Hungarian Meteorological Service
Greenhouse Gas Inventory Division

National Inventory Report for 1985-2006

Hungary

April 2008

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

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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 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), 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 Kht., az Állattenyésztési és Takarmányozási Kutatóintézet, a Környezetvédelmi és Vízgazdálkodási Kutató Intézet Kht. és a Debreceni Egyetem.

Jelen leltár az 1985 és 2006 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 hozzáférhető 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 2006. évi ÜHG kibocsátása 78,6 millió tonna szén-dioxid egyenérték volt, ami a rendszerváltozás előtti értéknél 32%-kal alacsonyabb. A 8 tonnánál kevesebb 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 kibocsátás csökkenés jelentős részben a rendszerváltozás, vagyis az energetikai, ipari és mezőgazdasági termelés radikális csökkenésének következménye. Noha az ország kibocsátása 2005-höz képest is csökkent 2%-kal, az elmúlt 10 év adataiból már nem rajzolódik ki markáns trend, az ÜHG emisszió 79 millió tonna körül ingadozik.

A 2005 és 2006 közötti kibocsátás csökkenés nagyrészt az energiaszektorban zajló folyamatok eredménye (-1,6 millió tonna).

- A fűtési időszakban az átlagos napi középhőmérséklet 0,74℃-kal volt magasabb az előző évinél, így a fűtési energiaigény mintegy 4%-kal, a lakosság gázfogyasztása pedig 7%-kal csökkent. Ugyanakkor a villamos energiatermelés fosszilis energiaráfordítása kis mértékben emelkedett.
- A vegyipar tüzelési célú fosszilis energiaigénye csökkent, ugyanakkor a nem

energetikai célú kőolajtermék felhasználás nőtt; e két folyamat eredményeként a CO2 kibocsátás csökkent.

- A fenti trendekkel szemben a közlekedési kibocsátás 4%-kal nőtt.

Az ipari folyamatok szektorban 6%-kos kibocsátás csökkenést volt tapasztalható (-0,4 millió tonna). Az építőipar növekedése nem ellensúlyozta a vegyipari termeléscsökkenésből és modernizációból fakadó kibocsátás csökkenést. Az alumíniumgyártás leállításával az ágazat kibocsátása a felére esett vissza.

A földhasználat változása, az erdőtelepítések és az erdőgazdálkodás összességében nyelőként viselkedik, vagyis ezek a folyamatok mintegy 6 millió tonna szén-dioxidot vonnak ki a levegőből.

Üvegházhatású gázok kibocsátása (CO_2 eé, Gg)	Bázis-év	1990	1995	2000	2002	2003	2004	2005	2006
CO_2, nyelők nélkül	85 795,5	73 335,2	62 046,0	59 201,8	58 822,2	62 124,6	60 401,1	61 662,1	60 388,8
CH_4, nyelők nélkül	10 139,2	9 455,5	8 216,6	8 271,4	8 182,4	8 183,0	7 957,3	7 891,0	7 808,4
N_2O, nyelők nélkül	19 223,7	15 132,5	8 825,9	9 557,7	9 452,5	9 420,8	10 180,8	9 716,9	9 574,9
HFC-k	1,74	0	1,74	205,7	403,6	498,9	525,8	517,6	606,9
PFC-k	166,8	270,8	166,8	211,3	203,3	189,6	201,1	209,4	1,5
SF_6	70,2	39,9	70,1	140,1	119,6	161,9	178,2	201,0	244,4
Kibocsátás (nyelőkkel)	**112 661**	**92 340**	**69 191**	**79 361**	**72 662**	**74 404**	**74 160**	**72 941**	**72 715**
Kibocsátás (nyelők nélkül)	**115 397**	**98 234**	**79 327**	**77 588**	**77 183**	**80 579**	**79 444**	**80 198**	**78 625**

A legfontosabb üvegházhatású gáz a szén-dioxid, amely az összes kibocsátás 77%-áért felel. A szén-dioxid emisszió döntő részben az energiaszektorban keletkezik, a fosszilis tüzelőanyagok elégetése révén. A CO_2 kibocsátásunk 30%-kal csökkent a 80-as évek közepe óta. A metán 10%-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 24%-kal csökkent. A 12%-nyi dinitrogén-oxid elsősorban a mezőgazdasági talajokból, illetve vegyipari termelés következtében kerül a levegőbe. A mennyisége a felére esett vissza 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 több mint háromnegyede az energiaszektor számlájára írható. A mezőgazdaság 11%-kal, az ipari folyamatok további 8%-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 (1985-2006)*
Megjegyzés: BY=a bázisév az 1985-87-es évek átlaga és 1995 az F-gázokra

2006-ban az *energiaszektor* a teljes kibocsátás 76,1%-áért volt felelős. A fosszilis tüzelőanyagokból keletkező szén-dioxid a legnagyobb tétel az üvegházhatású gázkibocsátások között, a szektor kibocsátásában 94,5%-ot képvisel, ezt követi a metán 4,1%-kal, majd a dinitrogén-oxid 1,4%-kal. A tüzelőanyagok közül az elégetett gáz okozza a legnagyobb kibocsátást (47,0%), majd a folyékony és a szilárd tüzelőanyagok következnek, s ez utóbbiaknak már csak 22,2% 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 csökken a teljes kibocsátás. Az energiaszektoron belül legjelentősebb az "energiaipar" alszektor 32,3%-kal, majd ezt követi a közületek, háztartások és mezőgazdaság fogyasztása ("egyéb szektor"), mely 28,1%-kot képvisel a teljes kibocsátásban. A legdinamikusabban ugyanakkor a közlekedés kibocsátása nő, 2005-höz képest 4%-kal, a 80-as évek közepéhez viszonyítva pedig 63%-kal volt magasabb az emisszió.

2006-ban a *mezőgazdaság* volt a második legjelentősebb szektor Magyarország üvegházhatású gáz leltárában, 11%-kal járult hozzá a teljes kibocsátáshoz. Az ágazat hozzájárulása a teljes emisszióhoz 1985 óta kismértékben ugyan, de folyamatosan csökkenő. (1985-ben még 15% 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 (69%) 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 emésztéséből származó CH_4 emisszió.

Az *ipari folyamatok* szektor a harmadik legnagyobb kibocsátó hazánkban, a teljes kibocsátás 7,5%-ért felelős. A legjelentősebb üvegházhatású gáz az ipari tevékenységek során a CO_2, ez 57,7%-ban járul hozzá a szektor kibocsátásához, majd ezt követi a N_2O 27,6%-kal és az F-gázok 14,5%-kal. A szektor kibocsátása 43,5%-kal csökkent a bázisévhez képest, az elmúlt évhez viszonyítva pedig 6,1%-os a csökkenés. A legnagyobb kibocsátók közé tartozik a salétromsav-, a cement- és az ammóniagyártás. Az *oldószerek és egyéb termékek használata* szektor a teljes kibocsátás 0,4%-át teszi ki. A bázisévhez viszonyítva ez 10,5%-os csökkenést jelent. Két jellemző üvegházhatású gáza a CO_2 és N_2O: az előbbi részesedése a szektorban 83,3%, az utóbbié 16,7%.

A *hulladékszektor* 5%-kal járul hozzá a teljes kibocsátáshoz. Szemben az előzőekben felsorolt ágazatokkal, a hulladékkezelésből származó emisszió növekszik, 2006-ban 34%-kal volt magasabb a kibocsátás, mint 20 évvel korábban. A szilárd hulladék lerakásából keletkezik a kibocsátás zöme (70%), míg a szennyvízkezelés 20%-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 többnyire nyelőnek tekinthető. (Ez alól egyedül a 2000. év volt kivétel, amikor a szektor kibocsátó volt a szőlők és gyümölcsösök fás biomasszájának jelentős csökkenése miatt). 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 fluktuál. 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 2006 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	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
NO_X	262.5	264.2	264.9	257.8	246.8	238	203.1	183.3	184	187.4	190.07
CO	931.1	--	--	963.1	--	997	913.4	835.8	796.1	774.29	761.29
NMVOC	232	263	228	215	205	205	149.6	141.8	149	142.4	150.3
SO_2	1403.6	1361.8	1285.3	1218	1102	1010	913	827.3	757.3	741	704.96

Indirekt gázok	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
NO_X	195.81	199.5	202.62	197.4	185.1	183.2	183.0	210.7	185.3	203.1	202.21
CO	726.87	733.36	736.93	592.4	592.4	578.8	573.8	600.3	585.4	585.2	595.81
NMVOC	150.1	145.4	140.6	165.5	166.0	162.3	160.1	169.0	157.0	176.2	186.77
SO_2	673.23	658.51	591.79	598.0	489.0	403.9	364.9	347.8	248.8	146.6	123.69

2. táblázat *Indirekt gázok kibocsátása. Az adatbázis nem teljes 80-as években.*

A kén-dioxid jelentős (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 Research Institute for Environmental and Water Management, 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 1985-2006. 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 2006, total emissions of greenhouse gases in Hungary, were 78.6 million tonnes carbon dioxide equivalents (excluding the LULUCF sector). With less than 8 tonnes, the Hungarian per capita emissions are below the European average. By ratifying the Kyoto Protocol, Hungary commited to reducing its GHG emissions by 6%. Now, our emissions are 32% lower than in the base year (average of 1985-87). However, this significant reduction is 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.

Emissions decreased by 2% (-1.6 million tonnes) between 2005 and 2006. However, there is no significant trend in the emissions of the last 10 years, they fluctuate around 79 million tonnes. Nevertheless, the reduction between 2005 and 2006 is mainly due to processes in the energy sector (-1.3 million tonnes):

- In the heating period, the daily mean temperature was 0,74 ^{o}C higher than in the previous year, so the energy demand of heating decreased by roughly 4 %. The natural gas consumption in the residential category decreased by 7%. At the same time, the fossil fuel input of electricity generation slightly increased.
- The fossil fuel needs of the chemical industry decreased, despite the increase in the use of petroleum products for non-energy purposes.
- In contrast with the above trends, the emissions in the transport sector grew by 4%.

Emissions from industrial processes decreased by 6% (-0.4 million tonnes). The growth in the building industry sector could not offset emission reduction due to decreased production and modernization in the chemical industry. By closing down the aluminium production, the emissions in the metal industry category were halved.

The most important greenhose gas by far is carbon dioxide accounting for 77% 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 30% since the middle of the 80's. Methane represents 10% in the GHG inventory. Methane is generated mainly in waste disposal sites and animal farms, but the fugitive emissions of natural gas is also an important source. CH4 emissions are 24% lower than in base year. Nitrous oxide contributes 12% to the total GHG emissions. Its main sources are the agricultural soils and the 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 growing tendency especially due to their applications in the cooling industry.

GREENHOUSE GAS EMISSIONS (CO_2 eq. Gg)	BY fixed	1990	1995	2000	2002	2003	2004	2005	2006
CO_2 . without LULUCF	85,795.5	73,335.2	62,046.0	59,201.8	58,822.2	62,124.6	60,401.1	61,662.1	60,388.8
CH_4 . without LULUCF	10,139.2	9,455.5	8,216.6	8,271.4	8,182.4	8,183.0	7,957.3	7,891.0	7,808.4
N_2O . without LULUCF	19,223.7	15,132.5	8,825.9	9,557.7	9,452.5	9,420.8	10,180.8	9,716.9	9,574.9
HFCs	1.74	0.0	1.74	205.7	403.6	498.9	525.8	517.6	606.9
PFCs	166.8	270.8	166.8	211.3	203.3	189.6	201.1	209.4	1.5
SF_6	70.2	39.9	70.1	140.1	119.6	161.9	178.2	201.0	244.4
Total (including LULUCF)	**112,661**	**92,340**	**69,191**	**79,361**	**72,662**	**74,404**	**74,160**	**72,941**	**72,715**
Total (excluding LULUCF)	**115,397**	**98,234**	**79,327**	**77,588**	**77,183**	**80,579**	**79,444**	**80,198**	**78,625**

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

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

By far, the biggest emitting sector was the Energy sector contributing 76% to the total GHG emission in 2006. Agriculture was the second largest sector with 11% while emissions from Industrial Processes (with Solvent and other product use) accounted for 8% and the waste sector contributed 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 gmissions from base year (1985-2006)*
Note: BY=average of 1985-87 but 1995 for F-gases

The *Energy sector* was responsible for 76.1% of total GHG emissions in 2006. Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 94.5% to sectoral emission, followed by CH_4 with 4.1% and by N_2O with 1.4%, in 2006. Among fuels, gases have the highest proportion (47.0%), liquids have less, and solids have the lowest, but the latter still represents 22.2% of the sectoral CO_2 emissions. Due to the changes in the fuel-structure in the '90s the most important source in the base years, the solid fuel have been displaced by natural gas decreasing the total emission. The most important subsector of the energy sector is Energy Industries with a proportion of 32.3%, followed by Other Sectors which represents 28.1% of the total emissions in this sector.Fugitive Emissions from Fuels play only a small role in emissions of the sector with 3.6%. The most dynamically increasing category is Transport which has 4% higher total emission in 2006 compared to 2005.

In 2006, *Agriculture* was the second largest source of greenhouse gas emissions in Hungary. It accounted for 10.7 percent of total emissions. The contribution of agriculture to total emissions decreased over the period 1985-2006 from 15.0% 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 68.74 percent of total N_2O. The total emissions from agriculture decreased over the period 1985-2006. 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 2006.

The *Industrial Processes* is the third largest sector contributing 7.5 % to total GHG emissions in 2006. The most important greenhouse gases during the industrial process is CO_2, contributing 57.7% to total GHG emissions in this sector, then followed by N_2O with 27.6% and F gases with 14.5%. The total sectoral emissions decreased by 43.5% between base year and 2006 and by 6.1% between 2005 and 2006. The most important emission subcategories are chemical industry and mineral products representing 41% and 40%, respectively.

The *Waste sector* represents 5.2% of total national GHG emissions. In contrast with other sectors, the emissions of waste sector show significant increase (+34%). In the base year the total GHG emissions from the waste sector accounted for 2.6% of total national GHG emissions. In all the years, the largest category is Solid Waste Disposal on Land,

representing 70% in 2006, followed by Wastewater Handling (20%) 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 most of the years and a net source of emissions in 2000. This result is determined largely by Forest Land, which is a major carbon sink. The Cropland living biomass is usually a net sink of carbon but can be 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 2006, the net removal was -5.9 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:

Indirect gases	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
NO_X	262.5	264.2	264.9	257.8	246.8	238	203.1	183.3	184	187.4	190.07
CO	931.1	--	--	963.1	--	997	913.4	835.8	796.1	774.29	761.29
NMVOC	232	263	228	215	205	205	149.6	141.8	149	142.4	150.3
SO_2	1403.6	1361.8	1285.3	1218	1102	1010	913	827.3	757.3	741	704.96

Indirect gases	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
NO_X	195.81	199.5	202.62	197.4	185.1	183.2	183.0	210.7	185.3	203.1	202.21
CO	726.87	733.36	736.93	592.4	592.4	578.8	573.8	600.3	585.4	585.2	595.81
NMVOC	150.1	145.4	140.6	165.5	166.0	162.3	160.1	169.0	157.0	176.2	186.77
SO_2	673.23	658.51	591.79	598.0	489.0	403.9	364.9	347.8	248.8	146.6	123.69

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

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. Therefore, 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 summers is 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, the rising of the risk is 30%. 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℃ by linear estimation for 106 years.*

Heating degree day (HDD) and cooling degree day (CDD) are quantitative indices demonstrated to reflect demand for energy to heat or cool houses and businesses. These indices are derived from daily temperature observations. The degree days were calculated over a year by adding up the differences between each day's mean daily temperature and the balance point temperature of 18℃. If the daily mean temperature is greater than 18℃, then we have (average temperatur e - 18) cooling degree days. If the average temperature is less than 18 degrees, then we have (18 - average temperature) heating degree days. The following figures show the time series of these indices. It can be seen that especially the cooling degree day values can show significant changes year by year.

Figure 1.2. *Heating degree day values in Hungary for the period 1985-2005*

Figure 1.3. *Cooling degree day values in Hungary for the period 1985-2005*

The year 2006 was countrywide a *bit warmer* than the average of many years. However, during the year there were also temperature extremities. For example, in June and July heatwave alarms had to be announced several times. In 2006 the countrywide yearly mean temperature was 10.3 ºC which was by 0.6 ºC higher than the 30-year average between 1961-90.

Figure 1.4. *Anomaly of the countrywide monthly mean temperatures 2006 (ºC) in Hungary*

1.2. Institutional arrangements

The Minister for Environment and Water has overall responsibility for the Hungarian Greenhouse Gas Inventory and the Hungarian National System for Climate Reporting. He is responsible for the institutional, legal and procedural arrangements for the national system and the strategic development of the national inventory. Therefore the designated *single national entity* is the Ministry of Environment and Water. Within the ministry, the Climate 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 have been 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 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. In the industry and solvent sector the former inventory compiler acted as sectoral expert, so he collected the data and prepared the inventory. The agriculture sector of the inventory has been prepared by the Research Institute for Animal Breeding and Nutrition for several years. This institute collects the data, chooses the calculation method, prepares the inventory in CRF format and sends it to the inventory compiler in xml format. For the forestry part of the LULUCF sector an internationally recognized expert is responsible for data collection, inventory preparation. For the revision of soil C stock changes a new player, Karcag Research Institute of University of Debrecen (Department of Soil Utilization and Rural Development), was contracted last year. For the preparation of the wastewater category of the inventory the Research Institute for Environmental and Water Management (VITUKI) is involved. 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 and Waste sector • Completion of CRF and NIR • Archiving • Coordinating QA/QC activities • Reporting to UNFCCC secretariat
Inventory preparation of wastewater subsector	Research Institute for Environmental and Water Management	• Data collection, choice of methods and EFs, inventory preparation • Involving subcontractors
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
Inventory preparation of Industry and Forestry	Contracted consultants	• Data collection, emission estimation • 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 will give 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…”

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 entire inventory 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 Climate Change and Energy Unit that supervises the core team approves the documents to be submitted.

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:

- Data requests and supply (with the relevant contracts)
- Documentations
- Xml files
- Calculations, background information
- Reports
- Literature
- QA/QC information
- Working folder

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 the Tier 1 methodology in accordance with the guidance of the GPG for several years. This analysis has been completed with the 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 15 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, 34%), "Fugitive Emissions from Coal Mining and Handling, CH_4" has the lowest contribution (CO_2 eq., 0.029%) 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 2006. Using the concept of "Combined uncertainty" from the Tier 2 methodology, LEVEL 2 and TREND 2 key sources were also identified, both consisted of 13 source categories. N_2O emission from manure management became key category in TREND 2 analysis in this year.

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 20 and 18 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 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
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	Yes	Level1	
CO_2 Emissions from Ammonia Processes	CO_2	Yes	Level 1, Trend 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**
2. Industrial Processes				
CO_2 Emissions from Metal Production	CO_2	No		
PFCs Emissions	PFCs	No		
Emissions from Substitutes for Ozone Depleting Substances	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	CH_4	Yes	Level 1, Trend 1	
CH_4 Emissions from Manure Management	CH_4	No		
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	Yes	Level 1, Trend 1	
6. Waste				
CH_4 Emissions from Solid Waste Disposal Sites	CH_4	Yes	Level 1, Trend 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**
6. Waste				
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

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 spreadsheet for documenting these quality checks is in testing phase.
- Reviews. Three external reviews were conducted in 2007: an in-country review by UNFCCC Secretariat, an ISO audit and an in-depth analysis of the inventory by a firm with experience in inventory preparation.
- 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 three research and development projects for the improvement of the inventory. A better forestry database is developed by the State Forestry Service, the Research Institute for Animal Breeding and Nutrition will work on country specific emission factors, and we will have better wood density data from the Forest Research Institute.
- Incorporation of ETS data in broader extent for revision of the used EFs and for better sectoral allocation of emissions
- Revision of the LULUCF sector will be continued.
- 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; therefore we can claim that the GHG inventory is subject to ISO 9001:2000.

Other QA/QC activities

Although not fully 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 76.88% in the total emission (in CO_2eq.). The least reliable is N_2O calculation representing 12.24%. CH_4, which has a medium reliability, has a similar proportion (9.79%). Fluoride gases are irrelevant here because their contribution to the total emission in only 1.09%. Accordingly, the *estimated* uncertainties of the emissions of different gases are as follows:

CO_2	±2-4%
CH_4	±15-25%
N_2O	±80-90%

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 2006) is 5% and the uncertainty introduced in trend in national emissions is 2.4%.

1.8. Completeness

During the preparation of the inventories, all efforts were made to fill in the tables as complete as possible. Although GHG inventories have been prepared year by year since 1994, the consistency of the inventories could be reached only by 2005 for the whole time series (1985-2003). (However, we could not determine so far the quantities used in fire extinguishing systems but made advances in specifying the fluoride gases used for foaming.) If new information becomes available during the preparation of the inventory or the calculation method is modified, every effort is given that these are reflected in the inventories of the previous years.

GHG inventory data are provided for the base year (the average of the three years 1985–1987) and the years 1985–2006. 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) 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 at the end of January.

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:

GREENHOUSE GAS EMISSIONS (CO_2 eq, Gg)	BY fixed	1990	1995	2000	2002	2003	2004	2005	2006
Total (including LULUCF)	112,661	92,340	69,191	79,361	72,662	74,404	74,160	72,941	72,715
Total (excluding LULUCF)	115,397	98,234	79,327	77,588	77,183	80,579	79,444	80,198	78,625

Table 2.1. *Total GHG emissions (including and excluding LULUCF)*
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 1985-2006*

Upon the collapse of the centralised planned economy, economic production decreased significantly until 1992 which was also reflected in the emission levels. However, in the last 10 years there's no significant trend in the total emissions.

Figure 2.2. *Emissions in the last 10 years show no significant 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 od 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):

GREENHOUSE GAS EMISSIONS (CO_2 eq. Gg)	BY fixed	1990	1995	2000	2002	2003	2004	2005	2006
CO_2 . without LULUCF	85,795.5	73,335.2	62,046.0	59,201.8	58,822.2	62,124.6	60,401.1	61,662.1	60,388.8
CH_4 . without LULUCF	10,139.2	9,455.5	8,216.6	8,271.4	8,182.4	8,183.0	7,957.3	7,891.0	7,808.4
N_2O . without LULUCF	19,223.7	15,132.5	8,825.9	9,557.7	9,452.5	9,420.8	10,180.8	9,716.9	9,574.9
HFCs	1.74	0.0	1.74	205.7	403.6	498.9	525.8	517.6	606.9
PFCs	166.8	270.8	166.8	211.3	203.3	189.6	201.1	209.4	1.5
SF_6	70.2	39.9	70.1	140.1	119.6	161.9	178.2	201.0	244.4
Total (including LULUCF)	**112,661**	**92,340**	**69,191**	**79,361**	**72,662**	**74,404**	**74,160**	**72,941**	**72,715**
Total (excluding LULUCF)	**115,397**	**98,234**	**79,327**	**77,588**	**77,183**	**80,579**	**79,444**	**80,198**	**78,625**

Table 2.2. *Trends in emissions of greenhouse gases in Hungary (1985-2006)*
BY=average of 1985-87 (1995 for F-gases) as fixed in 2007.

Figure 2.4. *Shares of gases in 2006*

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.

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 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. However, 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 a steadily increasing trend.

Figure 2.6. *F-gases trend (1985-2006)*

*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. After 1994 emissions from energy sector are fluctuating around 61000 Gg in CO_2 equivalent. The lower emission in 2006 is probably due to the lower energy demand of Manufacturing Industries and Construction and the favourable weather conditions in winter.

The energy sector was responsible for 76.1% of the total GHG emissions in 2006. Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 94.5% to sectoral emission, followed by CH4 with 4.1% and by N2O with 1.4%. Among fuels, gases have the highest proportion (47.0%), liquids have less and solids have the lowest, but the latter still represents 22.2% of the sectoral CO_2 emissions. Due to the changes in the fuel-structure in the '90s the most important source in the base years, the solid fuel have been displaced by natural gas decreasing the total emission. The most important subsector of the energy sector is Energy Industries (1.AA.1) with a proportion of 32.3%, followed by Other Sectors (1.AA.4), which represents 28.1% of the total emissions in this sector. This year the least contribution to the emission from fuel combustion has Manufacturing Industries and Construction Sector (1.AA.2).The conspicuous differences compared to the previous years' submissions in this rank are the result of reallocation of petroleum refining and manufacture of solid fuels. Fugitive Emissions from Fuels (1.B) play only a small role in emissions of the sector with 3.6%. The most dynamically increasing category is Transport (1.AA.3), which has 4% higher total emission in 2006 compared to 2005. The primary energy use of Hungary was 1152 PJ in 2006, by 0.1% lower than the use in 2005 (1153.2 PJ). The decreasing energy demand in 2006 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 2006 the Agriculture sector was the second largest source of greenhouse gas emissions in Hungary. It accounted for 10.7 percent of total emissions. The contribution

of agriculture to total emissions decreased over the period 1985-2006 from 14.5 percent in 1985 to its present share. Emissions from Agriculture include CH_4 and N_2O gases. Most of the total N2O emissions are generated in agriculture; it amounts to 68.7 percent of total N_2O. The total emissions from agriculture decreased over the period 1985-2006. 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 2006. The greenhouse gas emissions of agricultural activities were changed essentially in accordance with production.

The Industrial Processes sector was the third largest sector contributing 7,5 % to total GHG emissions in 2006. The total sectoral emissions decreased by 43.5% between base year and 2006 and by 6,1% between 2005 and 2006. Nitric acid, cement, ammonia productions dominates 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 most years and a net source of emissions in 2000. 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):

Indirect gases	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
NO_X	262.5	264.2	264.9	257.8	246.8	238	203.1	183.3	184	187.4	190.07
CO	931.1	--	--	963.1	--	997	913.4	835.8	796.1	774.29	761.29
NMVOC	232	263	228	215	205	205	149.6	141.8	149	142.4	150.3
SO_2	1403.6	1361.8	1285.3	1218	1102	1010	913	827.3	757.3	741	704.96

Indirect gases	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
NO_X	195.81	199.5	202.62	197.4	185.1	183.2	182.9	210.7	185.3	203.1	202.21
CO	726.87	733.36	736.93	592.4	592.4	578.8	573.8	600.3	585.4	585.2	595.81
NMVOC	150.1	145.4	140.6	165.5	166.0	162.3	160.1	169.0	157.0	176.2	186.77
SO_2	673.23	658.51	591.79	598.0	489.0	403.9	364.9	347.8	248.8	146.6	123.69

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

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

3. ENERGY (CRF sector 1)

3.1. Overview of the energy situation of Hungary in 2006

(Source: Energia Központ Kht., 2008)

The primary energy use of Hungary was 1152 PJ in 2006, by 0.1% lower than the use in 2005 (1153.2 PJ).
The decreasing energy demand in 2006 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 0.74^{o}C higher than in the previous year, decreasing the energy demand of heating by roughly 4%.
- 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) grew by 14.2% and the chemical industry by 5.8% (KSH, 2007). We must also highlight the 4% (nearly 3 PJ) increase in the use of petroleum products for non-energy purposes by the chemical industry and the construction industry compared to the previous year.
- Energy use of transport also added 3.8% compared to the previous year.

In addition to energy use, the economy also grew in 2006 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 1154.3 PJ were available of which 37.1% came from domestic production (428.8 PJ, including 34.2% nuclear production) and 62.9% (725.5 PJ) was net imported energy.
Within energy use the share of coals increased from 11.0% to 11.6% in 2006. The share of oil and petroleum products further grew from 25.8% to 26.8%, while the share of the other key energy type, gas decreased from 43.9% to 41.7%. Among primary electricity sources nuclear electricity accounted for 12.7% in 2006 and imported electricity represented 2.2% within the total primary energy use. The share of renewables' use increased from 4.3% to 4.7% in 2006. *Figure 3.1* shows the distribution of energy consumption during the last 16 years.
Use of natural gas was 14.2 billion m^3 in 2006 – 3.1 billion m^3 of domestic gas and 11.7 million m^3 of imports were available to ensure uninterrupted natural gas supply. Domestic gas consumption in Hungary has one of the highest shares in Europe (41.7%). In the structure of communal energy use natural gas represents 67.4%. 70% of households and institutions are supplied with natural gas.
In 2006 the amount of electricity generated from renewable energy sources was less than the previous year. The two main reasons of this regression were the decrease of electricity generated from biomass and from hydro power, this latter was due to unfavourable weather conditions. The decrease of electricity generated from biomass was due to that the amount of obligatory purchased electricity was less than in 2005. This amount was calculated by Energia Központ Kht. At the same time amount of electricity generated by wind power plants increased significantly, and installed wind power capacity exceeds 30 MW. The amount of electricity generated from biogas also increased.
The share of electricity generated from renewable energy sources represents nearly 4% of the total electricity consumption of the country.

Figure 3.1. *Distribution of total energy consumption in Hungary during the last 17 years. Electricity means imported electricity and electrcity produced by nuclear power plant (Source: Energia Központ Kht., 2008)*

Figure 3.2. *GDP and total energy consumption in Hungary (1985-2006) (Source: KSH, 2007; Energia Központ Kht., 2008)*

3.2. 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 the fuel consumption. *Figure 3.3* represents distribution of combusted fuel type in the base year and 2006.

Figure 3.3. *Fuel combustion in the base year (a) and 2006 (b)*

The most important subsector of the energy sector is *Energy Industries (1.AA.1)* with a proportion of 32.3%, followed by *Other Sectors (1.AA.4)*, which represents 28.1% of the total emissions in this sector. This year the least contribution to the emission from fuel combustion has *Manufacturing Industries and Construction Sector (1.AA.2)*. The conspicuous differences compared to the previous years' submissions in this rank are the result of reallocation of *petroleum refining* and *manufacture of solid fuels*. *Fugitive Emissions from Fuels (1.B)* play only a small role in emissions of the sector with 3.6%.

Figure 3.4. *Proportions of total GHG emissions in Energy Sector in base year and in 2006*

Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 76.8% (without LULUCF) to total, and 94.5% to sectoral emission (*Figure 3.5*). Within this, among fuels, gases have the highest proportion (46.8%), liquids have less, and solids have the lowest, but the latter still represents 22.6% of the sectoral CO_2 emissions.

Figure 3.5. *Distribution of emission of GHGs in energy sector in the base year (a) and 2006 (b)*

As regards methane emission, this sector represents 3.1% (without LULUCF) in 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 32.1%, which represents the second highest emission compared to other sectors *(Figure 3.6.)*.

As regards nitrous oxide emission, this sector represents 1.1% (without LULUCF) in the total greenhouse gas emission. Among nitrous oxide emitters, its proportion is 8.8%, 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 2006*

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

Figure 3.7. *CO_2, CH_4 and N_2O emissions in energy sector (1985-2006)*
Between 1988 and 2003 CH4 and N2O emissions from road transport are inconsistent with emissions from other years.

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 energy sector prepared by Energia Központ Kht. (2008). Input data for the fugitive emission calculation came from the Statistical yearbook of Hungary (KSH, 2007), discussions with the Hungarian Oil and Gas Company Plc. (MOL) and the Mining 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). Comparing the two approaches the difference was 1.66% in energy consumption and 0.96% as regards CO_2 emission in 2006. 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), naturally, for both approaches; and the potential CO_2 emissions from there were taken into account by filling the CRF tables appropriately. As a result of the 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. For example, in the case of liquid fuels, the IEF is only 22.56 t CO_2/TJ (in contrast to the 70 to 75 t/TJ of other sectors), because 41564 TJ of the 55310 TJ is used as feedstock (naphtha), and only 24.9% of this is converted to carbon dioxide.
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.*

Fuel type	Allocated under the sector …	IPCC code
Natural gas	Manufacturing Industries and Construction – Chemicals	1.AA.2.C
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*
(New categories are in bold.)

The amount of fuels used is normally the same or nearly the same as the values published by IEA, because Energia Központ Kht. 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.
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. The rate of the activity was taken equal to the amount of kerosene sold in Hungary – on the basis of the energy balance. 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
Passengers carried (thousands)	2,476	2,359	2,297	2,719	3,550	5,074	6,850
Transported quantity of goods (kt)	22	24	10	13	19	16	16
Quantity of kerosene (TJ)	8,957	7,602	8,150	8,358	8,610	9,368	9,210

Table 3.2. *Air travelling and transport performance in Hungary since 2000*
(Source: KSH, 2007; Energia Központ Kht., 2008)

Figure 3.8. *Passangers and aircraft movements at Ferihegy Airport since 1995*

Emissions from in-country aviation, which represent a very low proportion, were taken equal to the consumption of aviation gasoline, and calculated on the basis of this – in those years when the related data were available in the energy balance. Where this was not indicated in a separate line, consumption and emissions occur 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 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:
Központi Közlekedési Felügyelet, http://www.trafipax.hu/index.php?akt_menu=116)

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

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 includes facilities generating electricity and district heating stations. On an overall level, there are the largest users of fossil energy (27.7% in 2006).
For the first time petroleum refining and energy consumption of the manufacturing of solid fuels are calculated in this subsector. Previously petroelum refining was part of the manufacturing industries and construction sector, chemical industry (1.AA.2.C). Coke oven gas is arisen during the manufacturing of solid fuels and the consumption of this gas was taken into account only in the energy industry sector, while the energy consumption of the manufacturing was calculated until this submission under manufacturing industries and construction sector as part of the iron and steel industry (1.AA.2.A).

3.3.2. Methodology

Energy consumption data were taken from the energy balance (1985-2006) of the Energy Statistics Yearbooks prepared by Energia Központ Kht. Data obtained from Energia Központ Kht. – 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 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 case of fuel balance, while the sectoral energy consumption for coal is the aggregate of hard coal, brown coal, lignite, gas coke and coking coal. In the latter case it is necessary to use additional information, from e.g. statistical yearbooks (KSH, 1985-2006) or annual coal questionnaries (1990-2006) prepared for IEA by Energia Központ Kht.,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 as 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 (1985-2006)*

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. However, 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*.

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	***97.4***	***0.98***
Lignite	***112.0***	***0.98***
BKB	94.6	0.98
Coke Oven/ Gas Coke	108.17	0.98
Crude Oil	73.34	0.99
NGL	63.07	0.99
Gasoline	69.3	0.99
Jet Kerosene	71.5	0.99
Gas/Diesel Oil	74.07	0.99
Residual Fuel Oil	77.37	0.99
LPG	63.07	0.99
Bitumen	80.67	0.99
Petroleum Coke	98.08	0.99
Other Oil	73.33	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 2006 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 station started to measure the calorific value and the carbonate content of the fuels used in. 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 112.0 t/TJ in 2006. It should be noted that emission factor for the Hungarian lignite is 113 t/TJ according to the 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 part of 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, both mined in Hungary. The entire time series of emission factor was corrected using this method.
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	1.50	1.50	80.00	–	–
Natural Gas	0.50	3.00	2.40	5.00	1.00	0.10
Residual Fuel oil	3.00	0.60	0.60	3.00	0.60	3.00
Gas/Diesel Oil	3.00	0.60	0.60	3.00	0.60	3.00
Firewood	30.00	4.00	–	–	–	–

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

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

It should be noted that during the segregation process we have been keeping the original CH_4 and N_2O emission factors, which had been used in chemical industry, for petroleum refining until 2005. For 2006, calculation was made with default IPCC values, it is planned to change the old factors to default ones in the next submission to create consistent time-series.

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%. 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 data is not consistent. Energy consumption of the manufacturing of solid fuels is calculated for only 2006 in this subsector. The inconsistency in N_2O emissions from the previous years was solved. Calculation of non-CO_2 emission in pertoleum refining differs in 2006 compared to the previous years.

3.3.4. QA/QC information

As mentioned above, 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 like in the statistics, but there are some differences in energy values due to different NCVs.

3.3.5. Recalculation

In case of liquid and solid fuels, we continued to change N_2O emission factors to default IPCC 2006 factors for the missing years (1988-2003), because the former country specific values seemed much higher than the default ones and the values used by neighbouring countries, (See *Table 3.5*).
For the first time petroleum refining and energy consumption of the manufacturing of solid fuels are calculated in energy industries subsector. Previously petroelum refining was part of the manufacturing industries and construction sector, chemical industry (1.AA.2.C).
Coke oven gas is arisen during the manufacturing of solid fuels and the consumption of this gas was taken into account in the energy industry sector, while the energy consumption of the manufacturing was calculated until this submission under manufacturing industries and construction sector as part of the iron and steel industry (1.AA.2.A). In 2006, consumptions are allocated in appropriate end-use sectors and manufacturing of solid fuels is in its proper subsector.
The above mentioned process realigned subsectoral contributions to total emission in energy sector, but it did not effect the total emission of the sector.

3.3.6. Planned improvements

Non-CO_2 emission in pertoleum refining will be corrected in the next submission to create consistent time-series.
EU ETS will give opportunity to get detailed information from establishments that emit more than 500 kt CO_2/year. These installations can calculate their emission according to measurement data. Evaluating the measurements it is possible to define new emission factors that suit better to the Hungarian conditions. Instead of IPCC default emission factors we will calculate the national emissions using more appropriate values. Besides, we will get more detailed and technology-specific information about fuel combustion in the field of energy industry, manufacturing industry and construction.

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

3.4.1. 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-CO2 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) is 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
- Communications
- Storage

As regards other fuels from which only a part is subjected to direct combustion and other parts (e.g., bitumen) are not, these 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 subjected to direct combustion, no CH_4 and N_2O emissions are calculated here.

3.4.2. Methodology

The energy consumption data were also calculated on the basis of the national energy balance prepared by Energia Központ Kht. The calculation method and the associated problems are the same as those described under the Energy Industry (see 3.2.2).

Figure 3.10 illustrates the energy consumption of the sector. After 1990, i.e., following the economic changes, the quantities of fuels used was 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.

Figure 3.10. *Fuel combustion in manufacturing industry and construction*

Emission factors

The sources of the factors and the values of CO_2 factors are the same as those described under the Energy Industry (*Table 3.4*). 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*

3.4.3. 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 in the *energy industry* subsector, but it is included in the *chemicals* until 2005.

3.4.4. 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 like in the statistics, but there are some differences in energy values due to different NCVs.
During the segregation of petroluem refining from chemical industry, activity data and emissions were checked. N_2O and CH_4 emisssions were changed in some cases, where calculations were not precise.

3.4.5. Recalculation

While applying the QC procedures it was found that the used CO_2 emission factor of petroleum coke (26.75 tC/TJ) was not the default value (27.5 tC/TJ), even though it was written as default in the CRF. The EF was changed to the default factor which affected the emissions of the last two years (2004 and 2005) only.

LPG was used almost alone for combustion until 2004, its use as feedstock in the chemical industry suddenly turned up in the energy statistics in 2005, but it was not taken into account in the previous inventory, it was corrected in this submission.

Figure 3.11. *LPG consumption in the chemical industry 1985-2006*

Petroleum refining is now segregated from chemical industry (see *Figure 3.12*). Energy related use of liquid fuels was reported in the energy statistics until 1999, between 2000 and 2003 IEA and Eurostat oil questionnaires (made also by Energia Központ Kht.) provided auxiliary information to national statistics. Since 2004 energy statistics has handled oil refining and coke production together, but separately from chemical industry. Since liquid fuels are combusted only in refineries (at least in Hungary), the segregation is obvious.

Natural gas consumptions were obtained from IEA and Eurostat gas questionnaires. Before 1990 these data were estimated: since used fuels have high correlation (0.82) with input of crude oil and additives, consumption of natural gas could be calculated knowing the liquid fuel-use. (Data from 2004 were excluded because of standing out from other values, they must be checked.) This method may have errors, but it has no effect on total emission.

3.4.6. 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.

Energy consumption of the manufacturing of solid fuels is calculated for only 2006 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.

Figure 3.12. *Segregation of petroleum refining from chemical industry has no effect on total emission of energy sector*

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

3.5.1. 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 and no key source with 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. In 2006 *Table 3.7*. shows the changes in composition of the Hungarian car fleet.

Year	Proportion of the Eastern European cars
1997	56%
1998	50%
1999	45%
2000	42%
2001	39%
2002	34%
2003	30%
2004	23%
2005	16%
2006	18%

Table 3.7. *Proportion of the Eastern European cars in the Hungarian car fleet (Source: KTI (2006),KSH (2007))*

Electrification of the railways in Hungary decreased the solid fuel consumption with 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 is reported in the statistics separately, but the used amount by navigation are included under road transport similarly to previous years.
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 3.13. *Gasoline and diesel combustion, and total energy use in transport (1985-2006)*

Figure 3.14. *LPG, natural gas and solid fuel combustion in transport (1985-2006)*

Figure 3.13. 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*).

3.5.2. 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 (see *Table 3.4*).
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 (KSH, 1985-2007) and annual reports of Ministry of Economy and Transport about the Hungarian vehicle-fleet.
For the base years it was assumed that passenger cars with 2-stroke engine have same sharing in traffic like other gasoline vehicles. This assumption can be applied in the early 1990s, too. For the last three years, these data 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 3.15*). 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 Hungary. It was assumed that 20% of the new cars in 2004 were equipped with this type of catalytic converter.

Figure 3.15. *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	Coal - Lignite	29.7	Country specific value, see *Annex 2.3*
Gaseous fuels	Natural Gas	15.3	Revised 1996 Guidelines, Table 1-2

Table 3.8. *CO_2 emission factors in transport*

Methane and nitrous oxide emission factors for road transport are summarized in *Table 3.10*.

Methane and nitrous oxide emission factors for railways and navigation are summarized in the following table (*Table 3.9*). Emissions from in-country aviation, which represents a very low proportion, were taken equal to the consumption of aviation gasoline, and were calculated on the basis of this – in years when the related data were available in the energy balance. Where this was not indicated in a separate line, consumption and emissions occur 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
	Coal - Lignite	80.0	12.0
Navigation	Gas/Diesel Oil	5.0	5.0

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

3.5.3. 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. Recalculations in CH_4 and N_2O emissions are performed only for the base years (1985, 1986, 1987), 2004 and 2005, the method was applied for 2006, too.

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

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		
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 3.10. *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*

3.5.4. QA/QC information

After QC checks emission factors were changed to default factor in case of liquid fuels in the categories of navigation and railways, and emission factor of natural gas was also changed to default value in the road transport category. After the QC check activity data of liqiud and solid fuel used by railways in 2002 was modified according to the energy statistics.

3.5.5. Recalculations

CO_2 emissions from navigation and railways in case of liquid fuel were changed in the whole time-series, because gasoline's emission factor was used instead of gas/diesel oil factor. CO_2 emission from natural gas in the road transport category was also changed in the whole time-series.

3.5.6. 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.

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

3.6.1. Category description

Emitted gases: CO_2, CH_4, N_2O
Key source: Level 1, 2; Trend 1, 2 (see "Stationary Combustion" oil, coal, gas)

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

3.6.2. 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 3.16 illustrates the fuel consumption of the sector by types.

Figure 3.16. *Distribution of combusted fuels in the "other sector" (1985-2006)*

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 parallel with the significant reduction of coal and oil consumption, natural gas consumption has increased significantly. During the period 1985-2006 natural gas pipeline length has doubled (see *Table 3.18*), and the number of households supplied with natural gas has been increasing continuously. Population swithed from coal to natural gas combustion. At the same time, household heating oil was completely replaced by LPG during the last years of the analysed period, as shown in *Table 3.11*.

Sector	Fuel consump -tion (TJ)	1998	1999	2000	2001	2002	2003	2004	2005	2006
Commercial/ Institutional	Oil	965	899	1,127	1,055	580	366	744	289	41
	LPG	1,990	2,159	2,131	1,761	1,931	1,739	1,643	1,609	1,595
Residential	Oil	250	242	54	0	0	0	0	0	0
	LPG	12,480	11,951	12,091	10,483	10,659	9,353	8,836	6,688	6,890

Table 3.11. *Oil and LPG consumption in the institutional and residential sector (1998-2006)*

Figure 3.17. Monthly mean temperature anomalies in 2006 (1961-1990 climatical average)

Fuel consumption of the sector is determined by weather conditions. Annual mean temperature was 0.6℃ higher in 2006 compared to 1961-1990 climatical average, therefore the consumption relapsed by 6%.

The consumption rates of the subsectors are shown in *Figure 3.18*.

Figure 3.18. *Fuel combustion in the subsector of "other sector" (1985-2006)*

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 values are the same as those listed in *Table 3.4*)
Specific emission factors for CH_4 are shown in *Table 3.12*.

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

Table 3.12. *Specific emission factors for CH_4 in the "other sector"*

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 3.13*.

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

Table 3.13. *Specific emission factors for N_2O in the "other sector"*

3.6.3. HDD and energy demand of residential sector

Figure 3.19. *Comparison of residential fuel consumption and HDD between 1996 and 2006*

Heating degree day (HDD) is a quantitative index demonstrated to reflect demand for energy to heat houses and businesses. This index is derived from daily temperature observations. *Figure 3.19* illustrates the relationship between residential fuel consumption and HDD. Except 1998 the two lines are running parallel.

3.6.4. 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.

3.6.5. QA/QC information

No sector-specific information is available.

3.6.6. Recalculation

There was no recalculation.

3.6.7. Planned improvements

No sector-specific information is available.

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

3.7.1. Category description

Emitted gas: CO_2, CH_4
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 and CH_4 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 17% 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 (3.2 Overview of the sector).

3.7.2. Coal Mining

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 17% 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 3.20*).

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Coal production (10^6 t)	24.04	23.13	22.84	20.88	20.03	17.66	17.06	15.75	14.61	14.11	14.59
Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Coal production (10^6 t)	15.19	15.59	14.65	14.55	14.03	13.91	13.03	13.30	11.24	9.57	9.95

Table 3.14. *Coal production time-series in Hungary*

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

Figure 3.20. *Distribution of mined coal in the base year (a) and 2006 (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 – informed by the Mining Property Utilization Company in the Public Intrest –, 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 3.15. *In-situ CH_4 content in Hungarian mines*
(Source: REKK, 2004 (original data: Hungarian Geological Survey, disclosure of mines))

Table 3.15 shows the measured methane content of coal for in the last few years active mines in Hungary. Mine of Lencsehegy closed in 2004, previously it had been producing significant amount of coal having 0.0 m^3/t methane. In 2006 the only one operating mine was Márkushegy with 0.93 m^3/t in-situ methane content. Lignite is mined only in surface mines; 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 3.16*). For mining activities emission factors were derived from measurement data, in case of post-mining according to the IPCC 2000 Guidance, emission factor was calculated as 10% of 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 3.16. *Comparison of IPCC default and country specific emission factors for coal mining*

3.7.3. Oil and gas activities

Activity and consumption data related to extraction and primary handling were taken from Energy Statistics Yearbook. In addition, data from the KSH and from production companies were used.
In the past, emissions were calculated using the specific emission factors provided for *Eastern European technologies* in the Revised 1996 Guidelines. In response to the comments of the ERT and also due to the ambiguous relationship between activities and

specific emission factors, we contacted the production companies and the emission calculations were adjusted in cooperation with them, on the basis of the new information obtained. Such fundamental changes were required because the technologies used in Hungary are entirely based on "Western" equipment; therefore, the use of the specific emission factors for Eastern Europe, which are high and associated with great uncertainty, is not justifiable. Since we do not have own measurements, it was decided – on the basis of the data available from the production companies – that the Canadian calculation presented in the Background Papers published by IPCC (2002) would be used. Hungarian data for the activities indicated in this calculation were determined and multiplied by the provided specific emission factors.
The included technologies and the applied specific emission factors are as follows:

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

Table 3.17. *Source-specific emission factors in oil and gas activities (Source: IPCC - Background Papers, 2002)*

In addition, trial calculations were made using the specific emission factors for "Western" technologies from the Revised 1996 Guidelines. The results were in the same order of magnitude as before. Energy Statistic Yearbook contains a special category, the network loss, which is a statistical concept. The real fugitive emission is about one third of the network loss in natural gas distribution. The results of the above mentioned methodology and emission factor are in good agreement with the statistical value.
Gas transport represents the highest proportion in the emissions. In Hungary, gas supply, as well as the total length of pipelines, has been growing significantly over the past 20 years. Annual data for pipeline lengths are indicated in *Table 3.18.*
Flaring was estimated – due to lack of information about emission – on the basis of detailed production data obtained from oil and gas companies and using default emission factors of the 2006 Guidelines (IPCC, 2006).

Pipeline length (km)								
Year	1985	1986	1987	1988	1989	1990	1991	
Transmission	3,345	3,683	3,786	3,910	4,035	4,170	4,046	
Distribution	10,262	12,474	14,200	18,380	18,380	22,559	25,306	
Year	1992	1993	1994	1995	1996	1997	1998	
Transmission	4,188	4,368	4,468	4,684	4,907	4,957	5,069	
Distribution	29,611	37,568	45,113	53,436	58,074	63,585	67,161	
Year	1999	2000	2001	2002	2003	2004	2005	2006
Transmission	5,118	5,167	5,214	5,214	5,214	5,234	5,234	5,234
Distribution	70,589	72,540	74,559	75,836	78,018	79,377	80,519	81,033

Table 3.18. *Annual data for natural gas pipeline lengths (1985-2006)*

3.7.4. CH_4 emission from thermal water

This category, which was allocated under 1.AA.5.A (*Other stationary fuel combustion*) in the previous submissions, 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 in the *other* sector (Geothermal, Other Fuels) 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.
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.

3.7.5. 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.

3.7.6. QA/QC information

No sector-specific information is available.

3.7.7. Recalculation

There was no recalculation.

3.7.8. Planned improvements

We will do more accurate calculations in some categories using data from EU ETS.

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4. INDUSTRY (CRF sector 2.)

4.1. Overview of the sector

This sector includes emissions generated by non-firing processes related to industrial production. The major processes include cement, iron/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 the *Figure 2.6* in Trends of GHG Emission Chapter). The *Figure 4.1* below shows the emissions of the sector by gases:

Figure 4.1. *The most significant industrial gases. In comparison with them, the quantity of fluoride gases and methane is negligible. Note: BY=average of 1985-87 but 1995 for F-gases*

In the base year (averaged value for the three years 1985–1987 for CO_2, CH_4 and N_2O, and 1995 for HFCs, PFCs and SF_6), the most important GHG in Industry sector is CO_2, contributing 55.36 % to total GHG emissions in this sector, expressed in CO_2 equivalent, followed by N_2O (42.34%). Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) taken together contributed 2.23 % to GHG emissions (*Figure 4.1*). Total sectoral emissions decreased by 43.54% between base year and 2006.

Figure 4.2. *Shares of gases in Industry secor, in base year and 2006 (Gg CO_2eq)*

The chemical sub-sector accounted for 60,45% of total industrial GHG emissions in base year, followed by mineral sub-sector 30.49%, metal sub-sector 8.40% and F-gases 0,66%. On the other hand chemical sub-sector accounted for 41.00% in 2006, followed by mineral sub-sector 39.96%, metal sub-sector 4.57% and F-gases 14.47% (*Figure 4.3*).

Figure 4.3. *Shares of sub-sectors in Industry sector, in base year and 2006 (Gg CO_2eq)*

The most important emitter is chemical industry, especially the N_2O emission of nitric acid production (for details see there).

Figure. 4.4. *The emission in Industry.* *Note: BY=average of 1985-87 but 1995 for F-gases.*

The significant decrease of emissions in the period between 1988-1993 is strongly represented in each of the above figures. The reason for that is the economic transition mentioned already in the previous chapters. Due partly to closing down factories and to the reduction of capacity utilization, in the course of transition, 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 in1991 and eventually the aluminium production stopped in 2006;
- Ferroalloys: ceased to exist (1991);

- Ammonia: four out of five plants were closed down (1987, 1991, 1992 and 2002);
- Nitric acid: three out of four plants were closed down (1989, 1992 and 1996).

One of the reasons of temporary production decrease was that the modernization of the remaining factories was carried out that time and in the subsequent period, which 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 the plants having more advantageous emission factors in the aspect of environmental protection have been closed, causing unfavourable changes in the national emission factor. This was the situation e.g. in the production of nitric acid.

Since the mid 1990s, the emission by industry has been showing a slowly increasing but unbalanced trend reflecting the actual demands of production in the national economy.
An example is the (relatively) significant increase of methane in *Figure 4.5*, 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). The increase of industrial fuel consumption in the energy sector in 2005 can be attributed to the same reason.

Figure 4.5. *Chemical sub-sector, CH_4 emission (Gg, $CO_{2\ eq}$).*

4.2. Mineral Products (CRF sector 2.A)

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

Technology

Emitted gas: CO_2
Key source: Level 1

During cement production, CO_2 is generated 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 and CO_2 (calcinations).

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 sub-sector 1.A.2.B
As regards CO_2 generated during cement production, no direct measured data are available. Therefore, emissions of the initial years were determined on the basis of the data provided by the Central Statistical Office (KSH) and using the factors recommended by IPCC. In order to increase the accuracy of the inventories, we contacted the affected industrial sites and obtained the necessary data directly. Thus, the calculation is in accordance with the Tier 3 method recommended by the Good Practice.

Activity data

Production data for the whole time series were obtained directly from the factories. In 2000, production at one site was abandoned. Previous production data for this factory was obtained from the Cement Industry Association. Instead of cement or clinker production, raw flour consumption was used as the basis for calculating the emissions. This is more accurate because cement factories measure the amount and composition of the raw flour. No clinker export or import occurred. The table below shows the time-series production data for through 2006.

	Base year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Clinker, kt	3,173.2	3,245.5	3,242.7	3,210.4	1,987.6	1,598.3	1,905.7	2,154.0	2,233.2	2,079.0
Cement, kt	3,888.9	3,871.4	3,856.8	3,932.8	2,581.7	2,245.6	2,521.3	2,795.3	2,874.9	2,745.0
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Clinker, kt	2,193.8	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
Cement, kt	2,806.2	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

Table 4.1. *Clinker and cement production in Hungary*

Emission factors

Upon receiving information on the carbonate content of the raw flour from the producers and from the Association. the quantity of CO_2 was calculated using the following formula and the proper stoichiometric proportions:

$M_{CO2}=M*C*S$

Wherein M_{CO2} means the amount of carbon dioxide generated (t/year);
M means the amount of raw flour fed into the furnace (t/year);
C means the ratio of calcium carbonate in the raw flour; and
S means the stoichiometric ratio of CO_2 and $CaCO_3$ (44.01/100.1).

On a similar way we calculated also the amount of CO_2 generated from $MgCO_3$ using the corresponding stoichiometric ratio. The results were only corrected for cement kiln dust (CKD) in the case of wet technology, because 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.
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]:

	Base year	1988	1989	1990	1991	1992	1993	1994	1995	1996
CO_2/ klinker	0.5597	0.5608	0.5565	0.5248	0.5189	0.5395	0.5384	0.5367	0.5348	0.5496
CO_2/ cement	0.4570	0.4701	0.4679	0.4284	0.3995	0.3840	0.4069	0.4136	0.4154	0.4162
Total CO_2 (kt)	1,776	1,820	1,805	1,685	1,031	862	1,026	1,156	1,194	1,143
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
CO_2/ klinker	0.5504	0.5336	0.5460	0.5508	0.5581	0.5570	0.5472	0.5374	0.5095	0.5114
CO_2/ cement	0.4303	0.4017	0.4152	0.4171	0.4077	0.4271	0.4136	0.4104	0.3564	0.3479
Total CO_2 (kt)	1,207	1,206	1,240	1,395	1,408	1,497	1,474	1,341	1,199	1,295

Table 4.2. *Specific emission factors of clinker and cement and total CO_2 emission in 2.A.1 sub-sector (1985-2006).*

The default factor is 0.5071 t/t for clinker (with a CaO content of 65%), and 0.4985 for cements (Revised Guidelines). On the one hand, the table demonstrates that the rising tendency of recent years slowed down in 2004. On the other hand, it shows that the amount of additives used in cements produced in Hungary is high and increasing. 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. 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%.

According to the emission trading system 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 and 2006 are based on reports of the factories.

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 %**

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

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

The originally small uncertainty was further improved by using data of emission-trade.
By using the same calculation method for each year and data obtained directly from the operators, the consistency of the time-series data is guaranteed.

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, which is presumably due to incorrect data processing at KSH.
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

The whole time series was recalculated in 2003 through 2005. At the same time, uniformity of the calculation method was achieved by using a method based on raw flour, as mentioned above, and not on clinker, in all cases. Thus, consistency was achieved for the whole time series.
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.

Planned improvements

None.

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

Emitted gas: CO_2
Key source: none

Technology

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 received directly form the operators increased the reliability of the information.

Recalculation

Last year there was no recalculation.

Planned improvements

None.

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

Emitted gas: CO_2
Key source: none.

Technology

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, and 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, and these values were obtained on the basis of the data received from the manufacturers. For years where 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 where the default values were used, the uncertainty is higher. The recalculation ensures time-series consistency.

QA/QC information

No sector-specific information is available.

Recalculation

Till 2002 retrospectively, we received the data of limestone quantity used for separation of sulphur from the power plants, which enabled us to calculate the generated CO_2 emission.

Planned improvements

None.

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

Though the glass production is mentioned in the Revised Guidelines only as a source of NMVOC, based on the data explored according to the EU emission-trade directives, we determined the CO_2 emission of glass production. This 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 and 2006. The data of total produced quantity were provided by KSH. The CO_2 emission is only 75 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. We chose a method of creating a specific emission factor from the data of 2005, and using this with the data of production known from statistics we calculated the emission of the sector retrospectively. 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.

Recalculation

Following our QA/QC procedure, the specific emission factor has been re-estimated and the time series has been recalculated with this new value.

4.2.5. 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 2006 determined this way was 360 Gg which is 0.5 % of the total CO_2 emission. The following table contains the data of production and emission:

	Base Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Bricks and ceramics, kt	6,339.6	6,522.9	6,104.1	6,275.8	4,509.4	3,500.9	3,978.9	4,207.6	4,784.3	4,217.0
CO_2, Gg	562.7	579.0	541.8	557.1	400.3	310.8	353.2	373.5	424.7	374.3
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Bricks and ceramics, kt	4,222.7	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
CO_2, Gg	374.8	393.9	369.5	268.2	242.2	204.2	267.9	290.9	334.0	360.5

Table 4.3. *Bricks and ceramics production and CO_2 emission in Industry sector (1985-2006)*

4.3. 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.

In 2006 the production of the chemical industry decreased compared to 2005. This is demonstrated well by the time series of the production data in the tables shown later and the next figure.

4.6. Figure *Total emission from Cmemical sub-sector(1985-2006)*

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

Technology

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

Traditional ammonia production uses natural gas, the carbon content of which 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 ratio 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 eviews (2002), it was repeatedly noted that calculation based on ammonia produced is not sufficiently accurate and natural gas-based calculations are more reliable, as also recommended in the first place by the Revised Guidelines. Therefore, we contacted the factories and the emissions were subsequently calculated using the natural gas consumption data obtained from them.
The table below shows the production, use and emission data:

	Base year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Ammonia, kt	947.80	859.15	854.93	631.58	354.44	226.46	291.24	366.16	376.19	422.37
Natural gas, kt	782.01	695.82	709.47	553.82	334.15	230.05	281.18	334.30	330.72	369.11
CO_2, Gg	1,995.97	1,795.15	1,812.73	1,415.53	838.06	562.28	687.24	817.08	808.32	902.16
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Ammonia, kt	411.98	350.35	317.26	427.78	394.38	289.40	281.78	369.32	397.39	370.47
Natural gas, kt	353.90	313.51	279.67	361.59	326.22	232.75	231.52	297.96	336.47	316.36
CO_2, Gg	864.98	766.27	683.55	883.78	797.32	568.87	565.87	728.26	822.38	773.23

Table 4.4. *Ammonia production. amount of natural gas used in the process and CO_2 emission in Chemical sub-sector (1985-2006)*

The figures 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 1.6). The effects of abandoning this factory are clearly reflected in the changes of the IEF (see CRF database): until 1991-93. 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

According to the recommendation of ERT. 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.

Planned improvements

None.

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

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

Technology

Nitric acid 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 1989, another in 1992, and a third in 1996. Recently, two production lines were operated in the country – the older one was established in 1975 and used GIAP technology. This represented the major part (about 80 %) of the production volume. Emissions from this process were measured. Installation of a new and more advanced production technology was started in 2006. The other existing technology represents only 20 % and has been operational since 1984 (combined acid factory producing diluted and concentrated nitric acid).

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 1989, 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 two other abandoned factories and for the one to be abandoned in the near future (in the latter case, on the basis of measured emission data). For the combined factory, a value of 10 kg/t was used. Thus, the weighted average ranges between 11.04 and 14.51 kg/t in the time series, depending on the production volume. According to the Good Practice, the estimated specific emission of factories established before 1975 (such as the process in question) is between 10 and 19 kg N_2O/t.

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. Since 2004 process end gas has been treated with ammonia, CO_2 emissions are no longer an issue.
Production data were obtained from the factories for each of the 20 years in the time series. These and the emission data are shown in the table below:

	Base year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Nitric Acid, kt	1,013.09	965.19	891.48	732.35	377.47	210.55	310.34	460.11	310.28	453.83
N_2O, Gg	14.65	13.74	12.57	10.37	5.24	2.87	4.34	6.56	4.35	6.21
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Nitric Acid, kt	433.53	354.44	309.50	415.99	454.27	294.80	306.21	415.01	484.41	460.83
N_2O, Gg	5.98	5.02	4.40	5.79	6.29	4.04	4.27	5.70	6.26	5.25

Table 4.5. *Ammonia production (kt) and CO_2 emission in Chemical sub-sector (1985-2006)*

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. The time-series may be considered consistent.

QA/QC information

The data received directly from factories greatly improved the quality of data. This is of particular importance because, in the past. we could obtain only limited production data from KSH (due to confidential technologies). Similar improvements were achieved by the newly introduced emission measurements.

Recalculation

According to the recommendation of ERT, we supplemented the database with the CO_2 emission generated by the reduction reaction mentioned above, but it had to be defined as a new gas, since it had “no place” originally. We have since improved the calculation of emissions related to Nitric Acid technologies and applied QA/QC check of activity data.

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.

4.3.3. 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 0.693 Gg (0.01 %). Comparing to the data of the previous years (0.4-0.5 Gg), the effect of production increase in 2006 can be observed here as well.

4.4. Metal Production (CRF sector 2.C)

Emitted gas: CO_2
Key source: none

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

Technology

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.

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

Emitted gas: CO_2
Key source: none.

Technology

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.

4.4.3. Aluminium Production (CRF sector 2.C.3

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

Technology

During alum earth 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:

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Aluminium. t	73.862	73.875	73.507	74.643	75.186	75.13	62.877	26.818	27.879	29.647	31.91
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Aluminium. t	33.468	33.674	33.71	33.64	33.85	34.591	35.294	35.038	34.349	31.783	0

Table 4.6. *Amount of Aluminium Produced*

Measured emission data are 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:

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
CF_4. Mg	35.87	36.29	36.39	35.52	38.42	36.50	31.50	18.17	19.64	21.42	22.48
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
CF_4. Mg	21.48	21.41	23.05	23.60	28.40	26.75	27.19	25.38	26.96	28.01	0

Table 4.7. *CF_4 emission in Aluminium Production 2.C.3 sub-sector (1985-2006)*

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 volume 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 operates an accredited quality assurance system. We have seen very well kept production records. The data made available to us were taken 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.

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

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

4.5.1. Technology

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.

4.5.2. 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 in 2006 so was HFC-152a.
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 the 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.

4.5.3. 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.

4.5.4. 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.

4.5.5. Recalculation

In calculating the emission of HFCs used in foam blowing for the year 2005, we changed to the application of the method recommended by GPG and the specific factors. The data of 2004 were recalculated with the help of this method. The HFC-365mfc values, considered emission earlier, were taken out of the database.

4.5.6. 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.)

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

5.1. Overview of the sector

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 (1985-2006)*

In the year 2006 this category had a contribution of 0.4% (excluding LULUCF) to total greenhouse gas emissions (343,8355 Gg CO_2 equivalents). There has been a decrease of 10.49 % in greenhouse gas emissions for this sector from base year to 2006 and increase of 131,98% between 2005 and 2006. The significant increased due to N_2O uses from 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 previously 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 emissions (t emission/t paint):

	Base year	1990	1991	1992	1993	1994	1995	1996	1997
IEF NMVOC, t/t	0.331	0.325	0.283	0.294	0.260	0.247	0.231	0.371	0.394
IEF CO_2, t/t	0.972	0.953	0.821	0.855	0.749	0.706	0.656	1.084	1.154
	1998	1999	2000	2001	2002	2003	2004	2005	2006
IEF NMVOC. t/t	0.375	0.312	0.274	0.268	0.245	0.220	0.183	0.219	0.226
IEF CO_2 t/t	1.095	0.898	0.781	0.762	0.689	0.613	0.499	0.616	0.637

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

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):

N_2O (t)	Base year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Anaesthesia	497	548	512	422	377	426	476	389	499	470
Cartridge	321	344	304	207	163	165	167	137	145	137
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Anaesthesia	430	441	371	375	520	331	578	828	228	894
Cartridge	131	113	96	71	61	56	45	38	39	30

Table 5.2. *N_2O emission (1985-2006 t)*

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

In the past, no data were available for this sector. Thus, the entire time series could be regarded as “recalculation”. Following our QC procedure, the activity data for 1990 and 2001 were modified in 2008.

5.3.6. Planned improvements

None

6. AGRICULTURE (CRF sector 4.)

6.1. Overview of the sector

The Agriculture chapter summarised the greenhouse gas emissions from enteric fermentation by livestock, manure management and use, rice cultivation, agricultural soils and burning of agricultural residues. Energy consumption of agricultural activities (heat production of agricultural vehicles and machinery) are taken into account in the Energy chapter (chapter 3, CRF sector 1).

Until the middle of the 1980s, agricultural production in Hungary was developing in accordance with the ecological and economic potential of the country. The production level of factory farms established in the 1960s was in line with high quality standards in international comparison in many sectors, production increased year by year. The growth in agricultural production stopped in the period between 1985 and 1990, then underwent a drastic decrease after the political and economic changes in 1990. Between 1990 and 2000, the number of agricultural farms was reduced by more than 30%, the number of employees by more than 50%, the volume index of the gross agricultural production by more than 30% and the livestock by almost about 50%. Productivity was reduced in several sectors. Production per hectare of agricultural land was reduced in both of plant production and animal production. 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 of 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 changed essentially in accordance with the activity data: it slightly increased between 1995 and 2000 and stagnated between 2000 and 2006.

Major modernisations or high-scale investments have almost not been implemented since the 1970s and 1980s – in animal production practically nothing, and in plant production to a smaller extent. According to the order of the minister of agriculture and rural development No. 27/2007. (IV. 17.) farmers can apply for serious support from the European Agricultural Fund for Rural Development to modernise animal farms from 2007. The aim of the support is to modernise animal farms that it should comply with the requirements for manure storage, to improve feeding and technical level, animal health and food safety conditions, infrastructure as well as working conditions and productivity of the staff. Spread of requirements for "Good Agricultural and Environmental Conditions" and "Good Farming Practice" to be fulfilled for applying for animal management investments and single area payments and rural development supports is expected to affect greenhouse gas emissions of agricultural production.

Trends of greenhouse gas emissions of agricultural production between 1985 and 2006 are presented in Figure 6.1 (CH_4), 6.2 (N_2O) and 6.3 (total emissions in CO_2 eq). The constant decrease in methane emissions in the period is the result of the constant reduction of the number of animals. Nitrous oxide emissions show similar trends until 1995, and there were a slight increase between 1996 and 2006. The main reason of this is the increase in fertiliser use. (Nevertheless, fertiliser use of the Hungarian agriculture sector is still only slightly higher than the half of the amount between 1980 and 1985.)

***Figure 6.1**. CH_4-emissions from Agriculture*

***Figure 6.2**. N_2O emissions from Agriculture*

***Figure 6.3**. GHG emissions from Agriculture*

Figure 6.4. shows the changes in greenhouse gas emission from the agricultural sector between 1985 and 2006 in comparison with the base period (1985 to 1987).

Figure 6.4. *Trend in emissions from Agriculture, compared to the value of base year*

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

6.2.1. Technology

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

Enteric fermentation in animals is considered as significant source of CH_4 all over the world. The most important process of generation is the 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 is 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.

6.2.2. Methodology

Emissions deriving from enteric fermentation of livestock were calculated by using the Tier1 method of GPG 2000. The annual average population (Table 6.1) of livestock was determined on the basis of the basic data of the Hungarian Central Statistical Office (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 equation:

$$NoA_{2006} = (0.5*NoA_{Dec2005}+NoA_{Apr2006}++NoA_{Aug2006}+0.5*NoA_{Dec2006})/3$$

(Equation 6.1.)

Wherein:

NoA_{2006} = average annual population in the given livestock category in 2006. [1,000 head]
$NoA_{Dec2005}$ = population in the given livestock category on 1 December 2005. [1,000 head]
$NoA_{Apr2006}$ = population in the given livestock category on 1 April 2006. [1,000 head]
$NoA_{Aug2006}$ = population in the given livestock category on 1 August 2006. [1,000 head]
$NoA_{Dec2006}$ = population in the given livestock category on 1 December 2006. [1,000 head]

Animals	Population (1,000 head)										
	1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Dairy cattle	598	579	579	573	569	560	518	472	438	403	392
Other cattle	1,298	1,226	1,160	1,155	1,109	1,053	1,007	809	627	549	553
Buffalo	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Sheep	2,588	2,454	2,453	2,327	2,172	1,958	2,009	1,867	1,458	1,089	998
Goats	18	18	22	26	31	35	39	50	61	71	76
Camels	-	-	-	-	-	-	-	-	-	-	-
Horses	103	100	93	80	79	80	84	79	75	85	75
Asses and Mules	5	5.1	5	4.8	4.6	4.5	4.3	4.3	4.3	4.3	4.3
Swine	8,931	8,955	8,876	8,902	8,457	8,751	7,558	6,159	5,760	4,926	5,089
Total poultry	83,613	84,568	83,994	80,557	76,521	71,504	58,286	53,629	45,136	47,642	46,972
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Dairy cattle	396	387	381	385	390	377	345	330	309	300	275
Other cattle	535	512	494	484	443	416	431	428	424	420	428
Buffalo	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
Sheep	930	901	954	981	1,225	1,164	1,133	1,259	1,380	1,447	1,358
Goats	81	86	90	95	97	108	96	94	85	78	81
Camels	-	-	-	-	-	-	-	-	-	-	-
Horses	74	76	77	78	78	65	64	62	65	67	65
Asses and Mules	4.3	4.3	4.3	4.3	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Swine	5,536	4,953	5,338	5,585	5,063	4,821	5,093	5,049	4,385	4,022	3,944
Total poultry	48,845	42,785	49,289	51,885	50,738	53,335	50,298	46,214	44,468	48,845	42,785

Source: HCSO (2006)

Table 6.1. *Animal population data 1985-2006*

As regards the applied methods, the following should be noted:
In the frame of the methodological development detailed in chapter 6.2.6 the conversion into the Tier 2 method is in progress, but a certain part of the country-specific information pertaining to the characteristics of livestock (body mass, net energy requirements, composition of feed rations, methane conversion rate, etc.) is to be confirmed as well as to be further elaborated for the entire time series. So it was decided that the simplified Tier 1 method is kept in order to maintain the consistency of time series in the current state of the methodology development, and the emission factors collected in Table 6.2 are used for the calculations of 2006.

According to our preliminary calculations the value of the ”Dairy Cattle – CH_4 Emission Factor Enteric Fermentation” parameter can be between 99 kg CH_4 head^{-1} and 106 kg CH_4 head^{-1} in 1985, between 106 kg CH_4 head^{-1} and 114 kg CH_4 head^{-1} in 2005 and between 108 kg CH_4 head^{-1} and 116 kg CH_4 head^{-1} in 2006. The parameters based on expert judgement and used for the preliminary calculations are summarized in Table 6.3.
As regards the dairy sector the following pieces of complementary information are considered as important:

- Similarly to the current situation, in the dairy sector there were feed rations used that were based on high quality forage and grain even in 1985.

- Feeding technology has been changed in a way that currently almost only the TMR (total mixed ration) system is used.
- The composition of the rations has also been changed. The energy evaluation system currently used in ruminant feeding was introduced in Hungary in 1986. The requirements values were modified in 1999 and in 2004, too (beside other modifications, for example the maintenance requirement values of adult and young dairy and double-use cattle increased by 5%).
- There have not been any substantial changes in animal management systems (see also section 6.1 and 6.3.3).
- There has been significant improvement in genetic background of the dairy populations and the composition of the populations has also been changed. The significance of the double-use breeds has been decreased and the majority of the dairy farms having poor quality herds stopped milk production.

Animal	Enteric Fermentation (kg head^{-1} yr^{-1})	Comments
Dairy Cattle [1]	100	IPCC, Western Europe
Non-dairy Cattle [1]	48	
Buffalo	55	IPCC, developed countries
Sheep	8	
Goats	5	
Horses	18	
Asses & Mules	10	
Swine	1.5	
Poultry	0.015	Own, judgement [2]

Source: Rev Guidelines Ref. Man. Tables 4-3, 4-4

Table 6.2. *The emission factors used for calculation of methane emissions from enteric fermentation*

Notes:
[1 The production and feeding standards used in Hungarian cattle farming are close to the conditions indicated for Western Europe (Highly productive dairy sector feeding high quality forage and grain. Dairy cattle also used for beef calf production. Very small dedicated beef cow herd). Milk production standards are higher than the average Western European standards but are lower than the values indicated for North America.
[2 (according to Minonzio et al., 1998)
Currently, the default Tier 1 factors recommended for developed countries were used in the other categories for the entire period.

Parameter		1985	2005	2006
Body mass	**(kg)**	600	650	650
Milk yield	**(kg yr^{-1})**	4517	6429	6682
	(kg d^{-1})	12.4	17.6	18.3
DM (dry matter) intake of dairy cattle	**(kg $head^{-1}$ d^{-1})**	14.5 - 15.0	15.5 - 16.0	15.8 - 16.3
GE (gross energy) content of food	**(MJ kg^{-1} DM)**	18	18	18
Y_m (methane conversion rate which is the fraction of gross energy in feed converted to methane)	**(kg kg^{-1})**	0.058 – 0.060	0.058 – 0.060	0.058 – 0.060
EF (CH_4-emission factor from enteric fermentation of dairy cattle)	**(kg $head^{-1}$ yr^{-1})**	99 – 106	106 – 114	108 – 116

Table 6.3. *Estimation of parameters for calculation of CH_4-emission factor from enteric fermentation of dairy cattle*

6.2.3. Uncertainty and time series consistency

The non-recording-related errors of the different livestock populations were between 1.3% and 10% in 2006, the recording-related error is negligible (HCSO, 2006) As the annual average numbers calculated on the basis of HCSO data essentially represent calendar years, i.e., periods between 1 January and 31 December, they may differ from those presented by the FAO, which applies to 12-month periods starting on 1 October of the preceding year and ending on 30 September of the year under review. Livestock number time series from 1985 to 2006 are practically consistent in spite of the several changes made to the data collection methods and timing, and to the categories used before 2000. Based on the GPG 2000, the estimated uncertainty of the emission factors used for the calculations is ±20%.

Given the uniformity of the data collection and calculation methods in the entire period, the time series can be considered as consistent.

6.2.4. QA/QC Information

The agricultural greenhouse gas inventory is compiled by an outside expert (see Chapter 1.2, Institutional arrangements). The activity base data used in the calculations are derived from the official database of the HCSO. The documentation of the QA/QC methods used by the HCSO can be found in the referred databases (HCSO 1985-1989 and 1997-2005; 1990-1996; 2000a; 2000b; 2001; 2007a; 2007b). The most appropriate default factors in the framework of the applied Tier 1 methodology were selected on the basis of expert consultations, the aspects and the justification of selection were documented (see Table 6.2, 6.4 and 6.5). In the course of the compilation of the inventory the calculation documentation done by the outside expert on the basis of the general QC measures summarized in Table 8.1 GPG2000 as well as of the QA/QC measures listed at the individual source categories is checked by an internal expert of the Hungarian Meteorological Service Greenhouse Gas Division. The documentation is archived by the Hungarian Meteorological Service Greenhouse Gas Division and the Institute for Animal Breeding and Nutrition independently from each other. External co-expert opinion was prepared on the entire inventory, so also on the Agriculture chapter in 2007 (Systemexpert 2007).

In the field of QA/QC further improvement is expected due to the methodology development presented in chapter 6.2.6 as well as to the conversion into the Tier 2 method being in progress. In the course of the development the QA/QC guidelines of the GPG2000 will be taken into account as much as possible.

6.2.5. Recalculation

In the frame of NIR/CRF for 2006 no recalculation occurred in “Enteric Fermentation” category.

6.2.6. 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. Currently the following problems are to be solved:

- Method development for the calculation of methane emissions from the enteric fermentation of ruminants (cattle, buffalo, sheep, goat) in accordance with the method of the 2006 IPCC Guidelines (Tier 2)
- Method development for the calculation of methane emissions from manure management for ruminants (cattle, buffalo, sheep, goat) in accordance with the method of the 2006 IPCC Guidelines (Tier 2)
- Recalculation of methane emissions of the entire time series in the mentioned categories
- Determination of the accuracy of data and all the errors of the emission calculation
- Elaboration of a proposal for the regular check and review of the applied methods
- Assessment of the application opportunities of the 2006 IPCC Guidelines Tier 3 method for the mentioned categories

Later, the methodology development pertaining to the further parts of the agricultural greenhouse gas inventory will be performed as well, depending on financial and personal conditions.

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

6.3.1. Technology

Emitted gas: CH_4, N_2O
Key source: CH_4: none; N_2O: Level 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.

6.3.2. Methodology

Again, the Tier 1 method was used for the estimation of the CH_4 and N_2O emissions released during manure management. Conversion into Tier 2 method is in progress but the majority of country-specific information on livestock characteristics and manure management methods need to be confirmed and further elaborated, so the decision was made on keeping the simplified Tier 1 method in the current stage. (See also chapter 6.3.3.)

See chapter 6.2.2 and Table 6.1 regarding activity data. Table 6.4 (including the notes) contains the CH_4 emission factors used for calculation and the background of their selection. Table 6.5 gives an overview of the factors used to estimate the average annual nitrogen excretion of each livestock category. Table 6.6 shows the data related to the estimation of the amount of nitrogen excreted in different manure management systems, and Table 6.7 shows the emission factors used for the estimation of the N_2O emissions.

Animal	Manure Management (kg head^{-1} yr^{-1})	Comments
Dairy Cattle (1	6	IPCC, East-Europe
Non-dairy Cattle (1	4	
Buffalo	3	
Sheep	0.19	IPCC, developed countries
Goats	0.1	
Horses	1.4	
Mules & Asses	0.76	
Swine (2	3	IPCC, West-Europe
Poultry	0.078	IPCC, developed countries

Source: Rev Guidelines Ref. Man. Tables 4-5, 4-6

Table 6.4. *The emission factors (kg head^{-1} yr^{-1}) used for the calculation of the methane emissions from manure management*

Notes:
(1 In the case of manure management methods, the predominant technologies in cattle farming are those characteristic of Eastern Europe (solid manure systems).
(2 Unlike in cattle production, liquid manure systems, which are characteristic of Western Europe, are used in swine production in Hungary. Therefore, in the case of swine, the factor recommended for Western Europe in the Rev. 1996 IPCC Guidelines was used for the calculation of CH_4 emissions from manure management.
*Currently, the default Tier 1 factors recommended for **developed countries** were used in the other categories for the entire period.*
Climate: Cool (Average annual temperature in Hungary: 10 ℃)

Category	N_{ex} (kg N 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

Source: Revised Guidelines, Ref. Man., Table 4-20, p. 4.99, Walther et al. (1994)

Table 6.5. *Amount of nitrogen excreted by each livestock category (N_{Ex})*

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.

Animal category	Anaerobic	Liquid manure	Daily appl.	Solid manure	Pasture	Burning	Other system
Non-dairy Cattle	0	2	0	83	15	0	0
Dairy Cattle	0	4	0	88	8	0	0
Buffalo	0	0	0	60	40	0	0
Sheep	0	1	0	59	40	0	0
Goats	0	0	0	59	40	0	1
Horses	0	0	0	60	40	0	0
Asses & Mules	0	0	0	60	40	0	0
Swine	0	73	0	25	0	0	2
Poultry	0	26	0	74	0	0	0

Source: HCSO (2000), Mészáros (2000), Ráki (2003)

Table 6.6. *Amount of nitrogen excreted in various manure management systems (expressed as percent of the total nitrogen excretion)*

Manure management system	Factor (kg N_2O-N kg^{-1} N_{ex})
Anaerobic lagoon	0.001
Solid manure	0.001
Daily application	-
Liquid manure	0.02
Pasture	0.02
Burning	-
Other system	0.005

Source: Revised Guidelines, Ref. Man., Table 4-22, p. 4.104

Table 6.7. *Emission factors used for the estimation of nitrous oxide emission from various manure management systems*

6.3.3. Uncertainty and time series consistency

As regards uncertainty and time series consistency see chapter 6.2.3.
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:

In relation to manure management, the available parameters of Hungarian animal production systems were compared to the criteria listed for the Tier 1 factors in the Revised Guidelines. 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 for the entire study period, so the time series can be regarded as consistent.

The survey "*Agriculture in Hungary (Farm structure survey, Vol. I.-II.)"* issued by the HCSO in the close past is under procession, its data would expectedly be taken into account under the framework of NIR/CRF for 2007.

From 2007 the Government in the frame of the "New Hungary Rural Development Programme" supports the modernisation of agricultural plants, with special regard to environmental and animal welfare investments (see also 6.1). The impacts of the Programme are taken into account in the course of the methodological developments in progress (see 6.2.6).

6.3.4. QA/QC Information

See 6.2.4. and 6.3.3.

6.3.5. Recalculation

In the frame of NIR/CRF for 2006 no recalculation occurred in Manure Management category.

6.3.6. Planned improvements

See 6.2.6.

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

6.4.1. Technology

Emitted gas: CH_4
Key source: none

In traditional rice-cultivating countries significant amounts of methane can be released during the flooded period. Since the production volume is very low in Hungary, the importance of rice cultivation in the greenhouse gas inventory is negligible.

6.4.2. Methodology

Methane emissions from rice cultivation were calculated using the production area and the factors recommended by the Rev. 1996 IPCC 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. Uncertainty and time series consistency

Time series can be considered as consistent due to the consistency of the used database and the applied method. As regards uncertainty, see chapter 6.4.3.

6.4.4. QA/QC Information

See 6.2.4.

6.4.5. Recalculation

In the frame of NIR/CRF for 2006 no recalculation occurred in “Rice Cultivation” category.

6.4.6. Planned improvements

No significant development is planned in “Rice Cultivation” category in the near future.

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

6.5.1. Technology

Emitted gas: N_2O
Key source: Direct: Level 1, 2; Trend 2;
Indirect: Level 1, 2; Trend 1, 2

Agricultural soils emit about 65% of the greenhouse gas emissions of agriculture in CO_2 equivalent in the form of N_2O.

N_2O is a gaseous intermediate in the reaction sequence of denitrification and a by-product of nitrification. The emission of N_2O that result from anthropogenic N inputs occur through both a direct pathway (i.e. directly from the soils to which the N is added) and through indirect pathways (trough leaching and run-off, and through volatilisation as ammonia and NO_x and subsequent redeposition). The most important factor affecting the N_2O emissions from agricultural soils is the amount of N 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.

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 6.8.

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
$Frac_{PRP}$ (2006) Average (1985-2006) Min (1996) - Max (2005)	kg kg^{-1}	0.101043 0.088716 (0.078546-0.102055)
$Frac_{FEED-AM}$	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 Forage Crops	kg kg^{-1}	 1.50-2.10 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 Forage Crops	kg yr^{-1}	 GPG Eq-4.26 GPG Eq-4.27
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Crop Residues		
$Res_O/Crop_O$ Non-Forage Crops Forage Crops	kg kg^{-1}	 0.3000-1.600 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}/CropBF Non-Forage Crops Forage Crops	kg kg^{-1}	 1.50-2.10 0
$Frac_{DM}$, N-fixing-crops	kg kg^{-1}	0.850-0.870
$Frac_{NCRBF}$	kg kg^{-1}	0.0142-0.0230
$Frac_{BURN}$ $Frac_{BURN}$ for Cereals 1985-1989	kg kg^{-1}	0 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

Parameter	Dimension	Value
Direct Soil Emissions – Histosols		
F_{OS}	ha	0
EF_2	kg ha^{-1}	5
Direct Soil Emissions – Pasture, Range and Paddock Manure		
$Frac_{PRP}$ (2006) Average (1985-2006) Min (1996) - Max (2005)	kg kg^{-1}	0.101043 0.088716 (0.078546-0.102055)
EF_3	kg kg^{-1}	0.02
Indirect Soil Emissions – Atmospheric deposition		
$Frac_{GASFS}$	kg kg^{-1}	0.1
$Frac_{GASM}$	kg kg^{-1}	0.2
EF_4	kg kg^{-1}	0.01
Direct Soil Emissions – Leaching and Run-Off		
$Frac_{LEACH}$	kg kg^{-1}	0.3
EF_5	kg kg^{-1}	0.025

Table 6.8. *Parameters and values used for the calculation of N_2O emissons from Agricultural Soils*

Notes:
Crops used for calculations of N-input into soils:
Non N-fixing crops: cereals (wheat, meslin, maize, barley, rye, oats, triticale,), potatoes, sunflower seed, rape seed, linseed, poppy seed, tobacco leaves, sugar beet, hemp for fibre, lucerne seed, seeds of grass, silage maize and green maize, mixed green fodder harvested in autumn, mixed green fodder harvested in spring, grass, onions, garlic, carrots, parsley root, tomatoes, watermelon, melon, white cabbage, squash, sweet pepper, bonnet pepper, sweet corn, Hungarian red paprika,
N-fixing crops: bean, peas, lentil, broad-bean, lupin seed, soya-bean, lucerne hay, red clover hay, green peas, green beans.

In order to calculate the amount of N in the frame of manure use and on pastures the data of Table 6.5 and 6.6 (see also chapter 6.3.2) were also used beside Table 6.8. 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. *The nitrogen content of the used synthetic fertilizer*

Figure 6.6. *The nitrogen excretion by animals*

Figure 6.7. *The harvested production of the most important crops*

6.5.3. Uncertainty and time series consistency

As a result of the recalculations, the time series can be regarded as consistent. According to the GPG 2000, the estimated uncertainty of the sector is at least ±50%. This uncertainty derives from the uncertainty of the activity data (to a smaller extent) and of the emission factors (to a greater extent). As a result of the method conversion in 2006 and of recalculations, the time series is consistent.

6.5.4. QA/QC information

See 6.2.4.

6.5.5. Recalculation

In the frame of NIR/CRF for 2006 no recalculation occurred in “Agricultural Soils” category.

6.5.6. Planned improvements

Development of a country-specific calculation method being more detailed as it is now is expected after the closing of the developments described in section 6.2.6.

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

6.6.1. Technology

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 Government Decree 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 (solid content, product/by-product ratio, C to N ratio), the default values indicated in the Revised Guidelines (Ref. Manual, Table 4-17, p. 4.65, p. 4.83) were used.

6.6.3. Uncertainties and time-series consistency

We can only have assumptions in connection with the uncertainty of the calculations for the period between 1985 and 1989 According to the GPG 2000, the uncertainty of the factors is ±20% The time series can be regarded as consistent for the years taken into account.

6.6.4. QA/QC information

No information is available.

6.6.5. Recalculation

In the frame of NIR/CRF 2006 no recalculation occurred in “Field burning of agricultural residues” category.

6.6.6. Planned improvements

According to plans the competent authorities will collect data on the permitted field burnings from 2008.

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

7.1. Overview of Sector

7.1.1. Introduction

The estimates of the 2007 inventory submission are based on the methodology suggested by the *GPG for LULUCF (IPCC, 2003)* and the IPCC 2006 Guidelines (IPCC, 2006), and complies with the reporting requirements of Decision 13/CP.9 and 14/CP.11 for LULUCF sector. The complete coverage of the six top-level categories and the relevant gases, fulfilling the requirements arising from the Kyoto Protocol in two years time, made us initiate a comprehensive revision of the sector.
The developments are gradual and stepwise. It is necessary to emphasize that this submission is built on preliminary results. Data collection, data processing and methodological developments are continuing and our estimates will undergo further refinement and consolidation in the next few years.

7.1.2. Sector coverage

In the 2007 inventory submission Hungary reports carbon stock changes, as well as greenhouse gas emissions and removals from Forestland (CRF 5.A), Cropland (CRF 5.B) and Grassland (CRF 5.C). In the Forest land category living biomass and dead organic matter are reported. In the Cropland category living biomass and mineral soils are reported. In the Grassland category carbon stock changes in (mineral) soils are reported (all managed mineral soils combined in the Cropland category). 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 (CRF 5(IV)) and CO, CH_4, N_2O and NO_x emissions from biomass burning (on forest land, burning of slash) are reported (CRF 5(V)).

Emissions and removals from LULUCF sector have not yet been 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 converted to Forest Land category). Hungary has aggregate land-use statistics, which are appropriate for the implementation of the area representation method Approach 1. For the implementation of method Approach 2 for reporting carbon stock change of land converted to other land use categories, further additional data would be needed.

The LULUCF sector reporting does not include emission estimates from Wetlands (CRF 5.D), Settlements (CRF 5.E) and Other Land (CRF 5.F) land use categories. In these categories only aggregate area data in the land remaining the same land categories are reported. Reporting of these categories is optional. Non-CO_2 emissions from drainage of soils and Wetlands (CRF 5(II)) are not reported as drainage is a very rare activity. N_2O emission from disturbance associated with land-use conversion to Cropland (CRF 5(III)) has not yet been reported due to lack of suitable data. In Hungary there are no organic soils under cropland and grassland management, so emissions from organic soils are not reported. Controlled biomass burning is not reported, either (except for burning of slash in the Forest land category), because the biomass burning on site is by law a strictly limited activity in Hungary. The wildfires are not reported under any subcategories due to lack of appropriate database.

7.1.3. Land area representation used in Hungarian Inventory

The land area categories used in the inventory report are based on the data of the Hungarian

Central Statistical Office (HCSO). These land area categories are consistent with those defined in *GPG for LULUCF* (Table 7.1). The total official land area of the country is divided into the following nine land use categories as reported annually by the HCSO: Arable land, Garden, Orchard, Vineyard, Grassland, Forest, Reed, Fish-pond and Uncultivated land area. This data set and the methodology are published 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 methodology of the data collection (land-owner questionnaire) is well documented (Kecskés, 1997), and the categories match the real land use and the managed area. In addition, the data set is available since 1853.
The estimation of emissions from according to the IPCC methods needs activity data for the last 20 years. The base year in Hungary is the average of the years 1985, 1986 and 1987; it means that Hungary needs a consistent area database from 1965 to 2006.

However, this data set only provides information about the total net changes for each of the different land use categories, and it combines the Wetlands, Settlements and Other Lands categories as uncultivated lands. The IPCC Settlements category matches the HCSO built-up area statistics (HCSO, 2006). The areas of Wetlands and Other Land categories were determined by the CORINE land cover databases (in reference to 1990 and 2000).

The definition of area of forest land used in the HCSO statistics differs from the definition which is applied in the GHG inventory. To preserve the consistency of the Forest Land estimations, the original HCSO statistics were adjusted to the National Forestry Database.

To achieve a consistent area representation in Hungary for the whole time-series from 1965 to 2006, the HCSO land use data set was further adjustmented. There was a change in the methodology of data collection of kitchen gardens in 1992, which causes time series inconsistencies. Up to 1991 the kitchen gardens in settlements was included in this category, but after 1992 these gardens were included in the uncultivated land category. According to the methodological changes the garden data was adjusted retrospectively. (The gardens in a built-up area were shifted into the uncultivated lands in the whole time-series. This methodological change matches the IPCC definitions, where the gardens in built-up area are included separately from the arable lands, i.e. in the Settlements category.)

The third adjustment was executed in the arable land category because, during the years of the census, the data set was derived from the census and, from the land-owner questionnaires in other years. The more detailed results in the years of census can cause a big difference between the year of the census and the subsequent and the preceding years. These outliers were eliminated as well.
The “land area of Hungary by land use categories” statistics covers Hungary’s official total land area which varies due to the movements of the natural boundaries, year by year. These changes were negligible, and the data base was adjusted according to the average area of the country reported between 1965 and 2006. The differences were added or subtracted from the area of the Other Land category.

National application of IPCC land use categories in Hungarian inventory

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 both forests, as well as roads and other areas that are under forest management, but that are not covered by trees.

With respect to 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 categories, 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 fallowing:

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 in case it is not devoted for consumption of persons 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 persons 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 m² or above in case of berries and 400 m² 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. Vineyard also includes vineyard areas in kitchen garden (trellises), if the area is planted coherently (equal row width and planting space) and is at least of 200 m² 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.

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 bodies 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.). The other wetlands and water bodies sub-categories of the CORINE database are not applicable in Hungary.

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.

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

Other Land

The Other Land category contains the uncultivated agricultural lands (these are agricultural areas used earlier but currently not cultivated and not included in crop alternation due to economic, social or other reasons that may be reused without any major limitation for production at relatively low expenses using the available tools of the holding), unmanaged forest areas and other unproductive areas (cemeteries, rocky-gritty lands etc).

	Area (1,000 ha)						
	Forest Land	**Cropland**	**Grassland**	**Wetlands**	**Settlements**	**Other Land**	**Total**
1985	1,541.5	5,096.3	1,246.4	270.9	496.1	652.1	9,303.3
1986	1,547.2	5,087.9	1,233.7	271.3	499.7	663.5	9,303.3
1987	1,554.6	5,082.1	1,222.3	271.7	503.7	668.8	9,303.3
1988	1,554.7	5,075.4	1,209.9	272.2	507.4	683.8	9,303.3
1989	1,552.6	5,068.4	1,197.3	272.6	510.8	701.5	9,303.3
1990	1,574.0	5,062.4	1,185.6	273.0	514.4	693.9	9,303.3
1991	1,584.0	5,032.8	1,173.1	273.5	517.6	722.3	9,303.3
1992	1,591.7	5,005.4	1,164.0	273.9	521.0	747.3	9,303.3
1993	1,602.1	4,974.1	1,156.6	274.3	523.7	772.5	9,303.3
1994	1,612.1	4,947.6	1,148.0	274.8	526.5	794.4	9,303.3
1995	1,625.2	4,921.7	1,148.0	275.2	529.4	803.8	9,303.3
1996	1,637.4	4,908.4	1,148.3	275.6	534.3	799.2	9,303.3
1997	1,651.3	4,899.4	1,148.1	276.1	539.7	788.6	9,303.3
1998	1,663.7	4,877.8	1,147.8	276.5	545.1	792.4	9,303.3
1999	1,679.7	4,852.2	1,147.1	276.9	550.2	797.2	9,303.3
2000	1,672.7	4,802.7	1,051.2	277.4	557.2	942.1	9,303.3
2001	1,703.3	4,804.2	1,061.2	277.8	565.1	891.7	9,303.3
2002	1,714.6	4,804.2	1,063.1	278.2	569.7	873.4	9,303.3
2003	1,740.3	4,803.1	1,061.6	278.7	576.7	842.9	9,303.3
2004	1,770.3	4,804.2	1,059.6	279.1	583.3	806.8	9,303.3
2005	1,789.6	4,807.0	1,056.9	279.5	589.4	780.8	9,303.3
2006	1,805.8	4,802.7	1,014.5	280.0	596.7	803.7	9,303.3

Table 7.1. *Areas of IPCC land-use classes for the years 1985-2006 (1000 ha)*

The next figure (Figure 7.1) shows the distribution of the six, broad IPCC land-use categories in Hungary, in 2006.

Figure 7.1. *Hungary's area by land-use categories in 2006*

7.1.4. Quantitative overview

The LULUCF sector in 2006 was a sink of 5,909.89 Gg CO_2–eq, because the total emissions arising from the sector are smaller than total removals. (Figure 7.2, Table 7.2). LULUCF sector in Hungary has been a net sink of CO_2 during nearly whole time series (the year of 2000 excepted). A large sink is mainly due to fact that the total increment of the growing stock on forest land category has been higher then the annual harvest. In 2006 the net sink in living biomass on forest land was 4,661.0 Gg CO_2. The other main sink of CO_2 was the living biomass on Cropland (1309.77 Gg CO_2).
On the contrary the mineral soils in Hungary acted as a minor source of emission in 2006 (0.01 Gg CO_2). Mineral soils in Hungary have been sometimes minor sinks sometimes minor source during the last few years. The liming in agricultural soils added up to 32.19 Gg CO_2 in 2006. In addition the non-CO_2 emission from biomass burning on forest land (burning of slash) was 28.67 Gg CO_2-eq.

Figure 7.2. *Trend from LULUCF 1985-2006*

Year	1985	BY	1986	1987	1988	1989	1990	1991
CO_2	-2,909.49	-4,134.65	-4,001.70	-5,483.04	-5,814.70	-4,824.07	-5,922.74	-6,006.85
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
Year	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
CO_2	-7,413.70	-8,100.52	-9,818.18	-10,160.32	-5,927.86	-5,738.89	-7,082.63	-3,201.82
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	10.40
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
CO_2	1,743.12	-2,365.31	-4,549.42	-6,203.78	-5,313.28	-7,286.55	-5,938.56	
CH_4	1.27	1.22	1.22	1.23	1.24	1.28	1.24	
N_2O	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	
CO	11.14	10.63	10.71	10.80	10.89	11.16	10.88	

Table 7.2. *Emissions and removals from LULUCF 1985-2006 (Gg)*

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 2006 was 1,998.5 thousand ha, while the forest area covered by tree stands or earmarked for plantation was 1,869.4 thousand ha. The area actually covered by trees (i.e. the stocked area) was 1,805,802 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 5-12 years*, depending on the tree species, 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 Forestry 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.

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

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

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 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 5-12 years, depending on tree species (fast-growing poplars e.g. are surveyed once in every five years, while slow-growing oak and beech stands only once in a decade). 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.

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	0.590
Hybrid poplar	0.370
Indigenous poplar	0.395
White willow	0.330
Other softwood	0.560
Conifers	0.530

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).*

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.

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

In Hungary, data has not been collected systematically even in the main ecosystem types for dead wood, litter or soil. However, it seems justified to state that these pools continue to sequester carbon in the medium-term, rather than to lose carbon. 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. Both of them seem to be biased, but it is not clear to what extent (the increment may be underestimated due to increased growth rates, and the harvests may be underestimated due to inconsistent reporting practices). It seems that

harvest was underestimated more, at least in the last few years, as the new estimates demonstrate considerably lower removals especially if it is regarded that, unlike in the previous years, removals in the belowground biomass are now accounted for. 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. This also means that more and more deadwood and litter is left in the forest, 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 Forestry 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.

reporting year	harvested volume (m3)	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

Table 7.5. *Harvest statistics for the inventory years*

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 land cadastre. 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.

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

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

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 Forestry Database. This database is the most accurate database in the country on the forests. 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. Apart from double-checking of the data processing and correct application of IPCC assumptions and methodologies, partial QA/QC was performed at the national level within the LULUCF sector greenhouse gas inventory, involving the teams of the Hungarian Meteorological Service, as well as the National Forest Service. 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.

No recalculation was made this year. Recalculation may take place in the next few years if revisions of the activity data or the factors used will be conducted. However, we report some data either in another place or in another format this year.

This includes that emissions from biomass burning were previously reported in category CRF 5.G (Other), which are now reported under category CRF 5.A.1 FL remaining FL / Biomass burning, controlled burning. This only changed the aggregated emissions for forest category, but not those of the LULUCF sector.

Emissions and removals under "CL converted to FL" were previously reported under "OL converted to FL". Additionally, we corrected a typing error (for the year 2004 and back) to have carbon stock change values in the respective columns where, erroneously, CO_2 values were entered.

Furthermore, cells in the CRF tables for other lands converted to FL categories were filled in with IE as we cannot distinguish the land-use category before conversions by our data. It does seem likely, however, that the majority of all conversions occur on croplands. This however resulted in some changes in the reported values.

Finally, we also included IE for all conversions from FL to any other land, because there are no separate statistics for these conversions. Note that, as mentioned before, emissions from deforestations are included in those of forest land remaining forest land.

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.

7.3. CROPLAND (CRF sector 5.B)

7.3.1. Source category description

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 with its approximately 50% proportion from the total territory of the country. All the lands with annual crops, as well as orchards and vineyards with perennial woody crops are classified here.

The area of Cropland category (Figure 7.5) is based on HCSO annual land-use statistics, revised by the HCSO's and the inventory agency's experts to account for inconsistencies (for more details see chapter 7.1.3).
The CO_2 removals in living biomass, as well as emissions from cultivated mineral soils and agricultural lime application are reported under the category 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 cropland remaining cropland category.

Figure 7.5. *Area of Cropland category 1965-2006*

7.3.2. Methodology

Carbon stock change in living biomass

Choice of method

Carbon stored in the biomass of croplands was calculated taking the perennial woody vegetation (in Hungary including orchards and vineyards) into consideration. The changes in carbon in cropland biomass (ΔCC_{CB}) were estimated from the annual rates of biomass gain and loss provided by the default Tier 1 method.

Choice of activity data
The annual change of the area of orchards and vineyards was considered using the statistical data of the HCSO. A decrease was assumed where the perennial woody crops were harvested, while the remaining territory was assumed to have an increase of biomass.

Choice of emission factors

Under Tier 1, the default IPCC factors relevant for temperate climate region for all moisture regimes were applied.

Climate region	Above-ground biomass carbon stock at harvest	Harvest /Maturity Cycle/ (yr)	Biomass accumulation rate (G) (tonnes C ha^{-1} yr^{-1})	Biomass carbon loss (L) (tonnes C ha^{-1} yr^{-1})	Error range
Temperate (all moisture regimes)	63	30	2.1	63	75%

Calculation of carbon stock change in living biomass

In accordance with the calculation steps described in the *GPG for LULUCF (IPCC, 2003)* the following result was gained: in the inventory year of 2006, 197,100 ha (A_{acc}) of perennial woody crops were cultivated in Hungary, while 900 ha (A_{loss}) were harvested. Calculating with the default carbon accumulating rate (G) of 2.1 tonnes of above ground C ha^{-1} yr^{-1}, and with loss rate (L) of 63 tonnes C ha^{-1} yr^{-1}, the net change in carbon stocks (ΔC_{CC}) was 357,210 tonnes C yr^{-1}.

Climate region	Above-ground biomass carbon stock at harvest (tonnes C ha^{-1})	Harvest /Maturity Cycle/ (yr)	Biomass accumulation rate (G) (tonnes C ha^{-1} yr^{-1})	Biomass carbon loss (L) (tonnes C ha^{-1} yr^{-1})	Error range
Temperate (all moisture regimes)	63	30	2.1	63	75%

Uncertainty assessment

Uncertainty is considered rather low regarding the estimation of the total area of perennial woody crops as it is based on the data published in the annual report book of the Hungarian Central Statistical Office. Nevertheless the default uncertainty level of biomass stock factors is +75% if Tier 1 method is used.

Dead organic matter

The Tier 1 method assumes that the dead wood and litter stocks are not present in Cropland or are at equilibrium in agroforestry systems and orchards, therefore no carbon stock changes were calculated for dead organic matter.

Carbon stock change in soils

The carbon stock of the soil in Hungary has been changing especially for the last decade due

to increasing changes in the principles of soil cultivation. As soil is one of the main factors of production in addition to climate and wheather, determining both the quality and the economics of production, the knowledge of the effects of plant production on soil is very important. Among the land use practices the soil cultivation has the most radical effects on soil properties. The need for 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, Zsembeli, 2001). 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. All over the world several soil cultivation methods were studied in order to investigate their effects on the soil properties including the water balance and the C-cycle. 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).

Mineral soils

Choice of method

Since extended country-specific stock change factors are not available in Hungary at the moment, the estimation method used is based on the IPCC default factors. 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 knowing the number of the tools and machines that are used in reduced tillage. The methodology of these judgements is detailed in the *Choice of activity data* paragraph below.

Choice of activity data

In order to gain relevant activity data, the area of croplands was stratified by soil type, climate, management and input types. For the identification of the spatial extension and distribution of each sub-categories as defined by using all these types, the area data from the Central Statistical Office were harmonised with those originating from the Land Cover (CLC) Database of the CORINE project (1990, 2000), both from the reference year of 1990 and from the up-dated version of 2000. Though land use change data are not available for the period before 1990 and after 2000, the transitions were estimated by the interpolation and extrapolation of the available data.

Soil type

The soil types were determined on the base of AGROTOPO (digital soil map of Hungary) data base and 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).

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

Table 7.7. *Classififcation the croplands in Hungary by soil type in proportion to the total land in 2006*

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.

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

Table 7.8. *Classififcation the croplands in Hungary by climate in proportion to the total land in 2006*

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. In accordance with efforts to reduce drought damages and soil degradation, conventional soil cultivation was prospectively replaced by conservation tillage methods, among them mainly those that aim at the decrease of the depth of the regularly cultivated soil layer and the formation of a topsoil rich in organic matter. As the management of croplands considerably modifies soil C stocks, we estimated the area of the non-conventionally cultivated croplands. Among the main soil protective management practices that affect soil C stocks in croplands (e. g. residue management, reduced tillage, fertilizer

management applying mineral fertilizers and organic amendments, irrigation management), reduced tillage 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 by 2006.

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).

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

Table 7.9. *Classififcation the croplands in Hungary by input in proportion to the total land in 2006*

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 belonging 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 inTabe 7.10.

sub-categories				Area (kha)
Climate	**Soil**	**Management**	**Input**	
cold dry	HAC	full till	low	822.9
cold dry	HAC	full till	medium	523.2
cold dry	HAC	full till	high with no manure	74.8
cold dry	HAC	reduced till	medium	75.3
warm dry	HAC	full till	low	1216.8
warm dry	HAC	full till	medium	772
warm dry	HAC	full till	high with no manure	110.6
warm dry	HAC	reduced till	medium	112.9
cold dry	LAC	full till	low	31.8
cold dry	LAC	full till	medium	23.1
cold dry	LAC	full till	high with no manure	2.9
warm dry	LAC	full till	low	25.3
warm dry	LAC	full till	medium	18.4
warm dry	LAC	full till	high with no manure	2.3
cold dry	sandy	full till	low	62
cold dry	sandy	full till	medium	45.1
cold dry	sandy	full till	high with no manure	5.6
warm dry	sandy	full till	low	74.6
warm dry	sandy	full till	medium	54.2
warm dry	sandy	full till	high with no manure	6.8
cold dry	aquic	full till	low	161.4
cold dry	aquic	full till	medium	117.4
cold dry	aquic	full till	high with no manure	14.7
warm dry	aquic	full till	low	246.7
warm dry	aquic	full till	medium	179.4
warm dry	aquic	full till	high with no manure	22.4
TOTAL				**4802.7**

Table 7.10. *Classififcation the croplands in Hungary by climate, soil type, management and input factors*

Choice of stock change and emission factors

The relevant factors applied for the calculations, and taken from the GPG for LULUCF (IPCC, 2003), are indicated in Table 7.11.

sub-categories				SOC_{ref}	$F_{LU(0)}$	$F_{MG(0)}$	$F_{I(0)}$
Climate	**Soil**	**Management**	**Input**				
cold dry	HAC	full till	low	50	0.82	1	0.9
cold dry	HAC	full till	medium	50	0.82	1	1
cold dry	HAC	full till	high with no manure	50	0.82	1	1.1
cold dry	HAC	reduced till	medium	50	0.82	1.03	1
warm dry	HAC	full till	low	38	0.82	1	0.9
warm dry	HAC	full till	medium	38	0.82	1	1
warm dry	HAC	full till	high with no manure	38	0.82	1	1.1
warm dry	HAC	reduced till	medium	38	0.82	1.03	1
cold dry	LAC	full till	low	33	0.82	1	0.9
cold dry	LAC	full till	medium	33	0.82	1	1
cold dry	LAC	full till	high with no manure	33	0.82	1	1.1
warm dry	LAC	full till	low	24	0.82	1	0.9
warm dry	LAC	full till	medium	24	0.82	1	1
warm dry	LAC	full till	high with no manure	24	0.82	1	1.1
cold dry	sandy	full till	low	34	0.82	1	0.9
cold dry	sandy	full till	medium	34	0.82	1	1
cold dry	sandy	full till	high with no manure	34	0.82	1	1.1
warm dry	sandy	full till	low	19	0.82	1	0.9
warm dry	sandy	full till	medium	19	0.82	1	1
warm dry	sandy	full till	high with no manure	19	0.82	1	1.1
cold dry	aquic	full till	low	87	0.82	1	0.9
cold dry	aquic	full till	medium	87	0.82	1	1
cold dry	aquic	full till	high with no manure	87	0.82	1	1.1
warm dry	aquic	full till	low	88	0.82	1	0.9
warm dry	aquic	full till	medium	88	0.82	1	1
warm dry	aquic	full till	high with no manure	88	0.82	1	1.1

Table 7.11. *Categorization the croplands of Hungary by carbon stock and management factores in 2006*

Calculation of carbon stock change in soils

According to the estimation method described in the IPCC Good Practice Guidance for LULUCF (2003), Equation 3.3.4. the soil organic C stocks (SOC) were estimated for the beginning and the 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 (D).
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 of the different land-use categories (Forest land, Cropland, Grassland) have to be calculated combined, like it 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 is constant (in Hungary, the sum of the areas of Forestland, Cropland and Grassland categories, in 1965; the maximum area of managed land in the time-series). 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. The total carbon stock change of the forest, cropland and grassland mineral soils is reported aggregated in the Cropland remaining cropland category. The reported emissions/removals in the Cropland remaining Cropland (CRF 5.B.1), mineral soils category referes to the all managed soils in Hungary.
Aside from the land-use changes, the carbon stock change arising from the changes of cultivation practises was 9.9 Gg, in 2006.

land-use		A (ha)	SOC(0 –T) (Gg)	SOC0 (Gg)	D year	ΔCCC (Gg/year)
initial	reporting year					
CL	CL	4,802,700	183 563	183 761.2	20	9.9

Liming
In order to calculate the application of carbonate containing lime (calcic limestone), or dolomite ($CaMg(CO_3)_2$) to agricultural soils as a source of CO_2 emissions we had to determine the amount of carbonate containing chemical amendments that was used for soil reclamation in the reporting year. As this data is not available directly, we elaborated an indirect method for the calculations:

- The total area of the reclaimed soils is 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.
- The carbonate containing chemical amendments used for the reclamation of acidic soils are the followings: grinded limestone, grinded dolomite, beet potash, 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 determination of the proportion of acidic and salt affected soils where carbonate containing lime or dolomite was used is based on expert judgement. According to this judgement two third of the acidic soils are reclaimed with limestone containing

amendments while 27% with dolomite. In the case of salt affected soils half of them was estimated to be reclaimed with limestone or other carbonate containing material.

- Taking the usual dosage of lime and dolomite application for soil reclamation, 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.
- According to Tier 1 method described in the *GPG for LULUCF (IPCC,(2003)*, emission factor of 0.12 was be used to estimate CO_2 emissions due the application of carbonate containing lime, and 0.122 for dolomite.

Total reclaimed area in 2006: 9,120 ha			
Area of acidic soils: 7,279 ha		Area of salt affected soils: 1,077 ha	Area of sandy soils: 764 ha
Reclaimed with limestone:	Reclaimed with dolomite:	Reclaimed with limestone:	-
4,876 ha	1,719 ha	980 ha	

Table 7.12. *Reclaimed areas in Hungary in 2006*

Organic soils

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

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 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.

AREAS	
Input data	**Uncertainty %**
Determination of total area of croplands	2.2
Detemination of total area of orchards	6.1
Determination of total area of vineyards	5.8
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

Table 7.13. *Uncertainties of emissions from liming*

Source specific recalculations

Recalculations for the whole time series were carried out in the Cropland category. The reason for the recalculation were the methodological and data treatment problems revealed in the coarse of our QC activity. The human capacity for inventory preparation has increased, and new experts of soil tillage and management were involved. This ensured a more sophisticated judgement of the stratification of cropland areas. The effect of the recalculations appeared mainly in the refined determination of the management and input categories based on expert judgement.

The following reculculations have been made for this submission:

I. Agricultural lime application (whole time-series)
II. Carbon stock change in mineral soils (whole time-series)

I. Agricultural lime application

The estimation was made in accordance with the GPG for LULUCF Tier 1 methodology. The activity data were taken from the “Soil amelioration” statistics of the HCSO, instead of the commercial statistics of the Agricultural Economics Research Institute was used previously. The new database is consistant and is available from 1985. In the coarse of our QC activity revealed, that the applied emission factors differed from the values suggested by the GPG for LULUCF. The difference between the emission factors applied formerly and the present ones effected significant difference in the results.
The principle of the methodology of the recalculations is the same as described above in the

methodology of the annual calculations for 2006.

Soil emission of the Cropland and Grassland category

As noted above, the revision was based on the aggregate statistics of HCSO. The soil emissions were estimated using Approach 1 land representation method and Tier 1 methodology. The calculations were made for the period 1965-2006 in accordance with the GPG for LULUCF taking into account the last 20 years.
The principle of the methodology of the recalculations is the same as described above in the methodology of the annual calculations for 2006. Naturally the change (decrease) of the total area of croplands through the period of 1985-2005 was the main fact that mainly determined the soil stock change, but the relatively considerable change in the management practice (appearance of reduced tillage vs. conventional cultivation) also affected the soil carbon stocks.

7.4. GRASSLAND (CRF sector 5.C)

7.4.1. Source category description

The total territory of grasslands in Hungary was considerably decreasing during the last three decades; while approximately 1,300,000 ha were occupied by grasslands in 1975, only 1,050,000 ha remained by 2005. 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 something different. In 1975 more than 2 million cattle, 700 thousand geese and 2 million sheep were in Hungary, and these numbers just slightly changed till 1985: 2 million cattle, 1 million geese and 3 million sheep. These numbers show that the decade of the 1980ies was the peak period concerning animal husbandry based on grazing, which was also the period of the highest natural expenditures regarding the 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 7.2.2).
The CO_2 emissions from mineral soils occupied by grasslands are reported under the category CO_2 emissions from grassland remaining grassland. Hungary has aggregate land-use statistics, therefore to all removals and emissions of grasslands are reported under Cropland remaining Cropland category (for more detailes see chapter 7.3).

Figure 7.6. *Area of Grassland category 1965-2006*

7.4.2. Methodology

Carbon stock change in living biomass

Choice of method
In Hungary grassland management practices can be considered static, so according to Tier 1 method, no change in living biomass carbon stock was estimated.
Carbon stock change in soils
Grassland management, similarly to soil cultivation and crop production, is changing in Hungary, but contrary to the other sector's slight improvements, it suffers from degradation.

The improper grassland management practice has severe impacts on the soil carbon stock. Though In Hungary there are no extensive measured data yet, some results have been already achieved concerning CO_2-emission from grasslands (Nagy et al., 2007, Zsembeli et al, 2006).

Mineral soils

Choice of method
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 method.
Choice of activity data
In order to gain relevant activity data, the area of grasslands was stratified by soil type, climate, management and input.
Soil type
The method of the classification of the Hungarian grasslands according to soil types is based on the same approach that is described in the Cropland chapter (7.3). 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 in 2006.

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

Table 7.14. *Classififcation the grasslands in Hungary by soil type in proportion to the total land in 2006*

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.

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

Table 7.15. *Classififcation the grasslands in Hungary by management in proportion to the total land in 2006*

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 as follows:

sub-categories				Area (kha)
Climate	Soil	Management	Input	
cold dry	HAC	non-degraded	-	301.4
cold dry	HAC	improved	medium	1.5
warm dry	HAC	non-degraded	-	445.7
warm dry	HAC	improved	medium	2.2
cold dry	LAC	non-degraded	-	23.9
cold dry	LAC	improved	medium	0.1
warm dry	LAC	non-degraded	-	19
warm dry	LAC	improved	medium	0.1
cold dry	sandy	non-degraded	-	18.9
cold dry	sandy	improved	medium	0
warm dry	sandy	non-degraded	-	22.7
warm dry	sandy	improved	medium	0
cold dry	aquic	non-degraded	-	70.8
cold dry	aquic	improved	medium	0
warm dry	aquic	non-degraded	-	108.2
warm dry	aquic	improved	medium	0
TOTAL				**1014.5**

Table 7.16. *Classififcation the Grassland in Hungary by climate, soil type, management and input in 2006*

Choice of stock change and emission factors

The categorisation is partly based on expert judgement due to the lack of sufficient statistics about the recent management and input applied grassland management practice. Nevertheless the change in the management practice can be judged well on the base of the number of grazing animals and the degree of expenditures, while the input factors can be followed knowing the extent of fertilisation and irrigation of grasslands. The methodology of these judgements is detailed in the *Choice of activity data* paragraph.

sub-categories				SOC_{ref}	$F_{LU(0)}$	$F_{MG(0)}$	$F_{I(0)}$
Climate	Soil	Management	Input				
cold dry	HAC	non-degraded	-	50	1	1	-
cold dry	HAC	improved	medium	50	1	1.14	1
warm dry	HAC	non-degraded	-	38	1	1	-
warm dry	HAC	improved	medium	38	1	1.14	1
cold dry	LAC	non-degraded	-	33	1	1	-
cold dry	LAC	improved	medium	33	1	1.14	1
warm dry	LAC	non-degraded	-	24	1	1	-
warm dry	LAC	improved	medium	24	1	1.14	1
cold dry	sandy	non-degraded	-	34	1	1	-
cold dry	sandy	improved	medium	34	1	1.14	1
warm dry	sandy	non-degraded	-	19	1	1	-
warm dry	sandy	improved	medium	19	1	1.14	1
cold dry	aquic	non-degraded	-	87	1	1	-
cold dry	aquic	improved	medium	87	1	1.14	1
warm dry	aquic	non-degraded	-	88	1	1	-
warm dry	aquic	improved	medium	88	1	1.14	1

Table 7.17. *Classififcation the Grassland in Hungary by climat, carbon stock and management factores in 2006*

Calculation of carbon stock change in mineral soils

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 (D).

Aside from the land-use changes, the carbon stock change arising from the changes of management practises was -140.5 Gg, in 2006.

land-use		A (ha)	SOC(0 –T) (G g)	SOC0 (G g)	D year	ΔCCC (G g/year)
initial	reporting year					
GL	GL	1,014,500	53 002.9	50 192.1	20	-140.5

Liming
In Hungary the amount of lime applied in grassland management practice is insignificant as a source of CO_2 emissions.
Organic soils
In Hungary no organic soils are under agricultural grassland management.
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.

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

Table 7.18. *Uncertainties of emissions from Grassland category*

Source specifis recalculations

Recalculations for the years from 1985 up to 2005 were carried out for the sector of Grassland similar to the Cropland category. The principle of the methodology of the recalculations is the same as described above in the methodology of the annual calculations for 2006. For more detailes see chapter 7.3 and chapter 10.

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 Wetlands area (280,000 ha, 3% of the total Hungary's area) was determined by extrapolation from the CORINE databases in reference to 1990 and 2000. The CORINE is a land cover database therefore the managed and unmanaged lands can not be separated by it. The result of our area estimation (interpolation and extrapolation) doesn't provide information about the area data of the conversion to Wetlands categories. To the determination 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 is needed. In Wetland remaining Wetland category only area data are reported. (Parties don't 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 couldn't be significant because the total Wetland area doesn't change remarkably in Hungary, while the area of protected Wetland increases. Hungary is among the signatories of the Ramsar Convention, therefore emphasizes the preservation and sustainable use of Wetlands. In 2006 three wetlands became Ramsar listed sites, thus altogether 26 wetlands (204,875 ha) in Hungary had been included in the List of Wetlands International Importance, since 2006.

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 (596,700 ha, 6.41% 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 is reported. (Parties don't 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 detail area data and developed methodology. (Distinguish of the converted to categories isn't possible by our current data base.)

7.7. Other Land (CRF sector 5.F)

The Other Land category contains the uncultivated agricultural lands, unmanaged forest areas and other unproductive areas.

Area estimates based on the uncultivated land are statistics of the HCSO, which contains the built-up area matching the Settlements IPCC category and land that is covered or saturated water matching the Wetlands IPCC category as well. In accordance with the IPCC land use categories the area of the Settlements and Wetlands categories were subtracted from the HCSO Uncultivated land area.

The area of the other land category is 803,700 ha, 8,63 % of the total area of the country.
Under 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 are taken into account under Agriculture sector.

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

Parties do not have to prepare estimates for 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 reporting due to lack of 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 excluding. Therefore, the controlled burning of biomass is estimated under Forest Land category, and not occurring under other land-use categories.

Emissions from wildfires have not been included yet, due to lack of suitable database. The data collection is proceeding. These emissions will be included in 2008 inventory submission.

7.9. Sector specific QA/QC and verification

QC measures based on the General QC procedures (Tier 1) of *GPG (IPCC, 2000)*, Chapter 8.
The human capacity for inventory preparation had increased in 2007. This ensured a more wide range of QC activity than previously. The whole sector underwent a strict quality check (activity data, method, CRF tables and the whole procedure of making LULUCF inventory) and some incompleteness revealed. New data collections and methodological developments have been going on since this year to stop incompleteness and improve the sector coverage.

The main objects 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 of conversion factors and units through the calculation system;
- Data, calculation system and methodology are archived;
- 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 fulfill the reporting requirements arising from the Kyoto Protocol.

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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 since these biomass sources are re-grown, the resulting emissions are not treated in the inventory.

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 changes have been made in the emission calculations of the waste sector. For the first time, the emissions from sludge treatment have been estimated separately. The time series of waste incineration emissions have been partly recalculated.

8.1. Overview of the sector

The waste sector with 4116.84 Gg CO_2 equivalent represents 5% of total national GHG emissions. In contrast with other sectors, the emissions of waste sector show significant increase. In the base year (which is 1985-1987) the total GHG emissions from the waste sector amounted to 3000.84 Gg CO2 equivalent which accounted for 2.6% of total national GHG emissions.

In all the years, the largest category is Solid Waste Disposal on Land, representing 70% in 2006, followed by Wastewater Handling (20%) 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:

	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. 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.

	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_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.

	Disposed MSW [Gg]	Paper [%]	Textile [%]	Decomp. Organic [%]	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

	Disposed MSW [Gg]	Paper [%]	Textile [%]	Decomp. Organic [%]	Recovered methane [Gg]	Emitted methane FOD [Gg]	Emitted methane Tier1 [Gg]
1996	3294	19%	3%	32%		**122,6**	149,3
1997	3486	19%	6%	28%		**124,2**	158,2
1998	3575	18%	6%	31%		**125,9**	165,4
1999	3688	20%	5%	31%		**128,0**	174,7
2000	3799	14%	4%	41%		**130,4**	162,5
2001	3696	16%	3%	41%		**132,6**	166,1
2002	3717	16%	3%	31%		**134,7**	150,6
2003	3966	16%	3%	30%		**135,8**	154,8
2004	3978	15%	3%	31%		**136,9**	161,8
2005	4072	15%	3%	29%	0,0	**138,1**	159,6
2006	3902	16%	4%	24%	0,9	**138,1**	146,3
Trend	**-3%**					**51%**	**-11%**

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. 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 the formerly used recovery data could not be verified. However, this recalculation had a negligible effect.

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 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, for the first time, 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.

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 63%. 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.

Usually, collected wastewater undergoes aerobic treatment in the plants. The wastewater treatment plants can be regarded now as well managed, nevertheless MCF = 0.05 was taken as the mean value of the range given in Table 6.3 in the 2006 Guidelines for the year of 2006. (Previously MCF=0.15 was used). In case of river discharge, i.e. for untreated and only mechanically treated wastewater we calculated with MCF=0.1 (previously MCF=0 was used).

In 2006, about 77% of municipal wastewater was treated at least biologically, while 6% was untreated and 17% 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.

For the first time, sludge data are used for emission calculations. From this year on, there are reporting requirements on the amount and treatment methods of sludge. It gave us the possibility to estimate emissions from anaerobic digesters (MCF=1) and deposited sludge in landfills separately. It must be noted however, that the latter is taken into account in the SWDS category (6A). Based on the data from the Energy Centre Hungary, the amount of recovered methane was subtracted.

To summarize the above, in this inventory the calculation methods and the default MCF values from the 2006 Guidelines are used more consistently, at least for the year of 2006.
The following table summarizes our new results that fit more into the range of values characteristic for our region.

	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]	Emissions sludge
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	63%	23%	77%	6.69	23.21	3.42	8.77
Trend	***65%***	***-64%***	***78%***		***-31%***		

For the first time, 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)

	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	106.0	0.67
Trend	***5%***	***1%***

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 2004-2006. 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):

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Waste, Gg	244	219	243	197	71	152	253	340	316	338	330
Fossil CO_2, Gg	101	91	101	82	30	63	105	141	131	140	137
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Waste, Gg	330	339	356	352	348	353	258	192	160	303	398
Fossil CO_2, Gg	137	141	148	146	145	147	107	99	126	316	381

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 and 2006 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 2006 392 Gg municipal waste was incinerated together with 373 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

The time series of N_2O emissions has been recalculated using the default values of the new IPCC Guidelines.

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.

The most important recalculation resulted from an ongoing project aiming to revise the emissions/removals in the LULUCF sector. This inventory submission includes the results of Hungary's first attempts to comply with the reporting requirements of the GPG for LULUCF (IPCC 2003), Decision 13/CP 9, and Decision 14/CP11. Following these requirements we started to revise the LULUCF category, to set a consistent database for identifying and representing land areas consistently. Formerly, the calculations were based on the National Forestry Database and on the Agricultural Economics Research Institute's soil data. Our formal land-use database did not meet the new requirements (consistency and completeness) of area representation, so we had to set a new area representation system, and to specify national definitions of the 6 broad classes of the GPG for LULUCF.

The new area estimates of land use categories are based on the "Land area by land use categories" statistics of the Hungarian Central Statistical Office (CSO). These data are collected by questionnaires, and in the years of the census surveys they derive from the censuses. The time-series in this database start in the end of the 19th century for the total land of the country, the methodology of the data collection is uniform and well documented, thus transparent, consistent and complete. This database is basically an aggregate statistics about the productive land area of Hungary (arable land, garden, orchard, vineyard, grassland, forest, reed and fish-pond) and the uncultivated land area (uncultivated and or untellable land, e.g. public roads, railways, built in and not built areas and etc.). As the area data for the Settlements, Wetlands and Other Land IPCC categories are published in aggregation and the database does not contain information about the converted to categories, the CORINE land cover databases (CLC 90, CLC 2000, CLC Change) were used to get additional information about the spatial distribution of land use, and to subdivide the CSO Uncultivated category into Settlements, Wetlands and Other Land categories. (Concerning Forest Land, the data of the National Forestry Database has been used. However, we initiated new developments to be able to fulfil the reporting requirements arising from the Kyoto Protocol, therefore the Forestry subcategory will be revised as well at later stage.)

The most important recalculation resulted from an ongoing project aiming to revise the emissions/removals in the LULUCF sector. This inventory submission includes the results of Hungary's first attempts to comply with the reporting requirements of the Decision 13/CP.9, and Decision 14/CP.11. The key elements of our work on recalculations in 2007 were

- To improve the completeness of the inventory setting a new area representation method, identifying the total area of the country for each land-use categories

consistently.

- Estimating new carbon pools which were not estimated previously (mineral soils of afforested cropland areas, and living biomass in Cropland).
- To improve the consistency of the inventory, replacing the inconsistent activity data with consistent ones (all area data and liming consumption).
- To improve the transparency of the inventory (area representation, mineral soils and liming).
- To improve the accuracy of the inventory using GIS technology (mineral soils).

The principal changes that result in recalculated estimates are

- Revisions of are data, taking into account of improved and updated area data in Cropland and Grassland category.
- Improved estimates of the carbon stock change in mineral soils.
- The estimates of the carbon stock change in living biomass in Cropland.
- Taking account the afforested cropland areas in estimation of the carbon stock change in mineral soils.

The Figures 9.1 presents the changes due to recalculation of carbon stock change in mineral soils. The new results can be used with greater confidence in identifying trends, nevertheless to achive the consistency the land use-changes are estimated aggregated.

Figure 9.1. *Changes due to recalculation of carbon stock change in mineral soils*.

The Figure 9.2 shows the changes due to recalculation of liming.

Figure 9.2. *Changes due to recalculation of liming*.

The significant difference between the current results and the former ones derives from the appliance of new activity data and new methodology in accordance with the GPG for LULUCF. The new method based on the „soil melioration statistics" of the HCSO was developed for estimating the lime consumption, which provides more reliable estimation in identifying trends. The trends of the estimated lime consumption is similar to the trend of the other activity data (i.e. fertilizer consumption) of the agriculture, reflected the drastic decrease in the 1990s.

The estimation of carbon stock change in living biomass in Cropland results the bulk of the changes due to recalculations. This carbon pool was not taken into account previously. According to our results the carbon stock change in the perennial woody biomass in Cropland has significant influence on the total removal/ emission of the LULUCF sector. The living biomass in cropland is a sink of carbon in most of the years and a source of the emissions in 2000 and 2001. The effect of the new carbon pool changed the total removal of the LULUCF sector so significantly, that the sector became source of greenhouse gases instead of sink in 2000. The figure 9.3 shows the change of the trend of LULUCF sector due to the recalculation.

Figure 9.3. *Changes due to recalculation in trends of LULUCF sector.*

Recalculations and reallocations in other sectors

While applying the QC procedures for the energy sector it was found that the used CO_2 emission factor of petroleum coke (26.75 tC/TJ) was not the default value (27.5 tC/TJ), even though it was written as default in the CRF. The EF was changed to the default factor which affected the emissions of the last two years (2004 and 2005) only. CO_2 emissions from navigation in case of liquid fuel were changed in the whole time-series, because gasoline's emission factor was used instead of gas/diesel oils factor. In the reference approach CO_2 emission from gas biomass was corrected with the adequate emission factor.

For the first time petroleum refining and energy consumption of the manufacturing of solid fuels are calculated in energy industries subsector. Previously petroelum refining was part of the manufacturing industries and construction sector, chemical industry (1.AA.2.C).
Coke oven gas is arisen during the manufacturing of solid fuels and the consumption of this gas was taken into account in the energy industry sector, while the energy consumption of the manufacturing was calculated until this submission under manufacturing industries and construction sector as part of the iron and steel industry (1.AA.2.A). In 2006, consumptions are allocated in appropriate end-use sectors and manufacturing of solid fuels is in its proper subsector.
It should be noted that during the segregation process the original CH_4 and N_2O emission factors have been kept which had also been used in chemical industry, for petroleum refining until 2005. For 2006, calculation was made with default IPCC values, it is planned to change the old factors to default ones in the next submission to create consistent time-series.
The above mentioned process realigned subsectoral contributions to total emission in energy sector, but it did not effect the total emission of the sector (see Figure 9.4). Detailed information of segregation is provided in chapter 3.3.5.

Figure 9.4. *Changes due to reallocations in the energy sector*.

LPG was used almost alone for combustion until 2004, its use as feedstock in the chemical industry suddenly turned up in the energy statistics in 2005, but it was not taken into account in the previous inventory, it was corrected in this submission.

In waste sector, the CO_2 emissions from waste incineration were recalculated from 2004. The recently established Hungarian Waste Information System gave the possibility to use the Tier 2 method. Beside municipal waste data more details are available about incinerated industrial waste. Concerning nitrous-oxide emissions, the new default emission factors were used from the 2006 Guidelines. The emissions from industrial wastewater treatment have also been recalculated using better activity data. However, this recalculation is limited to the years 2002-2005, therefore this work will be continued.

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 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.

A new government regulation is under preparation which will facilitate the data collection for different emission inventory purposes and thus will be in line with the EU efforts for streamlining climate change and air pollution reporting.