to use COD values per wastewater output as given in Table 6.9 in the 2006 Guidelines. Special emphasis was given to industries with high COD output, e.g. food and beverage, paper and pulp, chemical industry. The difference between the new and the formerly used activity data can be as big as an order of magnitude. Unfortunately, we have not had access to activity data for 2007 up to the present, therefore data of 2006 were used for the time being. However, we expect newer data within the next week, so we can update our estimation for our official submission in April 2009.

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

- The Fraction of population with no connection to the public sewerage system (source: Hungarian Central Statistical Office;
- Fraction of total wastewater treated at least biologically (secondary treatment) (source: VITUKI)

Using these additional activity data, the following assumptions were made:
In accordance with the 2006 IPCC Guidelines, for people using septic systems or any other domestic means (no connection to public sewerage system), it can be assumed that half of the BOD settles, therefore MCF=0,5 was chosen. (Table 6.3 in the 2006 Guidelines). In the base year, the portion of population connected to public sewerage system was less than 40% now it's around 68%. It must be noted, however, that the percentage of dwellings connected to public sewerage systems is still below the Central-European average. It is further estimated, based on a study from the year of 2002, that around 20% of the wastewater/sludge is collected from those domestic systems and taken to treatment plants. Newer data indicate that the share of collected wastewater from septic system decreased to 5%.

Usually, collected wastewater undergoes aerobic treatment in the plants. However, as we have not much information about the quality of those plants, MCF = 0.15 was taken as the mean value between the values characteristic for well managed and overloaded aerobic treatment plants. (Table 6.3 in the 2006 Guidelines). For untreated and only mechanically treated wastewater we calculated with MCF=0. In 2007, about 75% of municipal wastewater was treated at least biologically, while 5% was untreated and 20% mechanically treated, which is a great improvement. In 1997 only 56% of wastewater was subject to at least secondary treatment, and 40% was not treated at all.

Considering industrial wastewater, statistics show that only 20% of all wastewater output is treated at least biologically. However, this statistics relates to the volume of the wastewater. If treatment methods are analyzed on COD basis, it can be concluded that about half of the COD is treated at least biologically. The reason behind this difference is the quite large amount of wastewater output with low organic content from some industries, especially the iron and steel industry.

Not enough information is available on the sludge generated during wastewater treatment and on the distribution of the degrading fraction between the water and the sludge phases. Therefore, the emissions from most of the generated sludge were not calculated separately. (Last year we made an attempt for calculating emissions from sludge separately. For the time being we don't have enough activity data to continue this experiment). Nevertheless, the emissions from deposited sludge in landfills are taken into account in the SWDS category. Based on the data from the Energy Centre Hungary, the amount of recovered methane was subtracted.

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

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

	Connected to public sewerage	Untreated or primary treatment	Secondary and tertiary treatment	Recovery Gg CH_4	Emissions domestic wastewater [Gg CH_4]	Emissions industrial wastewater [Gg CH_4]
Base year	39%	55%	45%		38.85	*1.48*
1990	41%	50%	50%		37.42	*1.30*
1991	42%	50%	50%		37.26	*1.17*
1992	42%	50%	50%		37.11	*1.06*
1993	42%	50%	50%		36.92	*0.96*
1994	43%	50%	50%		36.71	*0.87*
1995	43%	50%	50%		36.51	*1.05*
1996	43%	50%	50%		36.30	*1.22*
1997	45%	44%	56%		36.05	*1.07*
1998	47%	42%	58%		35.40	*1.05*
1999	49%	33%	67%		35.63	*0.94*
2000	50%	33%	67%		34.76	*0.90*
2001	52%	36%	64%	1.71	31.84	*0.68*
2002	55%	33%	67%	2.62	30.01	5.12
2003	58%	38%	62%	2.68	27.99	4.51
2004	61%	27%	73%	3.43	27.44	4.22
2005	64%	20%	80%	3.83	26.81	4.01
2006	66%	23%	77%	6.69	25.07	3.42
2007	68%	25%	75%	7.24	23.06	*3.42*
Trend					***-41%***	

As required, nitrous oxide emissions from domestic wastewater effluent were estimated using the IPCC default method and default parameters and emission factor. (Table 6.11 in 2006 Guidelines)
(Emission factor, (kg N_2O-N/kg –N) EF = 0.005, Fraction of nitrogen in protein (kg N/kg protein) F_{NPR} = 0.16 Factor to adjust for non-consumed protein: $F_{NON-CON}$ = 1.1; Factor to allow for co-discharge of industrial nitrogen into sewers: $F_{IND-COM}$ = 1.25)

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

	Protein consumption [g/capita/day]	**Nitrous oxide emission [Gg N_2O]**
Base year	100.0	0.67
1990	104.7	0.69
1995	95.0	0.62
2000	96.6	0.62
2001	93.9	0.60
2002	93.5	0.60
2003	103.0	0.66
2004	105.7	0.67
2005	105.4	0.67
2006	104.6	0.67
2007	104.6	0,66
Trend	***5%***	

8.3.3. Uncertainties and time-series consistency

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

Uncertainty of the emissions from household wastewater treatment:	
Per human populations	-5 % to +5 %
BOD/capita	-30 % to +30 %,
Maximum methane production capacity B_0	-30 % to +30 %
Uncertainty of the emissions from industrial wastewater treatment:	
Quantity of industrial wastewater:	-25 % to +25 %
Wastewater /unit of production COD/ unit of wastewater:	-50 % to +100 %
Maximum CH_4 production capacity B_o :	-30 % to + 30 %
Uncertainty of N_2O emissions	
Emission factor	order of 2
Per capita protein consumption	±10%
Used factors	±20%

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

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

8.3.4. QA/QC information

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

8.3.5. Recalculation

Initially, the emissions from this sector *were not calculated* for the period between 1985 and 1990, and this was completed during the first phase of the recalculation project. In addition, the emissions of the years from 1991 through 1997 were recalculated in the second phase.
In response to the recommendations of the Expert Review Team, the entire time series were recalculated in spring of 2007.
The emissions from industrial wastewater treatment have been recalculated for the years 2002-2005.

8.3.6. Planned improvements

According to a recently adopted legal instrument, operators are obliged to supply detailed data provided the rate of emission exceeds 15 m^3/day or the wastewater contains hazardous substances. As a result, more detailed information is expected to become available later on. Consistency of the time-series has to be verified and in case of industrial wastewater it has to be established.

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

8.4.1. Overview of sector

Emitted gases: CO_2, N_2O
Key source: none

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

8.4.2. Methodology

In Hungary, municipal waste incineration is carried out at only two places (at the Waste Incineration Works of Budapest and in Mátra Power Plant) and it is combined with power cogeneration. Recently, in 2004-2005, the former has been under reconstruction and operated at a reduced capacity. After project completion, its capacity increased but pollutant emissions were reduced.

For the calculation of CO_2 from fossil sources, we followed the recommendations of the Background Paper (page 459) published as a complement to the Revised Guidelines, i.e., a ratio of 0.415 (the average of the range of 0.33 to 0.5) was selected as the fossil proportion of CO_2 assuming a production rate of 1 t CO_2/t waste. This way, one can also calculate the amount of CO_2 released from biogenic waste using the ratio of 1-0.415, of course. (The latter is not included in the total of the emission inventory.) On the other hand, the incineration plant also calculated the ratio of the fossil part for 2002 and 2003, which was 50-52% in comparison with the default value. For these two years, these plant-specific values were used.

Now, the inventory compilers have access to the more detailed Waste Management

Information System which made possible to use Tier 2 method for calculating CO_2 emissions for the years 2004-2007. For the calculations, country-specific waste amount and component data were taken from this database and the emission factors were calculated using the default carbon content and fossil carbon fraction data from Table 2.4 – 2.6 in the 2006 Guidelines. The quantities of incinerated *municipal* waste and the time-series emissions of CO_2 *from fossil origins* are shown in the table below (Gg):

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

	BY	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
Waste, Gg Budapest	244	152	330	348	353	258	192	160	303	398	389
Waste, Gg All Incineration	244	152	330	348	353	258	244	367	642	765	761
Fossil CO_2, Gg	98	63	137	145	146	107	99	172	316	382	388

The decreases in the incinerated quantity between 1988 and 1990 and in 2003-2004 are caused by the reconstruction of the incineration plant.

According to our previous estimation, the quantity of incinerated industrial waste was about 40 % to 50 % of the municipal waste. However, the more detailed data from 2005-2007 show that the amount of incinerated industrial waste increases and it can be of the same magnitude as the amount of incinerated municipal waste. In 2005, the Waste-to-Energy Plant incinerated 303 Gg, while other facilities incinerated 339 Gg waste of different origin. In 2007 389 Gg municipal waste was incinerated together with 372 Gg industrial waste.

The N_2O emissions were recalculated using the default values of Table 5.6 in the 2006 Guidelines, that are 50 g N_2O / t for MSW, 100 g N_2O / t for industrial waste and 900 g N_2O / t for sludge. Previously, the value recommended by the Good Practice Guidance, which is 8.33 kg / kt, was used. That means a change of an order of magnitude, nevertheless, its effect is negligible in the inventory.

8.4.3. Uncertainties and time-series consistency

Data from the Incineration Works of Budapest are considered appropriate because they were obtained directly from the plant. Therefore, the ±5 % uncertainty recommended by the Good Practice is acceptable. The uncertainty of the default specific emission factors is likely to be higher. The uncertainty of N_2O emissions may exceed 100 %. Data from hazardous waste incinerators and co-incinerators are also precise and measured data. Certain incinerators did not supply data or supplied estimations only. The time series is most probably consistent.

8.4.4. QA/QC information

The Waste Incineration Works in Budapest operates a quality assurance system in compliance with the ISO 9000 series.

8.4.5. Recalculation

No recalculations this time.

9. OTHER (CRF sector 7.)

This sector not in use.

10. RECALCULATIONS

10.1. Explanations and justifications for recalculations and their implications for emission levels and trends

Although inventories have been prepared annually since 1994, the consistency of the entire time series (1985-2003) could be ensured only by 2005. All the changing reporting requirements were met even if with delays due to limited human resources. In addition to the recalculations, great emphasis was put on the determination of the Hungarian country-specific emission factors for the important technologies. All of these led to several recalculations of the inventories, thus the calculated values of the emissions changed accordingly. Since the details of those changes are described in the previous NIRs, this time we confine ourselves to the differences from the last submitted inventory.

10.1.1. ENERGY SECTOR

Emission and consumption in sectoral approach of natural gas used as feedstock was removed from *energy sector*. After consultation with Energy Centre, the Energy Statistics's provider, it became clear that emission from natural gas as feedstock is already treated in the sector of *industrial processes*. Nowadays, natural gas is used for producing ammonia, ethylene and carbon black. Distribution of fuel consumption between the above mentioned sectors can be seen in Fig. 3.1. Fig. 3.2. shows the CO_2 emission before and after the recalculation in the *energy sector (1.AA.2.C)*.

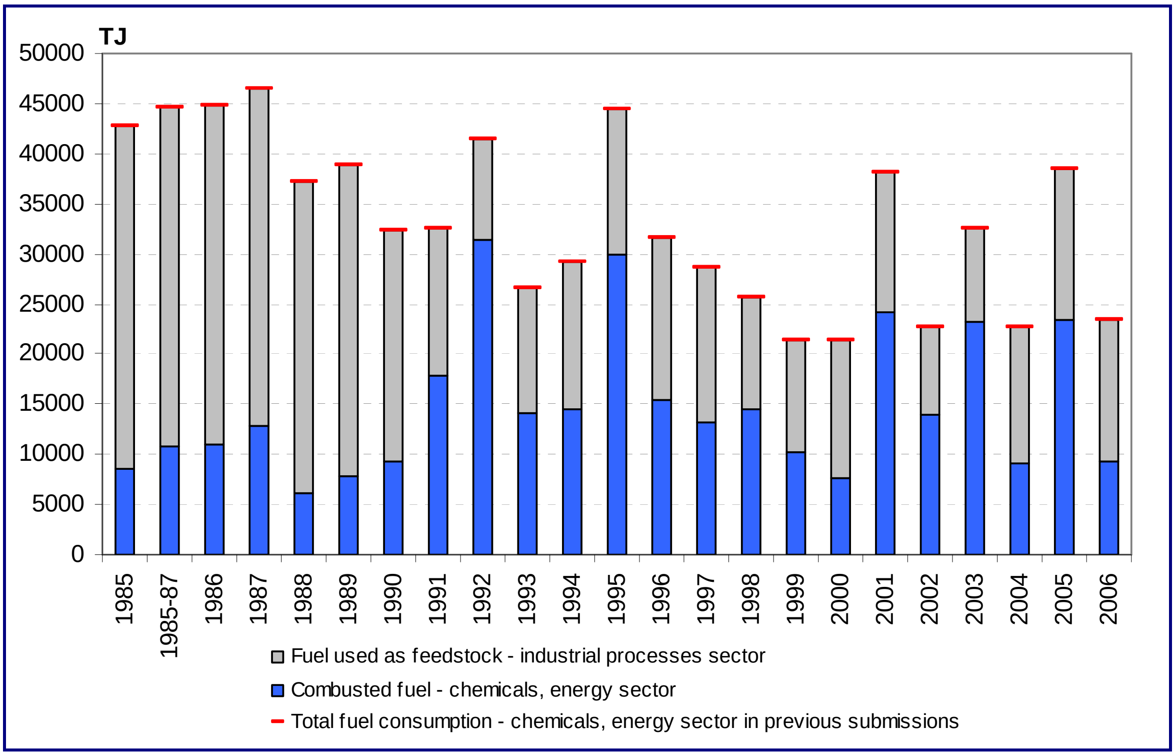


Figure 10.1. *Distribution of fuel consumption among sectors.*

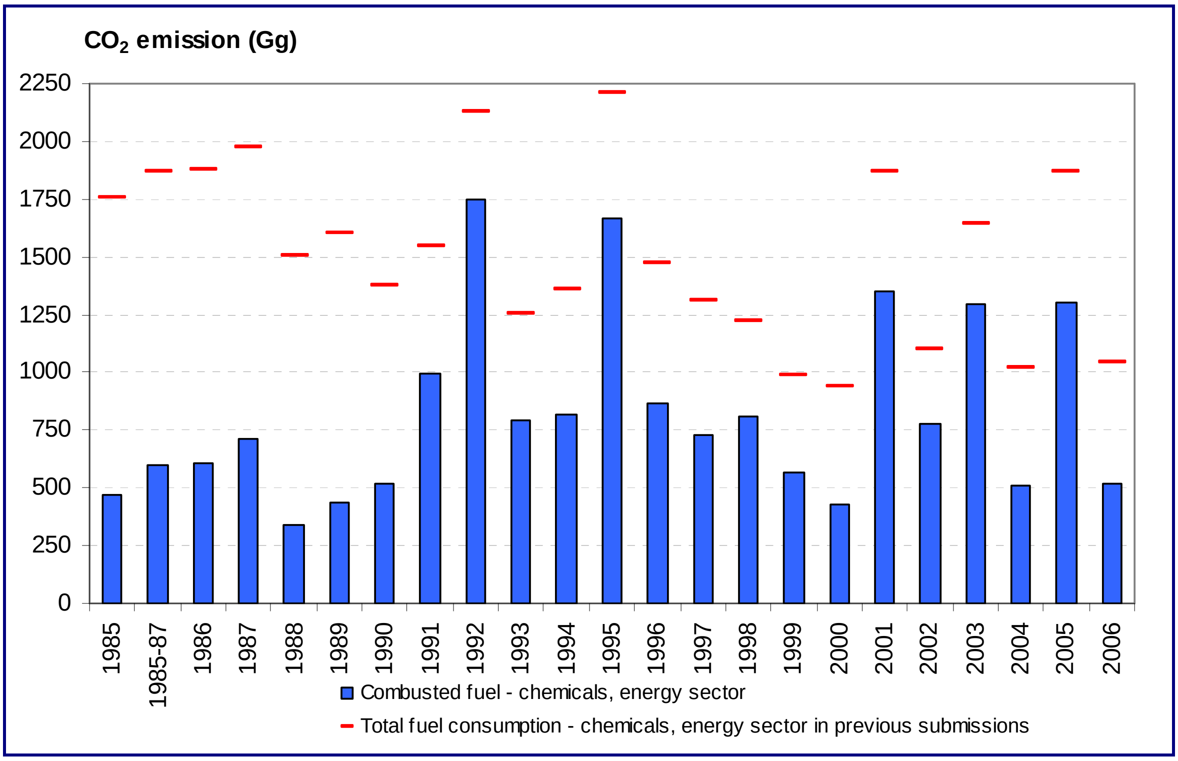


Figure 10.2. *CO_2 emission in the energy sector (1.AA.2.C) before and after the recalculation.*

Until 2008 submission petroleum refining was reported under *manufacture of chemical products* (1.AA.2.C). During the segregation process the original CH_4 and N_2O emission factors were kept, which were used in chemical industry, for petroleum refining until 2005. For 2006 and 2007, calculation was made with default IPCC 2006 values. In this submission the old factors were changed to default ones to create consistent time-series. This recalculation decreased the aggregated emission of the sector by 33 Gg CO_2 eq. on the average.

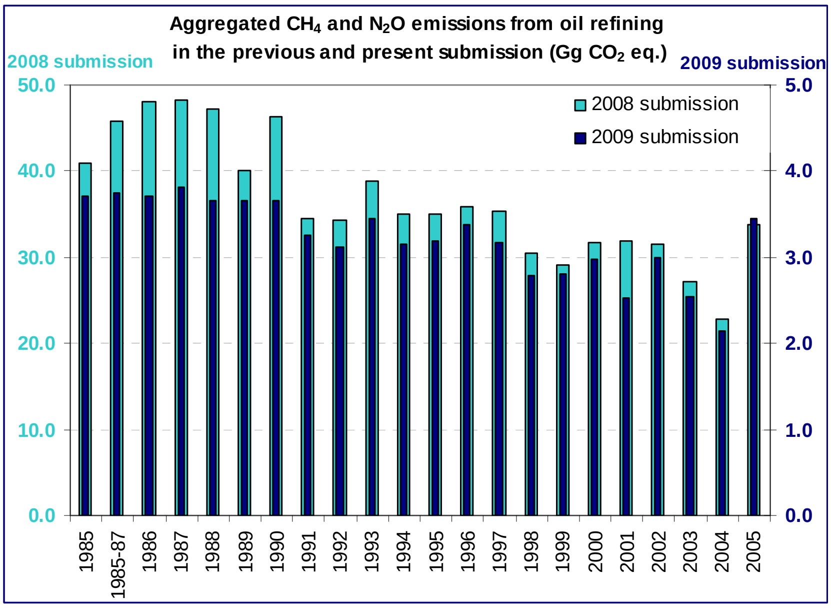


Figure 10.3. *Changes in aggregated CH_4 and N_2O emissions of oil refining as a consequence of recalculation to have consistent time-series*

10.1.2. AGRICULTURE SECTOR

The reasons for the recalculations are as follows:
4.A Enteric fermentation

- Following recommendations of the 2007 in-country review of Hungay's GHG inventory CH_4 emissions were recalculated in the categories of 4A Enteric Fermentation, Dairy Cattle and Non-dairy Cattle for the whole time series. The amount of the emission as well as timely change of the livestock (body mass, net energy requirements, feed rations, methane conversion rate, etc.) made necessary the implementation of Tier 2 methodology and the elaboration of the country-specific emission factors.
- Report of the cenrelized review undertaken in 2008 suggested for Hungary to include the rabbit and guinea fowl livestock in the inventory as well. In the course of the recalculation these livestock were taken into account (rabbit is accounted as other livestock and the guinea fowl livestock is included in poultry livestock).
- In the course of a QC procedure a minor error was found in the animal livestock data of poultry in the time series 1985-1999. The faulty data were corrected

4.B Manure management CH_4

- Tier 2 methodology (rabbits excluding) was adopted.
- According to the centralized review report the emissions from rabbit and guinea fowl livestocks is accounted (see 4.A Enteric Fermentation).
- The faulty data in animal population of Poultry were corrected in the time-series 1985-1999 (see 4.A Enteric Fermentation).

4.B Manure management N_2O

- According to the report of the latest centralized review the Rabbits as other livestock and Guinea fowls are included (see 4.A Enteric Fermentation).
- Faulty data on animal livestock of Poultry for the time series 1985-1999 was corrected (see 4.A Enteric Fermentation).

4.D.1.1 Direct Soil Emissions Synthetic Fertilizers

- In 2008 the Hungarian Central Statistical Office revised the data formerly provided for the years of 2004 and 2006 on the use of nitrogen fertilizers

4.D.1.2 Direct Soil Emissions Animal Manure

- According to the recalculaton of 4.B Manure management the amount of animal manure applied to soils changed for the whole time-series.

4.D.3.1 Indirect Emissions Atmospheric Deposition and 4.D.3.2 Indirect Emissions Nitrogen Leaching and Run off

- In 2008 the Hungarian Central Statistical Office revised the data formerly provided for the years of 2004 and 2006 on the use of nitrogen fertilizers
- According to the recalculaton of 4.B Manure management the amount of animal manure applied to soils have changed for the whole time-series.

Recalculations resulted in values higher by 12.0% on average in the case of the entire emissions (in CO_2-equivalents) of the agricultural sector (Range: 10.8% - 14.8%). The increase by individual gases is 44.8% on average for CH_4 emissions (Range: 39.8% - 50.6%), and 1.4% on average for N_2O emissions (Range: 0.7% - 3.0%).

10.1.3. LULUCF SECTOR

Recalculations for LULUCF include reporting of emissions/removals of Forestland and Cropland subcategories. The mean of changes after the recalculation is 28%. The following are the principal changes leading to recalculations:

- In the course of our quality control revealed that there was a sign mistake in our calculation sheet of the estimation of Forest Land living biomass, so we replaced the values in CRF table with the correct numbers for the whole time series in the 5.A.2.1 Cropland converted to Forestland category.

- In the period 2004-2006 minor transcription errors caused by rounding in decimals had been found between our calculation sheet and CRF table in the category 5.A.1 Forest Land remaining Forest Land. The errors were corrected.

- In 5.B.Cropland remaining Cropland/ Carbon stock change/ mineral soils recalculation has been undertaken due to changes in the activity data. In 2008 the Hungarian Central Statistical Office revised the data previously provided for the year 2005 and 2006 on Vineyard area.

- Revision of estimation of 5.B.Cropland remaining Cropland/ Carbon stock change/ living biomass for the whole time series. The recalculation has been undertaken in accordance with the GPG for LULUCF (IPCC, 2003) Tier 1 methodology, by vineyard and orchard plantation and harvesting statistics of the Hungarian Statistical Office and estimated activity data, partially.

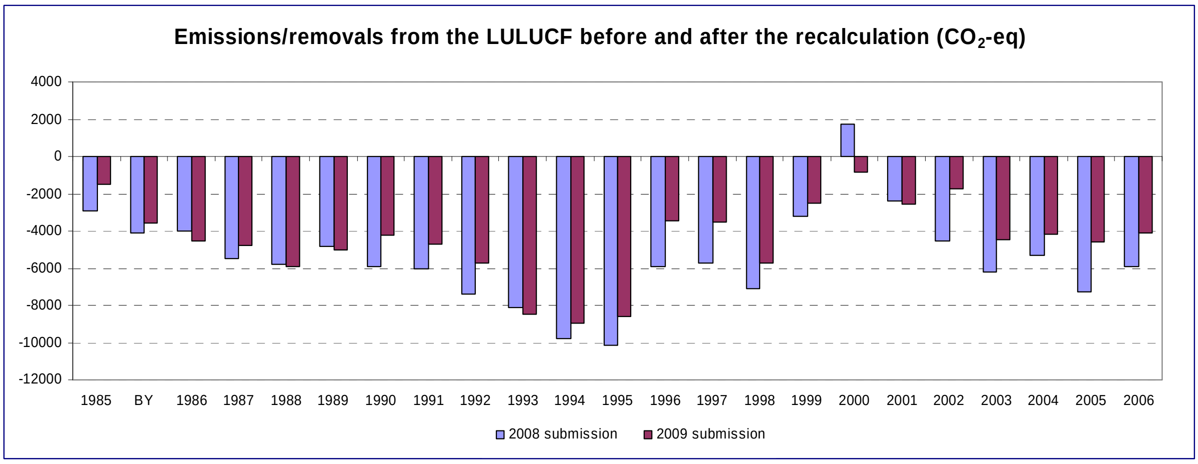


Figure 10.4. *CO_2-eq emissions/removals from LULUCF before and after the recalculation.*

There was also a small modification in the solid waste disposal category due to revised waste composition data. The effect of the recalculation was around 2.5 Gg more methane emissions for the last few years.

10.2. Planned improvements to the inventory

The revision of the LULUCF sector will be continued and all preparatory measures will be taken to be in a position in 2010 to report the selected forest management activity in accordance with the requirements of the Kyoto Protocol.

A new project has been started with the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) in order to improve our land-use area system to be able to apply the Approach2 method in the future.

A new project will be started to increase the consistency between different emission databases, especially the GHG inventory, the ETS data and the E-PRTR data. Also the development of a common central database is planned.

The inventory division is going to have direct access to emission reports from polluters under the governmental decree 21/2001. We would like to analyse the dataset and update the current country specific emission factors

It is planned to investigate the relation of fugitive emission from natural gas pipelines and emission from *residential* and *commercial/institutional* natural gas consumption.

The present consistency problems will be analysed further, especially in transport (CH_4, N_2O), cement production and industrial wastewater categories.

A multistage, methodological development program, jointly with the Research Institute for Animal Breeding and Nutrition, titled “Development and regular review of country-specific emission factors for the agricultural greenhouse gas (methane, nitrous oxide) inventory” is still in progress.

Our uncertainty estimation is planned to be refined, as well.

11. SUPPLEMENTARY INFORMATION

This submission is meant to be both under UNFCCC and the Kyoto Protocol. The latter requires supplementary information to be reported.

11.1. Calculation of the commitment period reserve (CPR)

The commitment period reserve is calculated in accordance with Annex to decision 18/CP.7. as 90% of the assigned amount or 100% of five times of the most recently reviewed inventory, whichever is the lowest.

Following the approach recommended by the expert review team, Hungary has interpreted the “most recently reviewed inventory” to mean the inventory 2007 as contained in the present 2009 inventory submission.

Calculations:
a./ On the basis of assigned amount:
90% of the assigned amount of Hungary that was fixed in 2007:
0.9 * 542,366,600 = 488,129,940 Mg CO_2 eq
b./ On the basis of the most recent inventory (2007):
75,943,517 * 5 = 379,717,586 Mg CO_2 eq

Based on the calculations above, Hungary's commitment period reserve is:
379,717,586 Mg CO_2 eq.

11.2. Information on changes in national system

There were changes neither to the national system nor to the registry in the level of the main responsibilities. The single national entity is the Ministry of Environment and Water, the Hungarian Meteorological Service is the responsible institute for inventory preparation.

However, new sectoral expert institute (Central Agricultural Office) has been involved in the preparation of the forestry part of the LULUCF inventory. This new institutional arrangement for LULUCF inventory preparation means that an institute instead of an individual has became responsible for the inventory preparation. It is planned that the participation of the Central Agricultural Office will be formalised by a government decree which is expected to enter into force in 2009.

Regarding QA/QC activities, it shold be mentioned that following an in-depth audit of our procedures, the ISO certification of HMS has been renewed in January 2009 which means that the GHG inventory preparation process is also subject to ISO 9001:2008. In addition, a new ISO document was introduced to enable the documentation of sector specific quality checks. This document includes a compulsory check list, summary of results of checks, suggestions for corrective actions similarly to the example given in Annex 6A of the 2006 Guidelines. Although this document is in the testing phase, the first experiences are promising (See Fig. A6-3 in ANNEX 6). The report on Forest Land category was reviewed externally by an internationally recognized expert on LULUCF as an important element of our QA/QC for the 2009 submission. The review report is available in Annex 3.4.

11.3. Information on changes in national registry

Changes to Hungary's National Registry are reported for the following period: from 29 August 2007 (Initial Review Report) to 15 April 2009.

The baseline for the reported changes is the Initial Report (submitted on 30 August 2006, updated on 27 September 2006), the Readiness Documentation and the Initial Review Report. Changes to the national registry during the reporting period are detailed in Annex 8, which was created in accordance with the provisions of the "SIAR Reporting Guidance for Registries".

The National Registry of Hungary has connected to the ITL on 11 July 2008 independently from the other EU member states. During the ETS-ITL Go-live process the National Registry of Hungary has connected to the CITL as well.

Hungary is in the process to replace its currently used GRETA v3.0 registry software with the latest version of the Community Registry (CR) software. The migration is planned to take place during 2009. To address all the future (after 15 April 2009) changes required by the software change, Hungary will submit a complete updated Amended Readiness Documentation (according to point 4.4 of SIAR Reporting Guidance For Registries) as soon as it will be available.

The currently used registry software has not been updated to be able to automatically generate the SEF report, since by the time of next year's SEF report Hungary will most likely use the CR software and, due to the very low number of transactions in the reporting period, the quality of the reported SEF data could be ensured by using manual database queries. The SEF report has been created using UNFCCC SEF Application v1.2 in "official" mode.

Change in contact details of the Registry Administrator

The alternative contact is Ms Katalin Kőbányai instead of Ms Adrienn Dunai

Name:	Ms. Katalin Kőbányai
Position:	Expert
Organization:	National Inspectorate for Environment, Nature and Water
Address:	Mészáros utca 58/a
City:	H-1016 Budapest
Tel.:	+36 12 24 9190
Fax:	+36 12 24 9298
E-mail:	kobanyai@mail.kvvm.hu