BELGIUM'S GREENHOUSE GAS INVENTORY (1990-2005)

National Inventory Report
submitted under the United Nations Framework Convention on Climate Change

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CHAPTER 1: INTRODUCTION

1.1. Overview

This sixth National Inventory Report documents the Belgian greenhouse gas emission inventory in accordance with the revised UNFCCC reporting guidelines on annual inventories. It is aimed at complying with decisions 11/CP.4, 3/CP.5 and 18/CP.8 of the *Conference of the Partie*s, and the Council Decision 280/2004/EC concerning a Mechanism for Monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.

The greenhouse gas inventory presented here contains information on anthropogenic emissions by sources and removals by sinks for direct greenhouse gases (CO_2, CH_4, N_2O, PFCs, HFCs, and SF6), indirect greenhouse gases (CO, NO_x, NMVOCs) and SO_2. It covers the period 1990-2005. Inventory data for the years 1991 to 2004 have only been recalculated where necessary, considering that a major update on the Belgian inventory was reported during the previous submission.

No changes have been made on the emissions of the inventory year 1990. The emissions of this year are set down in the Report by Belgium on the determination of the assigned amount pursuant to Article 8(1)(e) of Decision 280/2004/EC (March 2006) and in Report by Belgium for the calculation of the assigned amount pursuant to Decision 13/CMP.1 (December 2006)

This sixth National Inventory Report is presented according to the structure outlined in document FCCC/CP/2002/8, amended to fit to the Belgian national context. Complete CRF tables, for years 1990 to 2005, are provided as an annex to this report, under electronic format. Next to the emissions data, the CRF-tables are completed with – as requested - the standard indicators (notation keys), providing information on data gaps, methods applied, emission factors used, completeness and quality.

This national inventory report includes a description of the methodologies and data sources used for estimating emissions by sources and removals by sinks, a discussion of these estimates and their trends (including an analysis of the key source categories), and information on recalculation, uncertainties, quality assessment and quality control.

1.2. Institutional arrangements and process of inventory preparation

In the Belgian federal context, major responsibilities related to environment lie with the regions. Compiling greenhouse gas emissions inventories is one of these responsibilities. Each region implements the necessary means to establish their own emission inventory in accordance with the UNFCCC guidelines for the common reporting format. The emission inventories of the three regions are subsequently combined to form the national greenhouse gas emission inventory. Since 1980, the three regions have been developing different methodologies (depending on various external factors) for compiling their atmospheric emission inventories. During the last years important efforts are made to tune these different methodologies, especially for the most important (key) sectors. Obviously, this requires some co-ordination to ensure the consistency of the data and the establishment of the national inventory. This co-ordination is one of the permanent duties of the Working Group on « Emissions » of the *Co-ordination Committee for International Environmental Policy* (CCIEP), where the different actors decide how the regional data will be aggregated to a national total, taking into account the specific characteristics and interests of each region as well as the available means. The *Interregional*

Environment Unit (CELINE - IRCEL) is responsible for integrating the emission data from the inventories of the three regions and for compiling the national inventory. The National inventory report is than formally submitted to the National Climate Commission, established by the Cooperation agreement of 14 November 2002, for approval, before its submission to the Conference of the Parties to the United Nations Framework Convention on Climate Change and to the European Commission, under the Council Decision 280/2004/EC concerning a Mechanism for Monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.

1.3. Description of methodologies and data sources used

As a consequence of the responsibility of the regions in compiling greenhouse gas inventories, concomitant methodologies have been developed by the three regions for compiling their inventory from basic data. This section describes the general approach developed by each region. A similar presentation of the national inventory in Belgium has been applied in the chapters 3 to 8 for each of the IPCC sectors and for fluorinated gases (see section 4.2.4).

As the QA/QC procedures are not fully implemented in Belgium for the time being, these are not described in chapters 3 to 8 for each sector, but a general description is provided in section 1.5 below. Section 1.6 gives a detailed description of the uncertainty analysis of the emission inventory of 2003 that was carried out for the second time in Belgium during the last submission.

Inventory data for the years 1991 to 2004 have been recalculated, in a much less important way compared with last submission, as a consequence of methodological changes, harmonisation of allocation and/or methods between the regions, and access to new data sources. Emission figures of the greenhouse gases for 2005 are estimated on a temporary basis in Belgium in this submission.

The fluorinated gases (categories 2E and 2F) constitute an exception in that the emission inventory of these gases is set up at the national level as well as for each of the 3 regions, in a single, harmonised approach.

Contrary to all other sectors in the Belgian emission inventory, the emissions of CO_2 from road traffic are not calculated as the sum of the emissions of the 3 regions (see section 3.2.3 for further information). These emissions are calculated based on the national statistics (fuels sold on the Belgian territory) and IPCC default emission factors.

Because of the importance of fixing the emission quota of the reference years (1990 for all greenhouse gases except for the F-gases where 1995 is the reference year) in the framework of submitting the assigned amount report pursuant to Article 8(1)(e) of Decision 280/2004/EC before the 15th of January 2006 to the European Commission and the Decision 13/CMP.1 before 31 December 2006 to the UNFCCC-secretariat, special attention is gone during this submission to the optimization of the greenhouse gas emission inventory of the reference years. Of course in all cases of optimization time consistency is guaranteed.
In the same framework, the regions have done special efforts to harmonise methodologies between the 3 regions as much as possible and in the first place for the most important greenhouse gases (mainly CO2) and sectors. Some inconsistencies between methodologies in the 3 regions remain and will not be changed anymore in the future to keep the time consistency with the reference years within the regions. This is f.i. the case for the emission factors of CH_4 and N_2O in the manufacturing industry and construction and in the ‘other’ sectors where different sources (IPCC, CITEPA and EMEP/CORINAIR) remain used.

The regional inventory systems are fully described in the National Inventory System which has been reported by the end of 2006 to the secretariat of UNFCCC for the first time. An update of the National Inventory System will be made by the end of 2007.

1.3.1. Flemish region

In Flanders, the greenhouse gas inventory is set up by the *Department Monitoring and Research* of the *Flemish Environmental Agency* (VMM).

As it became an obligation in 2005 for the most important industrial sites in Flanders to report their emissions of greenhouse gases when exceeding a defined threshold value, the greenhouse gases (mainly for CH_4 and N_2O) of the industrial sector were revised during the last submission for the complete time series from 1990 on. This was among others the case for the refineries and the iron and steel sector.

The Flemish region has taken into account the information from the EU-ETS data based on Directive 2003/87/EC in a sense that reported sources in the EU-ETS framework are compared with the reported sources in the greenhouse gas emission inventory and completed if necessary. Next to this, the emissions of CO2 of the most important sources are also compared, where possible and relevant, in these two datasets.

CO_2 emissions

CO_2 emissions are mainly calculated on the basis of the energy balance, which is annually established by the *Flemish Institute for Technological Research* (Vito) [1] funded by the Flemish region. This is based on available statistical data and models, on the information coming from the obliged annual reporting of industrial emissions (mainly class I and class II companies and for emissions exceeding a given threshold value, compulsory since 1993) and on a survey among energy suppliers, federations and individual consumers. The methodology is described in the annual reporting document 'Energiebalans Vlaanderen : Onafhankelijke methode' ('Energy Balance Flanders : Independent methodology'). Last publication of this document dates from May 2006. The energy balances of all years can be found on http://www.emis.vito.be. This methodology is fine-tuned whenever necessary. Starting from this energy balance, the CO_2 emissions are calculated using CO_2 emission factors. These are mostly the default IPCC emission factors from the Revised 1996 Guidelines, except for some special products (blast furnace gas, coke oven gas, refinery gas, waste products) and sectors (refineries, electricity production) where more accurate, country-specific factors are used.

The other CO_2 emissions (non-energy consumption, waste incineration and process emissions of the glass- and ceramic production, steel production and the chemical industry) are calculated by using a country-specific methodology. In general, mostly Tier 1 methodology, the sectoral approach, was used for estimating the CO_2 emissions.

The emissions from the LUCF-sector in Flanders were completed during the 2006 submission. More in particular, the emissions and sinks of CO2 (total net emissions) of terrestrial ecosystems were newly estimated at that time. This source includes the emissions originating from the changes in carbon stock of grasslands, arable lands and forests, changes in biomass (aboveground) of trees in forests and the emissions as a result of cutting down the trees in forests (See section 7 for further detailed information).

CH_4 and N_2O emissions

CH_4 and N_2O emissions are mostly calculated by multiplying an activity data with an emission factor. Some of the emission factors used, originate from CITEPA [2], an institute that established these factors in the framework of the CORINAIR inventory and TNO [4]. In some cases these emission factors correspond with the emission factors described in the joint EMEP/CORINAIR handbook [3]. To conclude also country specific emission factors are used. The methodology used by the Flemish region to calculate the emissions of road transport, the so called MIMOSA-model, is mainly developed for policy objectives. This MIMOSA-model is an emission model that calculates the traffic emissions based on data of mobility per road segment. These emissions are calculated based on a traffic flow model of the Flemish region, which means that a geographical performance is possible.

Emissions of air traffic are calculated using the EMEP/CORINAIR methodology [3].

Industrial process emissions are estimated using specific plant information combined with specific (or default) emission factors or by using the results of monitoring work carried out in the plant.

Country-specific methodologies are developed for calculating the emissions of navigation and transport via railways, for agriculture (reference [6] for CH_4 and [7] for N_2O), for solid waste disposal [8] and for distribution, transmission and storage of natural gas.

1.3.2. Walloon region

The emission inventories of the Walloon region are compiled by the *General Directorate for natural resources and environment* (DGRNE) using the IPCC methodology (or EMEP/CORINAIR for some sectors where IPCC does not provide emission factors). Emission factors used, are examined with all industrial sectors. In some cases as agriculture and forestry, the emissions estimates are based on a specific study reflecting the Walloon environment.

One main data source for the inventory preparation is the energy balance delivered yearly by the DGTRE (Directorate general for Technology, Research and Energy). The energy balance describes the quantities of energy imported, produced, transformed and consumed in the Walloon Region in a given year. In 2003, an environmental integrated survey has been created which includes all pertinent environment-related reporting requirements for 300 companies. The environmental integrated survey is personalised to the 300 operators of the activities/installations pointed out by one or several regulations (four international Conventions and their protocols, seven European Directives, three European Regulations, two European Decisions, one European Recommendation, two Walloon laws, one Walloon Decree and several non legally binding agreements). The informations related to GHG emissions are used to calculate the emissions of the most important emitters in the industry, waste and energy sectors. In particular, the information coming from teh reporting under the ETS is used in GHG the inventory preparation.

The data source and inventory preparation are described in details in the National Inventory System.

1.3.3. Brussels region

The emission inventories of the Brussels region are compiled by the *Brussels Institute for Environmental Management* (IBGE-BIM) using the IPCC and EMEP/CORINAIR methodology. The emissions are calculated by multiplying an activity data by an emission factor. Generally, these activity data and emission factors used in the Brussels inventory are estimated on the basis of research projects funded by IBGE-BIM (for instance, the annual energy balance that is established on a survey among energy suppliers, federations and individual consumers). These projects combine the socio-economic Brussels specificities and the reference values found in the IPCC Guidelines, specific bibliographies like PARCOM, TNO, EPA,… as well as in the joint EMEP/CORINAIR handbook [3, 44] . The different sectors taken into account in the Brussels emission inventory reflect the characteristics of a strict urban environment.

The emissions from energy consumption constitute nearly all the emissions of this urban region.

1.4. Key sources categories

Key source categories are identified according to the Tier 1 method described in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories [10]. Both a Level Assessment (contribution of each source category to the total national estimate) and a Trend Assessment (contribution of each source category's trend to the total trend) are conducted.

The key source analysis is realised on the basis of a set of sub-categories, at the level of detail of the Sectoral Report Tables. When appropriate (detail for sub-categories not available), sub-categories are aggregated at a higher level. Sources that do not occur in Belgium as well as those that are not estimated (no data) and the LUCF sources are excluded. Each greenhouse gas emitted by a single source category is considered separately. This procedure leads to the determination of a set of fifty-four source categories, covering 99.5% of the total aggregated emissions. The key source analysis is performed by using CO_2-equivalent emissions calculated by means of the global warming potentials (GWPs) specified in the UNFCCC reporting guidelines on annual inventories.

The Level Assessment (see Annex 1) results in the identification of 27 key sources, covering 95%[1] of the total national aggregated emissions. 27 key sources are identified from the Trend Assessment (see Annex 1), as those that contribute 95% to the trend of the inventory. Key source categories identified form the Level and the Trend Assessments overlap to a large extent. As a whole (Level and Trend Assessments), 32 key source categories are determined (Table 1.1). The absolute change in direct greenhouse gas emissions of these key sources over the period 1990-2005 is listed in Table 1.1 and shown in Figure 1.1.

CO_2 emissions from road transportation is the first key source of greenhouse gas emissions in Belgium (17.3% of total aggregated emissions). It constitutes the main driver of emissions trends (Annex 1). CO_2 emissions from road transportation, electricity production and residential space heating are pointed out by the Level Assessment as the three main key source categories, each contributing to 15 to 18% of the total national emissions (together, these three sources cover 50% of the total emissions). CO_2 emissions from iron and steel industry and chemical industry (IPCC category 1.A.2.c) also constitute major key sources, which respectively account for 6.6 % and 5.4 % of the total emissions.

The three most important key sources of non-CO_2 emissions in Belgium are CH_4 emissions from cattle (enteric fermentation) (2.5%), N_2O emissions from nitric acid production (2.1%), and N_2O emissions from agricultural soils (1.5%). One may finally notice that the five key source categories which displayed the most important absolute increase in their emissions over the period 1990-2005 (figure 1.1, table 1.1), are CO_2 from road transportation (+5658 Gg CO_2-eq.), CO_2 from residential (+1953 Gg CO_2-eq.), CO_2 from commercial & institutional (+1686 Gg CO_2-eq.), energy related CO_2 from chemicals (IPCC category 1.A.2.c, +1470 Gg CO_2-eq.), and HFCs emissions from refrigeration and air conditioning equipment (+1117 Gg CO_2-eq.). On the contrary, CO_2 from Iron and steel (-4743 Gg CO_2-eq.), CH_4 from waste disposal on land (-1807 Gg CO_2-eq.), CO_2 from solid fuels (IPCC category

[1] This threshold (95%) is recommended in the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, for both the Level Assessment and the Trend Assessment ; it was determined to be the level at which 90% of the uncertainty in a 'typical' inventory would be covered by key source categories, for the Tier 1 method.

1.A.1.c, -1716 Gg CO_2-eq.), PFCs production (-1612 Gg CO2-eq.) and SF6 production (-1559 Gg CO_2-eq.) are the source categories that displayed the most important drop in GHG emissions between 1990 and 2005.

IPCC Source Categories	Direct Greenhouse Gas	Criteria for identification	Absolute emission trend (1990-2005)
			(Gg CO2 eq.)
ENERGY			
1.A.1.a. Public Electricity and Heat Production	CO2	Level, Trend	1204
1.A.1.b. Petroleum Refining	CO2	Level, Trend	357
1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	CO2	Trend	-1716
1.A.2.a. Iron and Steel	CO2	Level, Trend	-4743
1.A.2.c. Chemicals	CO2	Level, Trend	1470
1.A.2.e. Food Processing, Beverages and Tobacco	CO2	Level, Trend	-808
1.A.2.f. Other (Manufacturing Industries and Construction)	CO2	Level, Trend	-911
1.A.3.b. Road Transportation	CO2	Level, Trend	5658
1.A.4.a. Commercial/Institutional	CO2	Level, Trend	1686
1.A.4.b. Residential	CO2	Level, Trend	1953
1.A.4.c. Agriculture/Forestry/Fisheries	CO2	Level, Trend	-336
1A.3. Transport	N2O	Level, Trend	485
1A.4. Other Sectors	N2O	Level	4
INDUSTRIAL PROCESSES			
2.A.1. Cement Production	CO2	Level, Trend	110
2.A.2. Lime Production	CO2	Level	-79
2.B.1. Ammonia Production	CO2	Level, Trend	637
2.B.2. Nitric Acid Production	N2O	Level, Trend	-496
2.B.5. Other (Chemical Industry)	CO2	Level, Trend	687
2.C.1. Iron and Steel Production	CO2	Level, Trend	-411
2.E. Production of Halocarbons and SF6	SF6	Trend	-1559
2.E. Production of Halocarbons and SF6	PFCs	Trend	-1612
2.F.1. Refrigeration and Air Conditioning Equipment	HFCs	Level, Trend	1117
2.F.2. Foam Blowing	HFCs	Trend	-223
AGRICULTURE			
4.A.1. Cattle	CH4	Level, Trend	-695
4.B.1. Cattle	CH4	Level, Trend	-219
4.B.12. Solid Storage and Dry Lot	N2O	Level	-105
4.B.8. Swine	CH4	Level	-85
4.D.1. Direct Soil Emissions	N2O	Level, Trend	-273
4.D.2. Animal Production (2)	N2O	Level	-134
4.D.3. Indirect Emissions	N2O	Level, Trend	-255
WASTE			
6.A.1. Managed Waste Disposal on Land	CH4	Level, Trend	-1807
6.D. Other (composting)	CH4	Trend	-223

Table 1.1. : Key source category analysis: summary (see details in Annex 1).

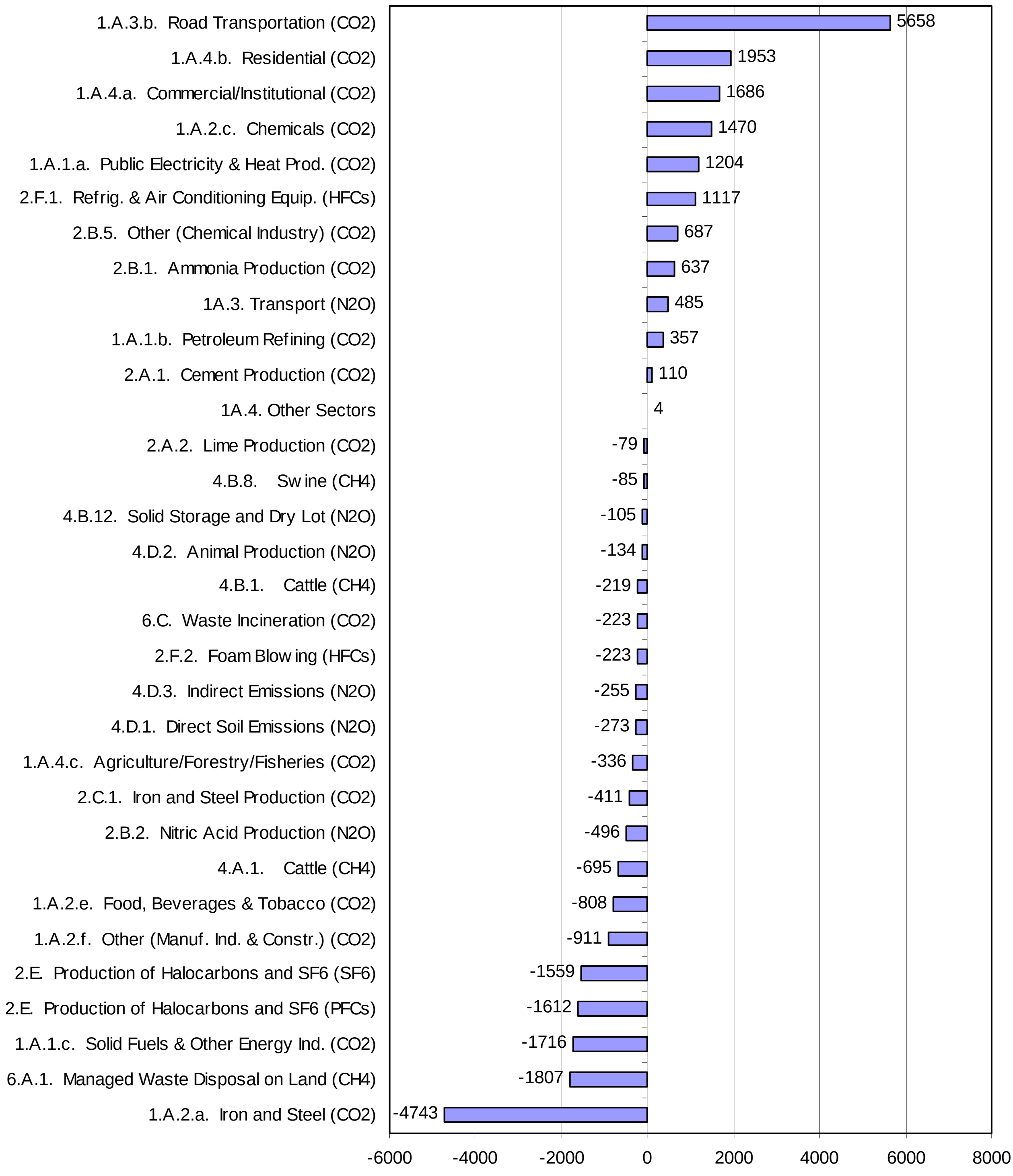


Figure 1.1. : Key source category analysis : GHG Emission Trends 1990-2005 (Gg CO_2 equivalent).

1.5. QA/QC plan and related issues

The Working Group on « Emissions » of the *Co-ordination Committee for International Environmental Policy* (CCIEP) has conducted intern quality insurance and quality control work by continuously exchanging information about methodologies used and estimated results. Feedback is given and extra controls are made by the responsible person for compiling the Belgian emission inventory of greenhouse gases. As a consequence this all gives extra checks of the regional emission inventories as well.

Independent audits of the greenhouse gas inventories of the regions and the national inventory have started in the course of 2002 and all the results of the 3 regions in Belgium became available in 2003. The purpose of these audits was to analyse the difficulties encountered while compiling the regional and national emission inventories in order to improve the quality and completeness of the Belgian national emission inventory and to evaluate the differences met between the present process of information and the IPCC Guidelines and the obligations need to be fulfilled in the framework of the Kyoto Protocol.

The results of these audits of greenhouse gases show clearly that - taking into account the limitations in available time, manpower and means – the Belgian national inventory is of qualitative good value. The difference between the actual situation in Belgium and the fulfilling of the IPCC Guidelines is mainly the absence of the complete implementation of the IPCC Good Practice Guidance [10] for the Belgian emission inventory.

Technical working groups are set up since the beginning of 2003 to investigate in detail the implementation of the Good Practice Guidance for the different sectors in Belgium and to try to limit the inconsistencies between the 3 regional emission inventories in Belgium as much as possible. The overall conclusion in the different technical working groups was that the regional and the national inventories in Belgium are set up to the best of the ability, that appropriate methods are used for all sectors and in accordance with the IPCC Good Practice Guidance.

Calculations of uncertainties on greenhouse gas emissions on the national level are calculated on Tier 1-level (see section 1.6 for more details).

Below the QA/QC procedures are describes as applied in the 3 regions in Belgium.

1.5.1. QA/QC in the Flemish region

In Flanders, the procedures to prepare the Flemish energy balance are part of a certified ISO 9001 system since July 2000. The certificate number is 08376-2003-AQ-ROT-BELCERT. This certificate is currently applicable to the development and implementation of complete evaluation methods and management concepts for the sustainable use of materials, energy and environment, including the electronic distribution of information on energy and environmental information (EMIS).

The quality system consists of quality procedures and planning activities. Specific for the preparation of the energy balance, there are 7 procedures in place.

EMIS-PRO 021	Energy balance Flanders	General procedure with methodology to prepare an energy balance for a specific year.
EMIS-PRO 022	Survey of industry	The procedure describes the methodology to carry out a survey in the industrial sectors in a specific year.
EMIS-PRO 023	Extrapolation of industry	The procedure describes the methodology to extrapolate the energy consumptions from the survey in the industry to a global energy consumption for the industry in Flanders for a specific year.
EMIS-PRO 024	Survey of service sector	The procedure describes the methodology to carry out a survey in the service sectors in a specific year.
EMIS-PRO 025	Extrapolation of service sector	The procedure describes the methodology to extrapolate the energy consumptions from the survey in the service sector to a global energy consumption for the service sector in Flanders for a specific year.
EMIS-PRO 026	Transformation sector	The procedure describes the methodology to compose the transformation sector in the energy balance.
EMIS-PRO 027	Survey of electricity sector	The procedure describes the methodology to carry out the survey for electricity and heat-production in cooperation with ANRE and implementation of the resolution.

Procedure EMIS-PRO 021 describes the general methodology used to establish a yearly energy balance for Flanders. Purpose of this procedure is to give information and instructions to be able to establish in a coherent way an energy balance for Flanders in a specific year. The procedure refers where appropriate to the other procedures for specific sectors.

The mentioned EMIS-procedures for the preparation of the energy balance for Flanders are part of the covering quality system of the expertise center IMS (Integral Environmental Studies) in VITO. The quality handbook of the expertise center gives an overview on the global quality system with references to the specific procedures of specific activities. An example of a general procedure is *'ALG-PRO 011 Continuous quality improvement, quality renewal and control of aberrations'*. This procedure describes the responsibilities and actions to be taken of all staff members in case aberrations occur.

In the beginning of 2004, in Flanders a study started to calculate the uncertainties (both on Tier 1 and Tier 2 level) and to guide in the implementation of a quality system (QA/QC-plan) of the emission inventory of greenhouse gases. Final results of this study became available in May 2004.
A complete development of the QA/QC system (among others further description in detail of all the procedures involved) as well as a first internal review became operational in the course of 2005, this means that the full implementation for all sectors and on the most detailed level is started in the beginning of 2006.
The quality system set up in Flanders is completely based on the standardized norm ISO 9001:2000.
In the process of development of the quality management system in Flanders, a gap-analysis was carried out, a quality structure and different standardized procedures were set up. A quality handbook was published which includes all aspects of a technical and organizational level to set up the emission inventory of GHG.
Standardized procedures of different levels are defined.
In what follows a summary is given of all procedures involved in the QA/QC-system:

More general procedures :
VMM/AMO/GP1/0.004: Procedure for the treatment of a complaint;
VMM/AMO/GP1/0.006: Procedure for the management of quality care-personnel files;

VMM/AMO/GP1/0.008: Procedure for the performance of audits;
VMM/AMO/GP1/0.010: Procedure for setting up a general quality care–management report;
VMM/AMO/GP1/0.011: Procedure for the management of documents.

More detailed procedures :
VMM/AMO/GP2/5.001: Procedure to determine non-conformities, quality problems and proposals for improvement and follow-up by means of corrective and preventive measures;
VMM/AMO/GP2/5.002: Procedure for the training of the personnel of the service "Emissie Inventaris Lucht" (Emission Inventory Air);
VMM/AMO/GP2/5.003: Procedure for the main process: setting up the greenhouse gas emission inventory;
VMM/AMO/GP2/5.004: Procedure to manage the Balanced Score Card.

The results of this Flemish study will be taken into account to set up a comparable system in the 2 other regions in Belgium.

1.5.2. QA/QC in the Walloon region

In Wallonia, the inventory is conducted by the Air Cell, which is part of the General Directorate for Natural Resources and Environment, and the latter has now obtained its EMAS certification. An ISO 9001 certification is also foreseen.

For what concerns the measurements used to determine country-specific emission factors, it can be mentioned that in Wallonia, before performing any air emissions measurements, all the laboratories must first be agreed by ISSEP, which conducts a review of material and methodologies used and check the compliance with the requirements of a legal decree (Arrêté royal du 13 décembre 1966 relatif aux conditions et modalités d'agrément des laboratoires et organismes chargés des prélèvements, analyses et recherches dans le cadre de la lutte contre la pollution atmosphérique (M.B. 14.02.1967)) .The updated list of agreed laboratories is published on the website of DGRNE, the responsible institut in Wallonia.

1.5.3. QA/QC in the Brussels region

In the Brussels region, the energy balance is established by an independent institute, ICEDD (Institut de Conseil et d'Etudes en Développement Durable), who is certified ISO 9001 for its internal procedures. For information, the emissions from energy consumption constitute nearly all the emissions of this urban region.

1.6 Tier 1 uncertainty calculation

1.6.1. General approach

The IPCC Good Practice Guidance Tier 1 methodology has been applied to assess the uncertainty in the emission greenhouse gas inventory. The uncertainty calculation is applied on the Belgian

greenhouse gas emission inventory of 2003 as submitted on the 15th of March 2006 to the European Commission.
A trend uncertainty analysis is performed for the years 1990 (1995 for F-gases) and 2003. All sectors (except LULUCF) are included in the calculation, this means that the uncertainty analysis of the emissions of F-gases is also included. The uncertainty calculation at a tier 1-level of the fluorinated greenhouse gases has been carried out in 2005 and 2006 by Econotec and the Vito [45] for the years 1995 (base year for F-gases), 2003, 2004 and 2005.

In Flanders, a complete study of the uncertainty was conducted in 2004 by an independent consultant, Det Norske Veritas, both on Tier 1 and Tier 2 level. The uncertainties were determined for the emission level 2001 and for the 1990-2001 trend in emissions for all source categories comprising emissions of CO_2, CH_4 and N_2O. These results are available in the technical report 'Quantification of Uncertainties – Emission Inventory of Greenhouse Gases of the Flemish Region of June 2004'.

As most of the data suppliers in Belgium do not provide any information on the associated uncertainty, the IPCC default values have been largely used in the 3 regions in Belgium, together with expert judgement regarding their applicability in the national /regional circumstances.

In the absence of default IPCC values, estimates have been searched in other sources such as the EMEP/CORINAIR guidebook [3] and studies on uncertainty in emission inventories conducted in other member states, in the case where national circumstances could be assumed comparable.

The results of the three regions have then been compiled using expert judgement and/or error propagation equation from the Good Practice Guidance, in order to produce one single table 6.1 (as expressed in the guidelines), presented in Annex III.

According to the available references, in most member states the ultimate choice of an uncertainty estimate is often based on expert judgement and is therefore also rather uncertain. However, as stressed by the IPCC Good Practice Guidance [10], uncertainty calculation is a mean to identify and prioritise improvement activities, rather than an objective on itself.

1.6.2. Methodology of the uncertainty calculation in detail by CRF category

1A1 Energy industries

According to table 2.6 of the IPCC Good Practice Guidance, the uncertainty on activity data is less than 1% in the case of a survey. The uncertainty takes into account that a complete survey of energy industries is conducted yearly for the purpose of establishing the energy balance. The uncertainty on emission factors originates from table 2.5 and page 2.15 of the IPCC Good Practice Guidance associated with expert judgement.

1A1b Petroleum Refining

The uncertainties both on activity data and emission factors for CO_2, CH_4 and N_2O are mainly based on IPCC Good Practice Guidance in combination with expert judgement and are mostly in line with the estimates given in other countries. For gaseous fuels the uncertainty on activity data is estimated as 1% because of very accurate statistics in Flanders for this fuel.

1A2 Manufacturing industries and construction.

According to table 2.6 of the IPCC Good Practice Guidance, the uncertainty on activity data is between 2 and 3 % in the case of a survey. In Belgium, the annual survey is cross-checked with other sources of information of the biggest industries. However, it is considered that measuring is more accurate for gaseous fuels (Monni and Syri, 2001) leading to 2% uncertainty on the activity data, compared in most cases with 5 % for solid fuels. For liquid fuels, the uncertainty lies between 2 and 8 %, depending on the sector considered. Higher values are chosen for biomass and other fuels, respectively 20 and 5%.

The uncertainty on emission factors is the same as for energy industries, as the same emission factors are used.

1A3 Transport

The uncertainty on activity data for CO_2 emissions from road transport is given page 2.49 of the IPCC Good Practice Guidance, which mentions that this is the main source of uncertainty for CO_2. The same uncertainty on activity data is used for all gases. For CH_4 and N_2O, the uncertainty on emission factors are those recommended by the IPCC Good Practice Guidance. A higher uncertainty is estimated for N_2O because of the lack of precise monitoring on the combustion conditions (vehicles types, average speed, etc…).

Default IPCC values are used for civil aviation, both for activity data and emission factors. For railways the uncertainty is allocated under the energy industries. In Belgium 93% of the train kilometres for passengers and 75% for goods are performed in a electrical way. The rest of the locomotives uses diesel as fuel. In the absence of IPCC default value, the uncertainty on activity data is estimated at 6 %, considering that this data is collected and delivered yearly by one single national operator. The emissions factors are taken from EMEP/CORINAIR guidebook where their uncertainty rating are respectively "C" and "E" for CH_4 and N_2O. This ranking seems quite consistent with the values used in Finland [40], respectively 60-110% for CH_4 and 70- 150 % for N_2O. Similar values were consequently adopted as a first estimate.

Fuel consumption in navigation is estimated on the basis of the traffic, which is quite controlled on the domestic scale. The uncertainty on activity data is estimated at 10 %. For emissions factors, the uncertainty is in the same range as for railways, considering the same rating of these emission factors in the EMEP/CORINAIR guidebook.

The CO_2 emissions under category "other" includes energetic emissions originating from the transport through pipelines (compression stations). An uncertainty is assumed of 5% on activity data (information data from the gas federation) and of 1% on the emission factor (default IPCC emission factor).

1A4 Other sectors

Commercial and residential fuel consumption is the main activity data in this sector. Surveys are combined with extrapolations in order to estimate the consumption. The uncertainty on activity data is based on the table 2.6 of the IPCC Good Practice Guidance and takes into account the type of fuels : natural gas is measured with accuracy, but wood consumption is extrapolated from available data. The uncertainty on emission factors is the same as for energy and industrial sectors (see table 2.5 of the IPCC Good Practice Guidance).

1B Fugitive emissions from fuels

Fugitive emissions under category 1B1 are linked to the production of coke. The production is assumed to be well known, while the uncertainty on the emission factor is estimated at 60 %, taking into account the EMEP quality estimate and range of values.
Uncertainty estimates on the fugitive emissions from oil refining and storage (category 1B2a) are assumed to be the same as in the category 1A1b for the activity data and for the emission factors (5% for the activity data and 50 % for the emission factor).

The uncertainty on the amount of gas leaked through the distribution network is high according to page 2.92 of the IPCC Good Practice Guidance. Since the activity data (length of pipelines for the different materials of pipelines) are based on information of the gas distribution company, the uncertainty is estimated at 10%. Emission factors (= leak rates) are based on measurements carried out by this company and their uncertainty is estimated at 30%.

2A Mineral products

For lime and cement plants, the uncertainty on activity data comes from the pages 3.15 and 3.21 of the IPCC Good Practice Guidance. The uncertainty on emission factors is assumed to be low, as plant-specific emission factors are used in these sectors.

The uncertainty on activity data for glass production is assumed to be comparable with the other industrial productions. The CO_2 emission factor of the EMEP/CORINAIR guidebook originates from studies in the Netherlands. Consequently, the uncertainty on the emission factor was taken from the NIR of the Netherlands for this sector.

2B Chemical industry

The only references found for the ammonia production are the Norwegian uncertainty calculation [41] and the Irish NIR. Average values from these references are used in this study following expert judgement.

Since there is only one producer of nitric acid remaining in the Flemish region since 2000 with reliable production data, the uncertainty of the activity data is estimated at 2%. Based on the Finnish evaluation in 2001, the uncertainty on the N_2O emission factor is estimated at 80% in spite of an agreement of this company for the emission factor used.
The same uncertainty in activity data is used for the production of caprolactam as for the production of nitric acid (2%) for the same reason. The uncertainty of the emission factor is estimated at 30% by expert judgment.

2C Metal production

The uncertainty on activity data is estimated at 2% because these figures come directly from the companies which dispose of good developed statistical systems., Their uncertainty is assumed to be in the low range of IPCC values as the emission factors are mainly plant-specific.

2E Production of halocarbons

The emission figures are a result of measurements combined with a mass balance. The calculated scientific and model uncertainty is 13 % (based on error propagation analysis).

The non-fugitive emissions of CF_4 are measured. Their calculated uncertainty is 45 %.

The uncertainty figures have been reviewed and confirmed by an external consultant (see 1.6.1 [45]) in 2004. However, they seem to be unrealistically low according to this consultant and the company itself. In order to get a conservative estimate, they have been doubled in the uncertainty calculation table given the small share of this emission source in the overall GHG emissions. The overall impact of this change remains limited (in the order of 0,1% of the total national GHG emissions).

2F Consumption of halocarbons

The main emission source is the application of distributed refrigeration systems (refrigeration plants in industry and the commercial sector, as well as air conditioning plants that are built and filled with refrigerant on site). The emissions are calculated as the product of the bank (activity variable) and the emission rate (emission factor). The size of the bank itself is calculated on the basis of past refrigerant deliveries and assumptions on the emission rate. Therefore the activity variable and the emission factor are correlated.

Because of this correlation, the uncertainty has been assessed globally, and this in particular by carrying out sensitivity analyses on the impact of the emission rate on the emissions, using the emission calculation model.

For the remaining emission sources, the uncertainty has been estimated in general separately for the activity variable and for the emission factor. Given the lack of statistical data and default values in the IPCC guidelines, the figures are generally based on expert judgement.

2G Feedstocks

The uncertainties both on activity data and emission factors for CO_2 are mainly based on expert judgment. Information originated from the emission inventories of Finland and the Netherlands is also taken into account to obtain a final uncertainty of 25% on activity data and of 30% on the emission factor.

3D N_2O from anaesthesia

The activity data is the number of hospital beds, which is well known. As no default emission factor is available by EMEP/CORINAIR nor by the IPCC Guidelines [10], a national specific emission factor has been estimated through surveys in hospitals. The uncertainty on this emission factor is considered high.

4A Enteric fermentation

The only activity data here is the national livestock census. The uncertainty is judged small taken into account the features of the monitoring (census twice a year, individual earmarks and registration for all bovines, …),. The emission factors are mainly the IPCC default values, using Tier 1 methodology. Consequently, the IPCC uncertainty estimate of 40% is used for the emission factor.

4B Manure management

The activity data are the livestock census, but also the type of animal housing. The type of housing is more difficult to assess than the number of animals. Consequently the uncertainty on the activity data is estimated at 10 %.

The CH_4 emission factors are based on a regional-specific study. However, given that many assumptions were necessary to calculate these emission factors, the uncertainty on these emission factors is estimated to be similar to the uncertainty on enteric fermentation emission factor.

The IPCC emission factors are used to calculate the emissions of N_2O. Consequently, the IPCC uncertainty (page 4.43) in combination with information of the Finnish emission inventory, are used in the uncertainty calculation.

4D Agricultural soils

This small source for CH_4 is linked to the manure applied during grazing. The same uncertainty as for CH_4 from manure management is applied.

In comparison with the previous agricultural sectors, N_2O emissions from soils involves the use of more activity data, such as the use of mineral fertilisers, the atmospheric deposition and runoff, the amount of manure applied on the fields, etc… Consequently the uncertainty on activity data is estimated at 30%, which seems in line with the values applied by other parties.

It is well known that the uncertainty of N_2O from agricultural soils is crucial for the determination of the overall uncertainty. Although most countries use the IPCC default values, the uncertainty on emission factors varies widely : 2 orders of magnitude (Norway, [41]), 509 % (UK, in IPCC Good Practice Guidance), 200 % (France and the Netherlands, NIR 2003), 100 % (Ireland, NIR 2003), 75 % (Finland, overall uncertainty for AD*EF, [40]), 24 % (Austria, NIR 2003). For the time being, a more or less average value of 250 % is used for this uncertainty calculation.

6A Solid waste disposal on land

In the Flemish region input data of waste disposal sites are available since 1990. There isn't waste disposal site in the Brussels region.

In Wallonia, complete statistics on the amount of waste input in solid waste disposal sites are delivered on a yearly basis since 1994. For the previous years, the amounts have been estimated using available data and expert judgement from the waste offices. Hence, the uncertainty on activity data is lower since 1994. However, given that in the model the activity data of a single year is used over a 25 years degradation time, the same uncertainty of 30 % (1990 estimate) has been applied on the whole time series.
For the same reasons, the activity data are assumed to be correlated for the calculation of the uncertainty in trend.

The overall uncertainty on emission factors reported in other member states goes from 30 % (Netherlands, Finland, Norway) to 50 % (Ireland, France). A provisional value of 40 % is adopted for this calculation.

6B Wastewater handling

IPCC recommends an activity data uncertainty of 5% for population and 30 % for BOD/person. An overall uncertainty of 20 % is considered for activity data. The same uncertainty is used for N_2O calculation, assuming that the uncertainty on the annual per capita protein intake and the fraction of nitrogen in these proteins lies in the same range.

The uncertainty on CH_4 emission factor reported by other parties goes from 48 % (UK, 2000) to 104 % (Finland), mainly depending on the uncertainty on the Methane Conversion Factor (fraction treated anaerobically). A default value is used for the time being and further expert judgement is needed on this estimate. Thus, an average uncertainty of 70 % is used for the time being.

For N_2O the default IPCC emission factor of 0.01 kg N_2O/kg N is used. This emission factor originates from table 4.18 of the IPCC 1996 Guidelines with a given range of 0.0025 to 0.0225. This range represents an uncertainty of –75% to +125%. An uncertainty of 110 % is used in this calculation.

6C Waste incineration

For N_2O, an uncertainty of 100% on the emission factor is applied, following IPCC Good Practice Guidance. The uncertainty on activity data (amount of waste) is estimated at 5%.

In Wallonia, CO_2 emissions are measured in each waste incinerator. The confidence interval was calculated for each of the incinerators, based on the standard deviation of the mean. Those uncertainties were then combined according to equation 6.3 of the IPCC Good Practice Guidance, using the 1990-2001 average quantities of waste for each plant. This estimate gives an overall uncertainty of 24 % on the CO_2 emission factor. However , the estimate of the biogenic content of the waste is another source of uncertainty. Six results on the average composition of the municipal waste are available since 1997, allowing a calculation of the confidence interval. It appears that the average biogenic part of those wastes is rather stable, although the effect of some waste policies such as separate collection of paper can be observed. The uncertainty based on the confidence interval is 3%. Using equation 6.4, the total uncertainty on the CO_2 emission factor is 24,2%.
In Flanders the major uncertainty for the estimation of CO_2 is the estimation of the fossil carbon fraction. As in Flanders the methods to determine this fossil carbon fraction are identical for this sector (combustion of waste without energy recuperation) and for the energy sector (combustion of waste or other fuels with energy recuperation), the uncertainty on the CO_2 emission fraction for waste combustion is estimated at 10% (the same as for category 1A1-other fuels).The average of both estimations gives an average uncertainty of 17 %.

Flaring in the chemical industry is monitored, uncertainty on activity data is estimated at 20% according to expert judgement. The uncertainty on the emission factor is estimated at 20 %.

6D Composting

The uncertainties both on activity data and emission factors for CH_4 are based on expert judgment and results in an uncertainty of 30% on the activity data and 200% on the emission factor.

1.6.3. Results and discussion

The Tier 1 analysis of the uncertainty results in an overall uncertainty of 7.5 % in the 2003 inventory for Belgium and a trend uncertainty 1990-2003 of 2,7 %. While the uncertainty on CO_2 emission is estimated at 1,9 %, the emissions of CH_4, fluorinated gases and N_2O are much more uncertain, respectively 24 %, 27 % and 100 %.

As in other Parties, this outcome is largely determined by the uncertainty on the estimate of N_2O emissions from agricultural soils. While reviewing the uncertainty calculation of five industrialised countries, Rypdal and Winiwarter [42] pointed out that *"The differences in uncertainty are, in particular, due to different subjective assessment of the uncertainty in emissions of nitrous oxide from agricultural soils"*. The other sectors of which the combined uncertainty represent more than 1 % of total national emissions are N_2O emissions from liquid fuels in the residential sector, N_2O from nitric acid production in the chemical industry and CH_4 from enteric fermentation.

It can be pointed that, given the relatively limited change in the emissions from agricultural sources between 1990 and 2003, their influence is not as large in the case of the trend.

CHAPTER 2: TRENDS IN GREENHOUSE GAS EMISSIONS

GHG emission trends are presented in this section. Emission trends are analysed for each greenhouse gas and for the main key sources, as well as in an aggregated format, using global warming potential (GWP) values. The distribution of emissions by gases and by sources is also commented. A more detailed analysis of the drivers of the emission trends is presented in the belgian fourth National Communication. A distance-to-target assessment, aiming at evaluating progress of Belgium towards fulfilling its commitment under the Kyoto Protocol and the EU 'burden sharing' agreement, is commented as well. A division of GHG emission trends at the regional level is presented in Annex 2. Trends of indirect GHG and SO_2 are presented at the end of the chapter.

2.1. Emission trends for aggregated greenhouse gas emissions

Total greenhouse gas emissions (without LUCF) in Belgium amounted to 143.8 Mt CO_2 eq in 2005 (Table 2.1.), which constitutes an decrease by 1.3 % compared to GHG emissions in 1990. Emissions in 2005 are 2.1% under base year emissions[2] (Figure 2.1). Under the Kyoto Protocol and the EU 'burden sharing' agreement, Belgium is committed to reduce its GHG emissions by 7.5%. Assuming a linear target path from 1990 to 2010, total GHG emissions in 2005 were 3.6 index points above this target path.

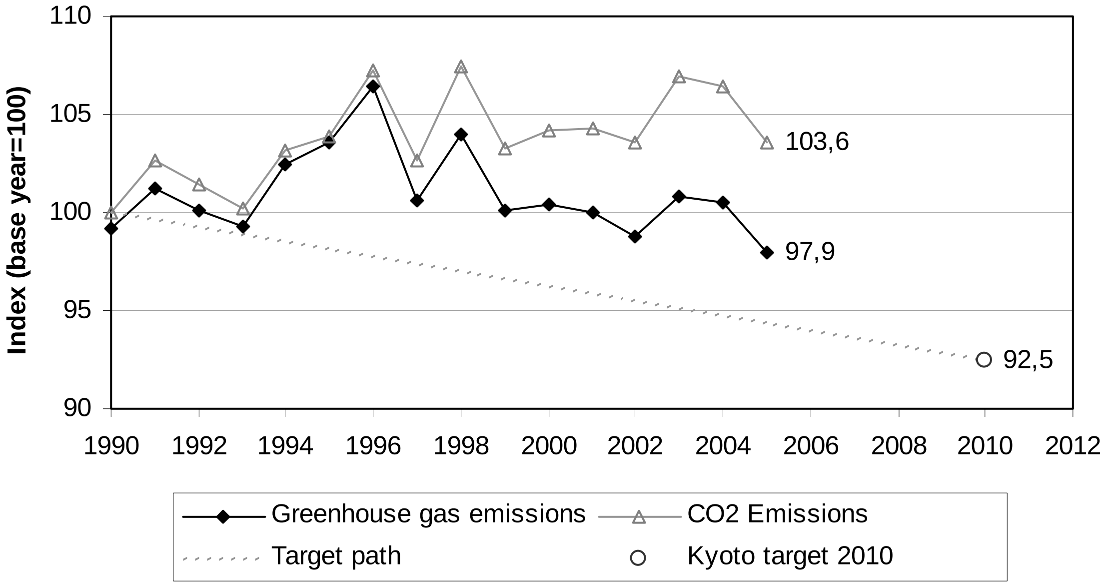


Figure 2.1. : Belgium GHG and CO_2 emissions 1990-2005 (excl. LULUCF), compared with Kyoto target.

Unit: Index point (base year emissions = 100).

Note: For the fluorinated gases, the base year is 1995; as the y-axis refers to the base year, the index value for the year 1990 is not necessarily 100.

[2] Base year is 1995 for fluorinated gases, 1990 for other gases

Table 2.1. : Overview of Belgium GHG emissions and removals from 1990 to 2005 (Gg CO_2 equivalents).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Net CO2 emissions/removals	117650	121108	119192	117871	121314	122272	126434	120794	126687	121719	122502	121358	120987	125595	125574	122959
CO2 emissions (without LUCF)	119081	122300	120755	119354	122880	123658	127691	122203	127972	122942	124053	124155	123325	127312	126748	123329
CH4	10825	10714	10662	10595	10586	10605	10344	10159	9990	9768	9463	8948	8452	8077	7964	7833
N2O	12010	11952	11587	11952	12487	12905	13416	13043	13156	13018	12651	12479	11859	10969	11121	11049
HFCs	434	434	434	434	434	434	513	621	751	787	893	1028	1245	1399	1461	1454
PFCs	1753	1678	1830	1759	2113	2335	2217	1211	669	348	361	223	82	209	306	141
SF6	1663	1576	1744	1677	2035	2205	2120	525	270	120	109	105	94	75	51	43
Total (with net CO2 emissions/removals)	144335	147463	145448	144287	148969	150757	155044	146355	151524	145760	145979	144139	142719	146323	146478	143478
Total (without CO2 from LUCF)	145766	148655	147011	145771	150535	152143	156301	147763	152809	146983	147529	146937	145057	148040	147651	143848

Table 2.2. : Overview of GHG emissions and removals in the main sectors from 1990 to 2005 (Gg CO_2 equivalents).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Energy	112728	116759	115372	114161	116212	116498	121342	115389	121094	115721	116769	117547	116028	120047	119378	116372
Industrial Processes	16398	15702	15487	15529	18135	19428	19088	16572	16106	15823	15812	15038	15215	14730	15209	14637
Solvent and Other Product Use	246	246	249	247	244	240	238	238	237	236	253	252	250	250	250	249
Agriculture	13043	12827	12753	12905	12931	13082	12917	12824	12813	12861	12484	12349	11999	11511	11413	11259
Land-Use Change and Forestry	-1431	-1192	-1563	-1483	-1566	-1386	-1257	-1408	-1285	-1223	-1550	-2798	-2337	-1717	-1173	-370
Waste	3351	3120	3150	2928	3012	2895	2715	2740	2559	2342	2211	1751	1565	1503	1402	1332

2.2. Emission trends by gas

The major greenhouse gas in Belgium is carbon dioxide (CO_2), which accounted for 85.7 % of total GHG emissions in 2005. Methane (CH_4) accounts for 5.4 %, nitrous oxide (N_2O) for 7.7 %, and fluorinated gases for 1.1% (Figure 2.2). Emissions of CO_2 increased 3.6% during 1990-2005, while CH_4, N_2O and fluorinated gas emissions have dropped with respectively 27.6%, 8.0% and 67.1 %[3] during the same period.

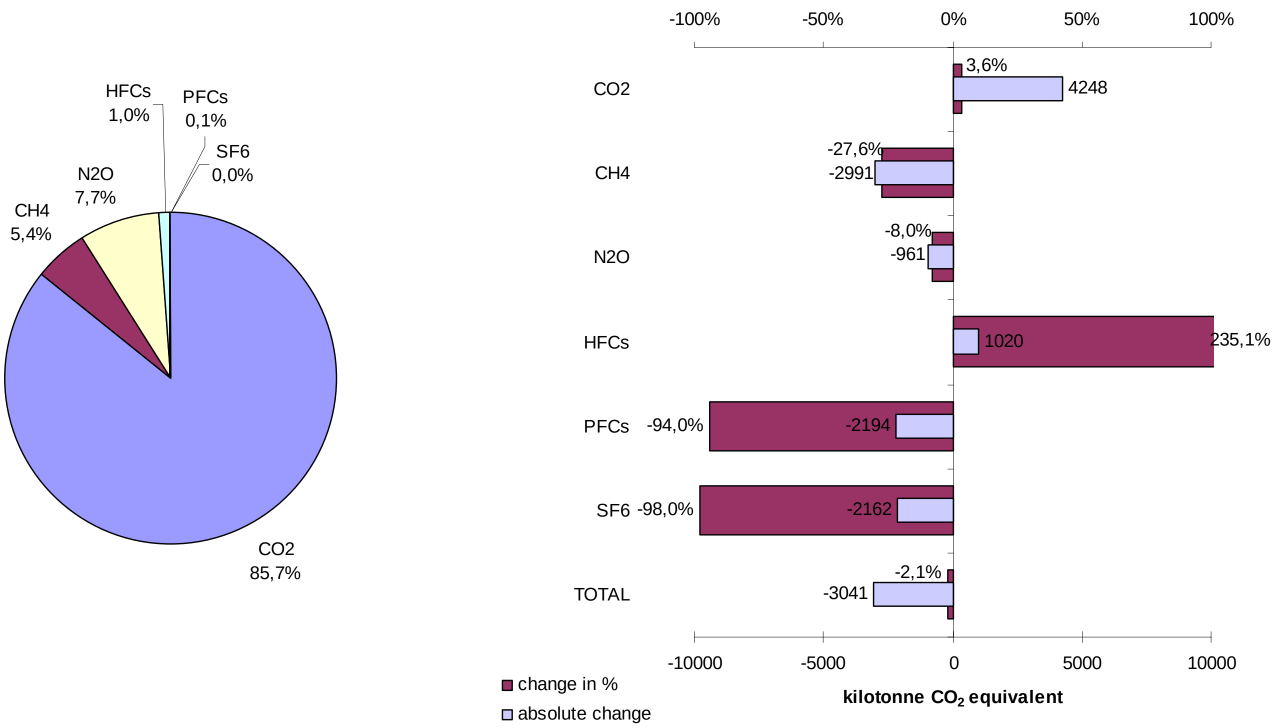


Figure 2.2. : Share of greenhouse gases in Belgium (2005), and changes compared to base year (1990 for CO_2, CH_4 and N_2O; 1995 for F gases)

Total CO_2 emissions (without LUCF) in Belgium amounted to 123.3 Mt CO_2 eq in 2005 (Table 2.1.). A net sink of 370 kton CO_2 eq is reported for the LUCF sector, which offers only a tiny compensation for these emissions (0.3%). Due to the large contribution of CO_2 to total emissions (85.7%), GHG emissions in Belgium are closely connected with the emissions of CO_2, mainly related to energy consumption.

Total CH_4 emissions amounted to 7.8 Mt CO_2 eq in 2005 (Table 2.1). CH_4 emissions have substantially decreased since 1990 (-27.6%), mainly due to the deep cut in emissions from landfills.

Total N_2O emissions in Belgium amounted to 11.0 Mt CO_2 eq in 2005 (Table 2.1). The largest key sources that contribute to N_2O emissions are nitric acid production and direct soil emissions, followed by indirect emissions and transport. Other various sources contribute to a lesser extent to N_2O emissions.

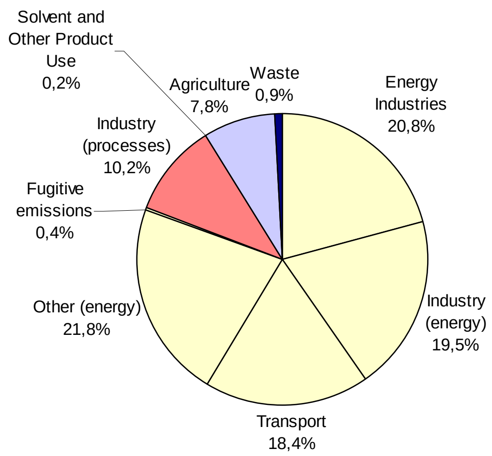
Emissions of fluorinated gases in Belgium amounted to 1.6 Mt CO_2 eq in 2005. Compared to 1990, this represents a decrease of 57.4% (67.1% when compared to 1995). The major decrease is observed in the production of PFC's and SF_6 (-97%). In the meantime, emissions from refrigeration and air conditioning have increased.

[3] compared to 1995 emissions

2.3. Emission trends by source

An overview of the contribution of the main sectors to Belgium greenhouse gas emissions is given in Figure 2.3. Energy industries, manufacturing industry, transport, space heating and industrial processes are the most important sectors in the total GHG emissions in 2005. Agriculture (7.8 %) and waste (0.9%) account for the remaining part. Main drivers of the total increase in GHG emissions are the transport sector and space heating (residential, commercial, institutional and agriculture sector). In absolute terms, these sectors have respectively increased by 6.0 Mt CO_2 eq and 3.3 Mt CO_2 eq (Figure 2.3(b)). On the contrary, total emissions from energy industries, industry (energy and process), agriculture and waste have declined over the period 1990-2005.
The sections below give a detailed picture of the main key sources that contribute to GHG emissions in each of the four sectors : energy, industrial processes, agriculture and waste.

(a)



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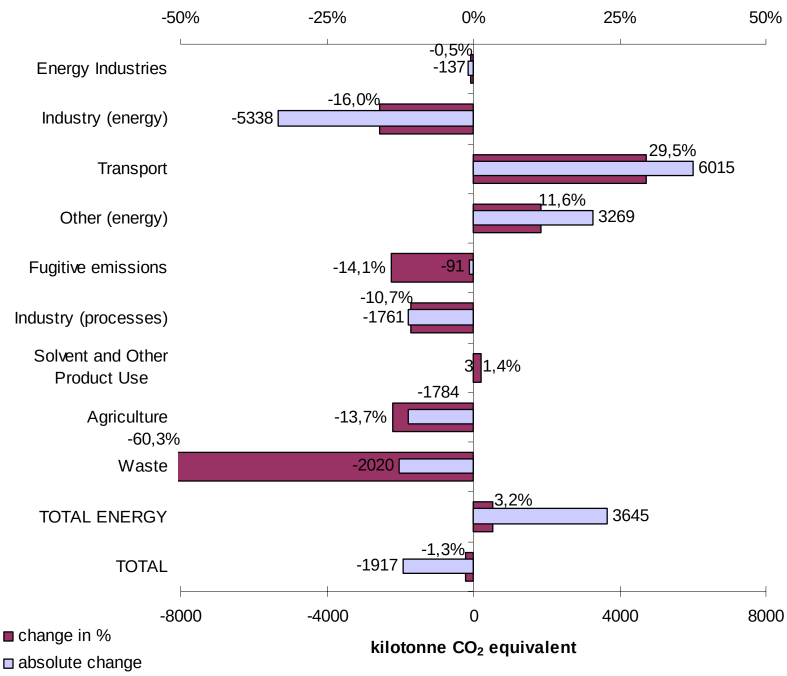
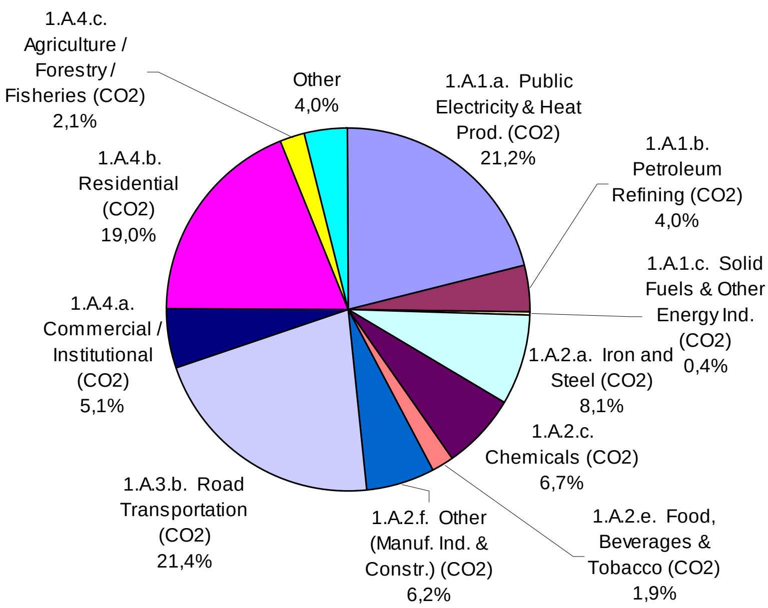


Figure 2.3. : GHG emissions : share of main sectors in 2005 (a) and changes from 1990 to 2005 (b).

2.3.1. Energy

In 2005, energy consumption accounted for 80.9% of total GHG emissions in Belgium. The largest key source category in the energy sector is road transport (21.4%), followed by 'public electricity and heat production' (21.2%), by residential space heating (IPCC category 1.A.4.b) (19.0%), iron and steel (8.1%) and chemicals (6.7%). All together, these five categories account for more than 76% of the emissions of this sector (Figure 2.4(a)).

(a)



(b)

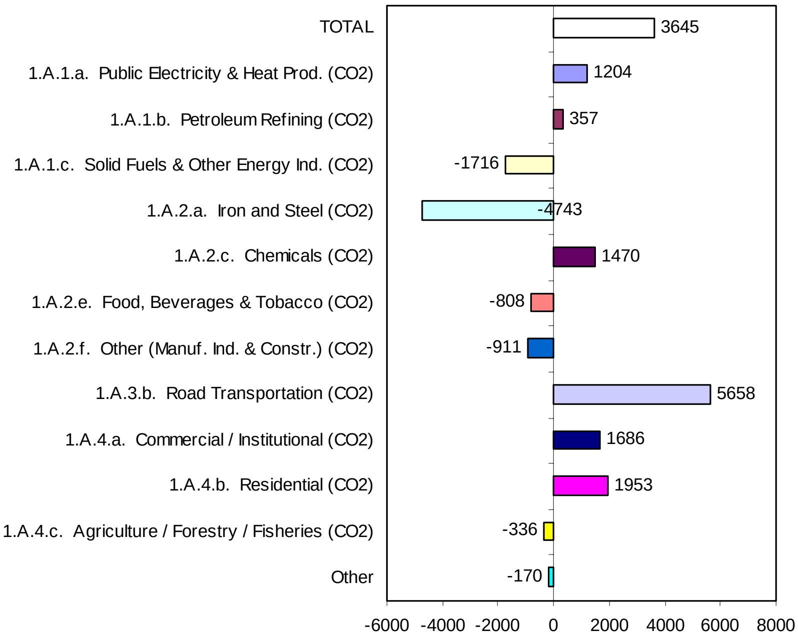


Figure 2.4. : GHG emissions in sector 1 'Energy':
(a) share of largest key sources in 2005
(b) changes from 1990 to 2005 (Gg CO_2 equivalent)

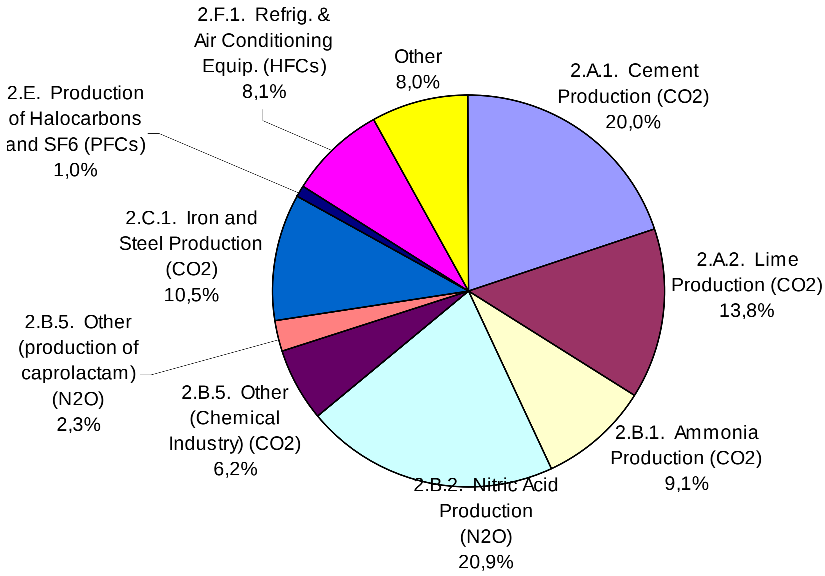
Although GHG emissions from the energy sector substantially decreased between 2004 and 2005 (-2.5%), these emissions are 3.2% above 1990 emissions. The main drivers of this overall increase are CO_2 emissions from road transport (+29.4% compared to 1990), and from space heating (residential and commercial/institutional, which increased respectively 9.7% and 39.5%). In the road transport sector, most indicators are increasing : the number of cars has increased by 30% between 1990 and 2004, together with traffic (vehicle km) which has risen in the meantime by 32%. There is a marked switch from petrol engines to diesel. The number of petrol engines has dropped slightly between 1990 an,d 2004 (-2%), while the number of diesel engines has almost doubled (+ 98%) for the same period. Figure 2.4.(b) shows to the extent to which the different emission sources have contributed to the overal increase in the energy sector. N_2O emissions from transport, although rather small contributor to emissions in the energy sector (0,7%), have more than doubled between 1990 and 2005. This is partly due to the introduction of catalytic converters (the use of catalytic converters on all petrol-engine cars was made compulsory in Belgium in 1993), but also to the ageing of the first converters, which leads to an increase in their N_2O emissions. On the other hand, CO_2 emissions from the iron and steel sector, solid fuels and other energy industries (IPCC category 1.A.1.c) and some other sectors of the manufacturing industry (IPCC category 1.A.2.f) have respectively decreased with 33.4%, 80.0% and 11.3%. In the iron and steel sector, one blast furnace closed in 2005 and is the main driver of the decrease observed in 2005.

2.3.2. Industrial processes

GHG emissions from industrial processes accounted for 10.2% of total emissions in 2005. The share of emissions by the largest key sources in this sector is shown in figure 2.5, as well as changes in emissions over the period 1990-2005. N_2O emissions from nitric acid production are the main key source in this sector (20.9% of the sector emissions), followed by CO_2 emissions from cement production (20.0%), CO_2 emissions from lime production (13.8%), CO_2 emissions from iron and steel production (10.5%) and CO_2 emissions from ammonia production (9.1%). Other key sources include HFCs emissions from refrigeration and air conditioning equipment (8.1%) and CO_2 emissions from other industrial processes in the chemical industry (6.2%).

As a whole, GHG emissions from industrial processes have dropped with 1761 kton CO_2 equivalent between 1990 and 2005 (-8.1%). This reduction mostly originates in the PFCs and SF_6 emissions from the category 'production of halocarbons and SF_6', which peaked in 1995, and then dropped to almost zero. N_2O emissions from nitric acid production have also decreased (-496 kton CO_2 eq.), while CO_2 emissions from ammonia production and HFCs emissions from refrigeration and air conditioning equipment have grown considerably (+637 kton CO_2 eq. and 1117 kton CO_2 eq. respectively).

(a)



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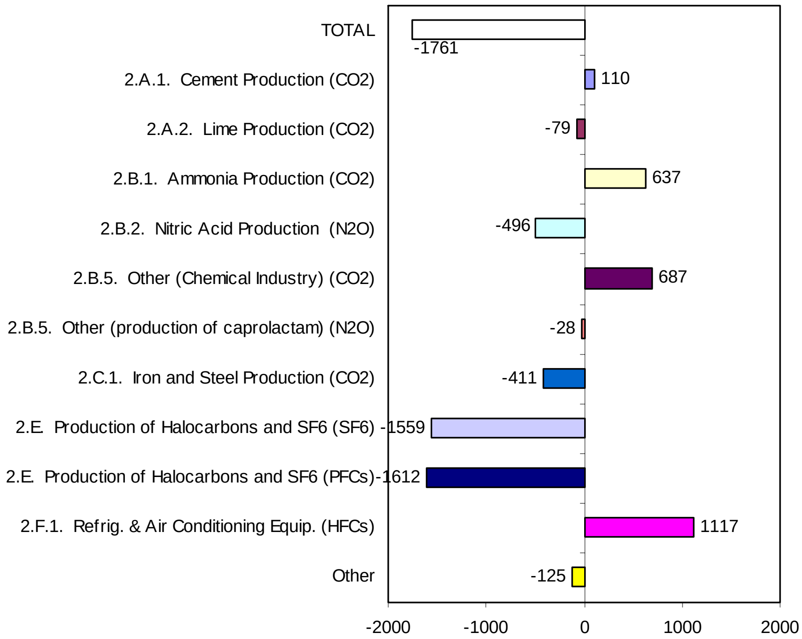


Figure 2.5. : GHG emissions in sector 2 ‘Industrial processes’:

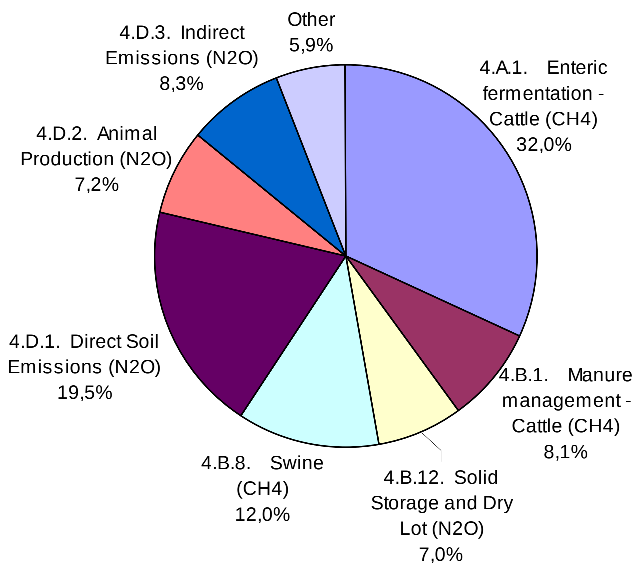
(a) share of largest key sources in 2005

(b) changes from 1990 to 2005 (Gg CO_2 equivalent)

2.3.3. Agriculture

GHG emissions from agriculture accounted for 7.8% of the total emissions in Belgium in 2005. About one third of these emissions are CH_4 emissions from enteric fermentation of cattle (Figure 2.6(a)). N_2O emissions from soil account for another 19.5%, followed by CH_4 emissions from swine (12.0%), N_2O indirect emissions (8.3%), and CH_4 emissions from management of cattle manure (8.1%). Overall, emissions from agriculture have decreased by 13.7% between 1990 and 2005. All key sources of this sector have dropped. The main drivers of the GHG emission decrease in this sector are CH_4 emissions from cattle, and direct and indirect N_2O emissions (Figure 2.6(b)).

(a)



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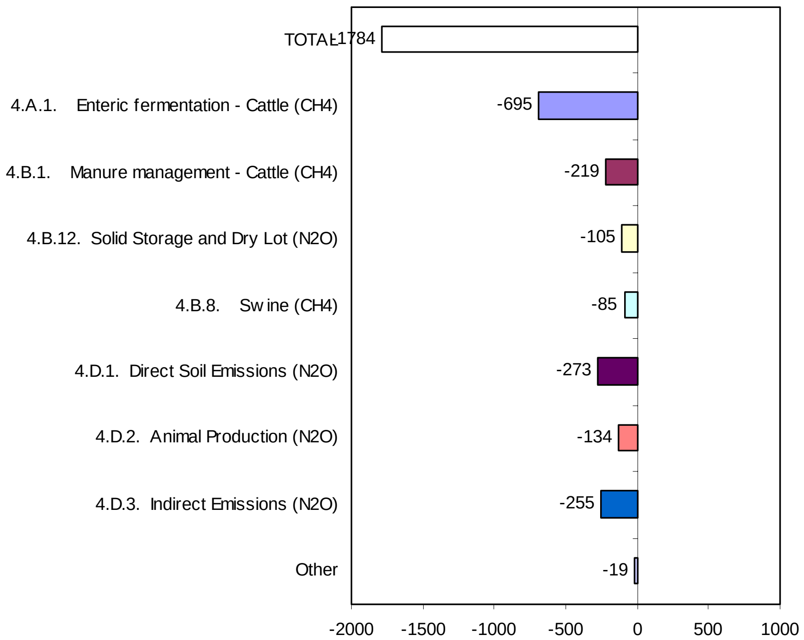
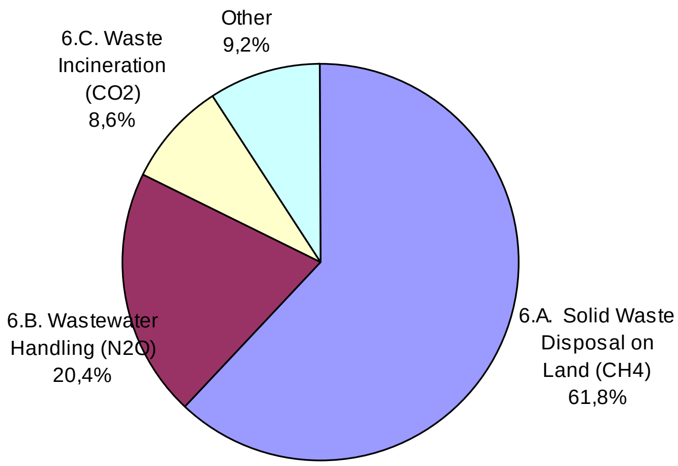


Figure 2.6. : GHG emissions in sector 4 ‘Agriculture’:
(a) share of largest key sources in 2005
(b) changes from 1990 to 2005 (Gg CO_2 equivalent)

2.3.4. Waste

GHG emissions from waste accounted only for 0.9% of the national emissions in 2005. CH_4 emissions from waste disposal on land represent 61.8% of total emissions of the sector (Figure 2.7(a)). Other main sources in this sector are N_2O emissions from wastewater handling (20.4%) and CO_2 emissions from incineration (8.6%). CH_4 emissions from landfills have continuously decreased since 1990 (Figure 2.7(b)), mainly as a result of the increased biogas recovery in landfills, by flaring or for energy purposesleading to a substantial cut of GHG emissions for the entire sector (-60.3%). CO_2 emissions from waste incineration also contributed to the overall decrease of emissions in this sector (-66%).



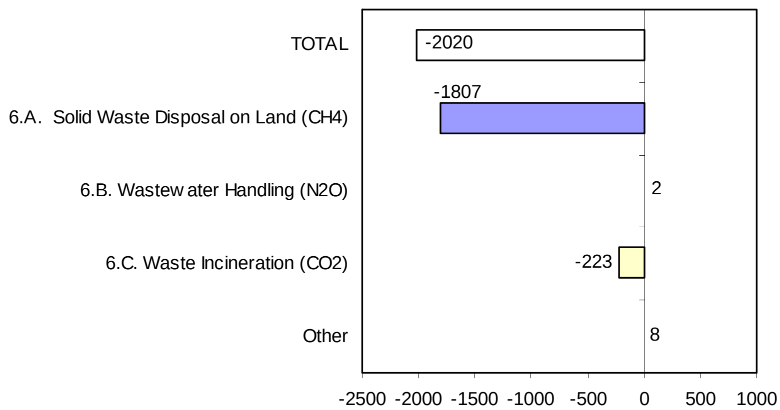


Figure 2.7. : GHG emissions in sector 6 'Waste':

(a) share of largest key sources in 2005
(b) changes from 1990 to 2005 (Gg CO_2 equivalent)

2.4. Emission trends for indirect greenhouse gases and SO_2

Emissions of ozone precursors (CO, NO_X, NMVOCs) and SO_2 are presented in Figure 2.8 (share of sectors and changes 1990-2005). These data are commented below.

2.4.1. Nitrogen oxides (NO_X)

The primary NO_x emitting source in Belgium is transport (51.9% in 2005), followed by energy industries (15.5%) and manufacturing industries (15.1%). Total NO_x emissions have substantially decreased (-26.0% in 2005 compared with 1990), mainly as a result of improved performances in the production of electricity. Emissions from transport have decreased with 27% between 1990 and 2005, thanks to the use of catalytic converters on petrol-engine cars (since 1993-94), as well as emissions from energy consumption in industry. On the other hand, NO_x emissions from space heating have increased with 11% (notably as a result of the more widespread use of natural gas for heating). NO_x emissions from waste incineration have also increased in 2005, compared to 1990 (+16%).

2.4.2. Carbon monoxide (CO)

CO emissions in Belgium come mainly from energy consumption in industry (41.6%), transport (32.4%), and industrial processes (13.0%). Fuel combustion for space heating also contributes to some extent (11.6%).
Between 1990 and 2005, national CO emissions fell by 49.0%, chiefly as a result of the introduction in 1993 of catalytic converters and to some extent following efforts made by industry, particularly the steel industry and refineries, and the diminished use of coal for heating purposes.

2.4.3. NMVOC

NMVOC emissions are caused mainly by the use of solvents and other products (33.6%), followed by combustion of petrol for transport (23.0%). Some industrial processes also contribute (17.9%), as well as fugitive emissions from fuels (14.1%). On the whole, these emissions decreased by 64% between 1990 and 2005, partly as a result of altered vehicle emission standards, and partly as a result of the prevention of solvent use.

2.4.4. Sulphur dioxide (SO_2)

SO_2 emissions produced by the energy, industry and residential (space heating) sectors declined sharply in Belgium between 1990 and 2005, leading to a general drop of these emissions by 60%. These reductions basically coincide with fuel substitution and with cuts in the sulphur content of the oil products used. The energy sector still accounts for 41.9% of SO_2 emissions, followed by space heating (21.8%) and energy consumption in industry (20.6%).
In the transport sector, sulphur dioxide emissions have dropped (-92% in 2005 compared with 1990), mainly due to the constant reduction in the sulphur content of fuels since 1996.

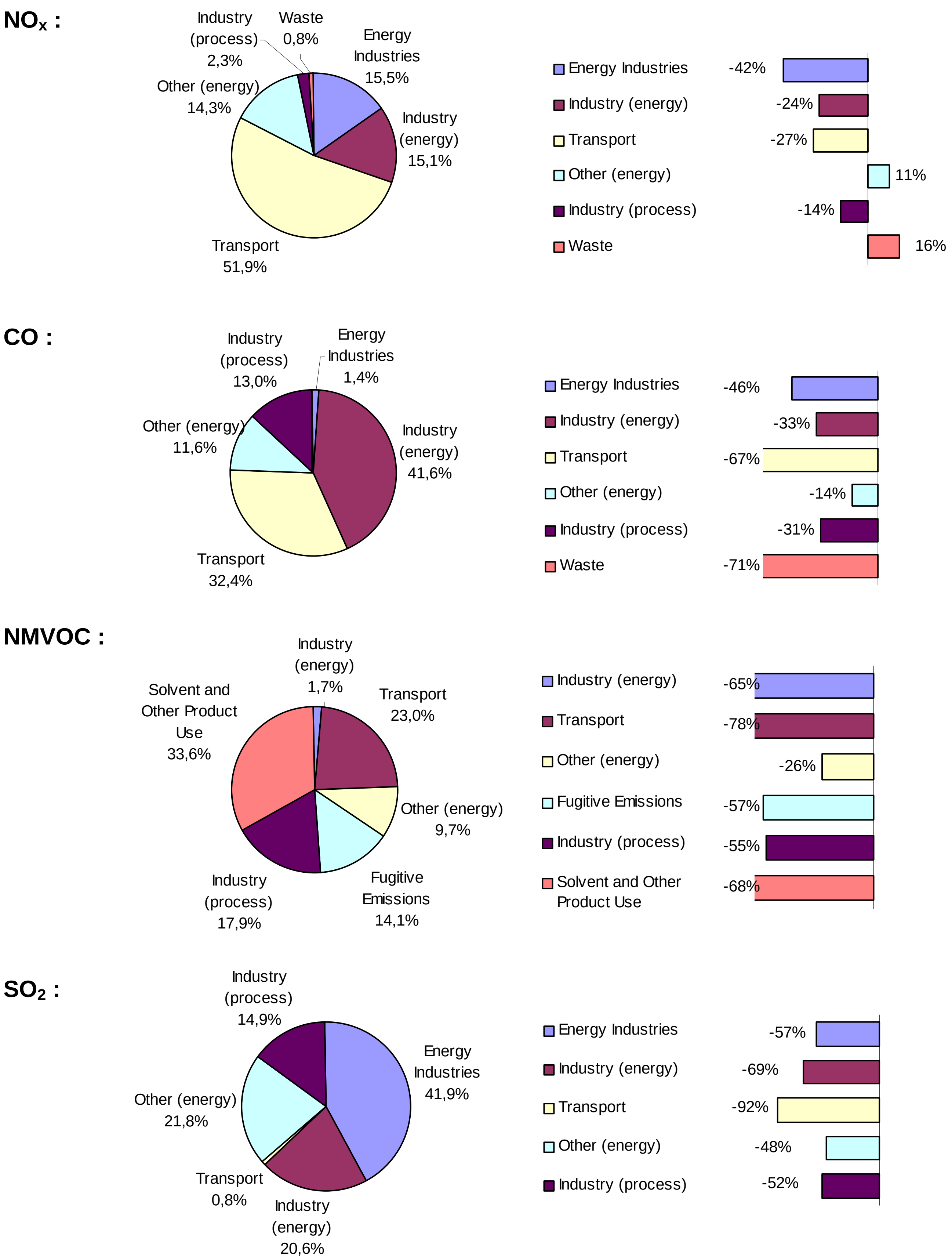


Figure 2.8. : Indirect GHG emissions and SO_2 : share in 2005 and changes 1990-2005.

CHAPTER 3: ENERGY

3.1 Overview

3.1.1 Energy

In 2005, Belgium's apparent gross consumption of primary energy rose to 56.2 Mtoe (Million tonnes oil equivalent), i.e. approximately 5.38 toe per inhabitant. This level is higher than the consumption per inhabitant in neighbouring countries and above the European average. Nearly 75% of Belgium's energy needs are met by the import of fossil fuels (41.833 Mtoe in 2005). This was made up of 5,454 Mtoe of coal, 22,227 Mtoe of oil (crude and petroleum products), and 14,152 Mtoe of gas. In 2005, the primary production of energy, 91% of which was derived from nuclear fuels (whose use provided 55.4% of the electricity produced), amounted to 13,607 Mtoe. Although the hydroelectric potential is vigorously exploited in Belgium, its share in the production of energy remains negligible given the topography of the country. The production of wind energy is also very limited, due to the lack of open spaces exposed to the wind, which greatly constrains the potential for the development of on-shore wind energy. Nevertheless, wind energy from offshore wind farms, could contribute significantly to the production of electricity from renewable energy sources in the future. The use of other renewable sources of energy, in particular biomass, which is currently insignificant, could also eventually contribute to the primary energy production, assuming regional objectives are met.
The residential and other sectors are the largest end consumer of energy in Belgium. The transport sector has the most spectacular increase recorded over last 25 years (+65% from 1979 to 2005). During the same period, the industrial sector as a whole saw its overall consumption decrease by 16%. Structural and technological changes have undeniably played a dominant role in this evolution. The recent evolution of the energy market in Belgium is furthermore marked by a very strong reduction in the consumption of solid fuels, mainly on the part of industry (cokes, iron and steel). The primary consumption of gas is increasing sharply, especially because of a stronger demand for electricity generation.

To prepare the Belgian greenhouse gas inventory for the section energy, the regional energy balances of Flanders, Wallonia and Brussels are the prime source of activity data and not the Belgian energy balance because of the regional responsibility to set up the atmospheric emission inventories. One exception on this general rule is the calculation of the emissions of CO_2 originating from road transport (see sections 1.3 and 3.1.3).

The energy industries contain the following sectors: the public electricity and heat production, petroleum refining and the manufacture of solid fuels and other energy industries. Petroleum refining only occurs in the Flemish region.

The category 'Public Electricity and Heat production (1.A.1.a)' includes fuel combustion emissions associated with the generation of electricity for commercial or public sale. The auto-generators category is mapped out in the IPCC category 1.A.2 'Manufacturing Industries and Construction' and 1.A.4 'Other sectors'. The allocation to the sub-categories under 1.A.2 and 1.A.4 depends on the type of the sector or industry where the energy is used. However, the allocation of CHP (Combined Heat and Power) plants needs more explanation. The most recent CHP units are in joint venture with the energy sector, in which all heat is delivered to the industrial plant and the electricity is sold to the energy sector. In these cases, all fuel in the energy balance is included in the energy sector.

The emissions of CO_2 originating from category 1.A.1.c 'Manufacture of Solid Fuels and Other Energy Industries' are the emissions coming form the combustion in the cokes ovens. The emissions of the others pollutants are reported in the category 1.A.2. in Flanders except for the CH_4-emissions which are reported in category 1.B.1.b. In Wallonia and Brussels, the emissions of others pollutants are reported in category 1.A.1.c (CH_4 emissions are in fact negligible and the N_2O emissions are rather small). The fugitive emissions are reported in category 1.B.1.b.

3.1.2 Industry

The following industries are integrated in category 1.A.2.f (Other): non-metallic mineral products, (cement, lime, asphalt concrete, glass, mineral wool, bricks and tiles, fine ceramic materials), metal products, textile, leather and clothing and other industry (wood industry, rubber and synthetic material, manufacturing of furniture, recycling and construction included).

The urban environment of the Brussels region does not satisfy the establishment of the great surfaces required by industry. With the exception of a manufacturer of cars, the Brussels industry is made up of small and very small manufactures with high added value or close to the ultimate consumer. All these "industries" are integrated in category 1.A.2.f (Other).

3.1.3 Transport

Belgium is provided with a very dense road (4.7 km/km²) and rail (112 m/km²) network. These densities of road and rail networks should be looked at in conjunction with the very high density of population in Belgium : relative to the number of inhabitants the infrastructure is close to the European average. The port of Antwerp is very important for Belgium. It is the second largest European seaport, and one of the 5 largest in the world. The port of Antwerp benefits from excellent connections to the hinterland and the large French and German industrial basins by waterway (1500 km of navigable routes). It has also been decided to strengthen the rail infrastructure giving access to the port of Antwerp. Road transport is the mean of transport the most generally used in Belgium, both for the transport of goods and passengers, generating severe traffic congestion. Even though congestion is lower than in the neighbouring countries, the number of road accident victims is very high, but is going down. Damages to the environment resulting from fuel use in road traffic are considerable. Goods are transported, on average, over a longer distance by railway (125.3 km in 1998) than by navigable waterways (58.4 km), but the gap between these two modes of transport has lessened in recent years.

Since the submission in 2004, the CO_2 emissions for road transport are based on fuels sold. These figures are originating from the Belgian energy balance of fuels sold. Emissions of CH_4 and N_2O are not calculated based on the Belgian energy statistics, but are the sum of the emissions calculated by the 3 regions using a methodology based on the COPERT methodology in the Walloon and Brussels region and a country-specific methodology (the so-called MIMOSA-model see also section 1.3.1) in the Flemish region.

3.2 Methodological issues

Greenhouse gas emissions are mostly reported directly by the individual large companies on the basis of their fuel consumption. For most sectors the remainder of the emissions is calculated on the basis of the remaining fuel consumption (estimated as the difference between energy consumption reported in the regional energy statistics for the whole sector and the fraction reported by the large companies) and standard emission factors. The emission factors of CO_2 are the same for all sectors and are listed below. In these emission factors of CO_2 the IPCC default oxidation factors are already adjusted. These oxidation factors take into account that not 100% of the carbon in the fuel is transmitted to CO_2. This factor is 0.98 for solid fuels and 0.99 for liquid and 0.995 for gaseous fuels.

Products	**emission factors (g CO_2/MJ)**		
	Flanders	Wallonia	Brussels
coal tars	92,7	-	
coking coal	92,7 [6]	92,7	92.7
Brown coal/lignite		99,2	
coke oven coke	106,0	106 [3]	
crude oil	72,6	-	
Refinery gas	55,1 - 56,5 [1]	-	
LPG	62,4	-	
Gasoline	68,6	-	
Kerosene	70,8	-	
gas/diesel oil	73,3	73,3	73.3
lamp petroleum	71,1	-	
residual fuel oil	76,6	76,6	76.6
Naphta	72,6	-	
petroleum coke	99,8	99,8	
other petroleum	72,6	-	
natural gas	55,8	55,8	55.8
coke oven gas	47,4 (till 2001) and 38-40 (from 2002) on[5]	47.4	47.4
blast furnace gas	250-265[5]	256,8-264,3 [4]	
other products	[2]	-	
biogas	-	75 [3]	
Waste gas	-	66-72,5 [3]	
Industrial waste	-	86,6 [3]	
Black liquor	-	100 [3]	
wood	-	100 [3]	

Table 3.1. : Emission factors used to calculate energy related emissions of CO_2 (IPCC default unless indicated).

[1] Inquiry with the refineries
[2] Depending on the product in question, information through inquiries with the companies involved or default
[3] Source: EMEP/CORINAIR
[4] Country specific emission factors
[5] Inquiry with the electricity sector and iron and steel sector
[6] The default IPCC value, this is not used for the large power plants

In the lime and cement plants, the CO_2 emission factors originated until 2004 from the IPCC 1996 Guidelines. Since this year, CO_2 emissions from solid fuel and waste have been reported directly by the companies on the basis of their fuel consumption and fuel analyses.

Fuel		UNIT	$CO_2 \times 10^3$
Fuel	cement	g/GJ	78[c]
Diesel oil	cement	g/GJ	74[c]
Coal	cement	g/GJ	92,7-105
Petroleum coke	cement	g/GJ	96
Industrial waste	cement	g/GJ	75-102
Gas naturel	cement	g/GJ	56[c]
Coal	Lime	g/GJ	92,7-105
Industrial waste	Lime	g/GJ	88
Coke	Lime	g/GJ	100[c]
Fuel	Lime	g/GJ	77,2[i]
natural gas	Lime	g/GJ	55,8[i]

Table 3.2. : Emissions factors per fuel in lime and cement plants.
(Source : IPCC[i] and EMEP/CORINAIR[c])

3.2.1 Energy industries (category 1.A.1)

Public electricity and heat plants (category 1.A.1.a)

CO_2

The activity data are collected from energy statistics and from surveys of the individual companies. The number of companies is limited and well known. For the large power plants in the public electricity sector, the CO_2 emissions are reported directly by the power plants and based on analyses of the fuels.
For the smaller plants for which no emissions of CO_2 are reported directly to the responsible authorities, default CO_2 emission factors are used except for specific fuel types. In that case more detailed information of the individual companies is used (see table 3.1).
In the Brussels region there is only one significant power plant. The electricity is produced from the municipal waste incineration. The CO_2 emission factor from EPA is used. The fraction of organic municipal waste has been deduced from analyses of dustbins [37 and 48] and have led to a fraction of biomass origin, variable for the whole time series, from 62 % to 53 %. For the smaller plants in Brussels, default CO_2 emission factors are used (see table 3.1).

CH_4 and N_2O

In Flanders, emission factors from TNO (Netherlands) [4] (Table 3.3) are used to calculate the emissions of N_2O for the installations for public electricity and from the EMEP/CORINAIR handbook (table 27) [3] to calculate the emissions of CH_4. These emission factors are agreed with the electricity producers.

In Wallonia and in Brussels, emissions of CH_4 and N_2O are calculated using emission factors of the IPCC Guidelines.

Fuel	UNIT	CH_4			N_2O		
		Fl (1)	**Wall (2)**	**Br (2)**	**Fl (3)**	**Wall (2)**	**Br (2)**
Coal	g/GJ	0,6	1	/	1,40	1,40	/
Fuel	g/GJ	0,7	3	/	0,60	0,60	/
diesel oil	g/GJ	0,03	1,5	/	0,60	0,60	/
natural gas (in gas turbine	g/GJ	2,5	2,5 (4)	2.5	0,10	0,10	0.1
natural gas	g/GJ	0,1	1	/	0,10	0,10	/
Cokes gas	g/GJ	0,1	1	/	0,10	0,10	/
blast furnace-gas	g/GJ	0,1	1	/	0,10	0,10	/
H_2-gas	g/GJ	0,00	-	/	0,00	-	/
Dry sludge	g/GJ	0,6	-	/	1,4	-	/
Bisfenol-resin	g/GJ	0,6	-	/	1,4	-	/
Agricultural waste	g/GJ	-	30	/		4	/
Municipal waste				-	60 g/ton (1)		60 g/ton (1)
Coffee	g/GJ	-			1,4		
Olive seeds	g/GJ	0,6			1,4		
Biofuel	g/GJ	0,7			0,6		

Table 3.3 : Emission factors of CH_4 and N_2O for the sector 1.A.1.a Public electricity and Heat Production.

(1) Source: CITEPA
(2) Source: IPCC
(3) Source : TNO
(4) Source : Corinair

Petroleum refining (category 1.A.1 b)

As indicated in section 3.1.1. petroleum refining only occurs in Flanders. The emissions of CO_2 are reported to the responsible authorities by the Belgian Petroleum Federation and the petroleum refining companies. Since 2005 (emissions 2004) these emissions are reported by the companies on an obligatory basis .

CH_4 and N_2O emissions from petroleum refining are calculated using a combination of monitoring results (for the 2 largest companies) and emission factors of CITEPA [2] for the smaller companies. These emission factors are based on the input of crude oil :

- 0.24 g CH_4/ ton crude oil originating from 6% auto-combustion *4 g CH4/ton crude oil;
- 22 g N_2O/ton crude oil originating from 6% auto-consumption and an emission factor of 9g/GJ (50% fuel oil and 50% gas);
- To calculate the fugitive emissions an emission factor of 5 g CH_4 / ton crude oil is used.

The results of the monitoring of the emissions of CH_4 and N_2O became available in 2005 (emissions 2004) only for 2 companies exceeding the threshold value (10 ton/year for N_2O and 100 ton/year for CH_4). Based on these results, the emissions of CH_4 and N_2O were revised from 1990 on during the

previous submission (partly monitoring and partly extrapolation) and actualized emissions for the complete time series were included in the inventory.
All CH_4-emissions of this sector are allocated in category 1.B.2.a and all N_2O-emissions are allocated in category 1.A.1.b because of the diffuse character of the CH_4-emissions.

Manufacture of solid fuels and other energy industries (category 1.A.1.c)

As indicated in section 3.1.1. the emissions originating from category 1.A.1.c 'Manufacture of Solid Fuels and Other Energy Industries' are the emissions coming form the combustion in the cokes ovens.
In Wallonia, in the category 1.A.1.c the emission factors for CO_2 and CH_4 are those proposed in the EMEP/CORINAIR guidebook and the IPCC Guidelines [24] until 2004. Since 2005, the CO_2 emissions have been giving directly by the plant in their reporting under the emission trading scheme. For N_2O, emission factors from the Table 1.8 of the Revised 1996 IPCC Guidelines [28] are used.

Fuel	**UNIT**	**Wallonia**	
		CH_4	**N_2O**
Diesel oil	g/GJ	1,5(2)	0,60(1)
natural gas	g/GJ	2,5(2)	0,10(1)
Coke oven gas	g/GJ	1(2)	0,10(1)
blast furnace-gas	g/GJ	0,16(2)	0,10(1)

Table 3.4. : CH_4 and N_2O emissions factors per fuel in the coking works.

(1) Source: IPCC
(2) Source: EMEP/CORINAIR

There was a coke plant in the Brussels region until 1993. The emission factors used, are the same as the ones used in Wallonia (except for CH_4 for which emission factors from EPA are used).

In Flanders the emission factors used to calculate the emissions of CO_2 are included in table 3.1. The calculation and the allocation of the emissions of CH_4 is done in a different way in Flanders. These CH_4-emissions are allocated in the category 1.B.1.b (see this section for more explanation of the methodology used). Contacts with the relevant industry in Flanders indicates that no emissions of N_2O occurs in this sector.

3.2.2 Manufacturing industry and construction (category 1.A.2)

CO_2

General

The energy consumption data originate from the regional energy balances in the 3 regions, supplemented with specific information from the companies themselves, for example activity data from iron and steel industry.

To calculate the emissions of CO_2, the emission factors listed in table 3.1 are used.

Iron and steel sector

The CO2-emissions from the iron and steel sector are partly put in category 1.A.2.a (energetic part / except for the emissions from the cokes ovens which are allocated in the category 1.A.1.c) and partly in category 2.C.1 (process part).

In Wallonia, the CO_2 emissions from the blast furnace are calculated by a CO_2 balance :

CO_2 from “fuel inputs and reducing agents” – CO_2 from “blast furnace gas used for energy purposes” – CO_2 in “pig iron”.

In the Flemish region, the CO_2 emissions from the blast furnace gas are calculated by using plant specific emission factors based on measurements carried out by the company.

The CO_2 emissions from the blast furnace gas used are included in the category where the energy is used.

Other sectors

In the lime and cement plants, the CO_2 emission factors as presented in table 3.2 and CO_2 plant specific emission factors are used (activities take place only in the Walloon region).

CH_4 and N_2O

General

The emissions of CH_4 and N_2O in Flanders are calculated using emission factors originating from CITEPA [2] (Table 3.5).
The emission factors used to calculate the emissions of CH_4 and N_2O in Wallonia are based upon those proposed in the EMEP/CORINAIR guidebook and the Revised IPCC Guidelines.
In the Brussels region, a specific study has been funded on behalf of the IBGE-BIM [12] to determine the emission factors to take into account specific socio-economic conditions in Brussels.

			Flanders (1)	**Wallonia**	**Brussels (4)**	**Flanders (1)**	**Wallonia**	**Brussels (4)**
Fuel	**Boiler**	**Unit**	**CH_4**			**N_2O**		
Coal		g/GJ	0.27	10 (2)	1.5	12.3	1,4 (2)	3
Coke oven gas		g/GJ	0.5	1 (2)		3	0,1 (2)	
coke		g/GJ	-	10 (2)		-	4 (2)	
Natural gas	>50MW	g/GJ	0.3	1 (2)	2.5	3	0,1 (2)	1,5
	<50MW			4 (3)				
blast furnace-gas		g/GJ	0.5	1 (2)		3	0,1 (2)	
Fuel	>50MW	g/GJ	0.1	3 (2)	3	13.4	0,6 (2)	14
	<50MW			2 (2)				
Diesel oil	>50MW	g/GJ	0.1	1,5 (2)	1	13.4	0,6 (2)	12
	<50MW			2 (2)				
Biogas	< 50MW	g/GJ	-	4 (3)		-	0,1 (2)	
Waste gas	<50MW	g/GJ	-	2,5 (3)		-	0,1 (2)	
Industrial waste	<50MW	g/GJ	-	10 (3)		-	2 (3)	
Black liquor	50MW	g/GJ	-	15 (3)		-	0,6 (2)	
Wood	50MW	g/GJ	-	30 (2)		-	4 (2)	

Table 3.5. : Emission factors of CH_4 and N_2O in the sector 1.A.2 Manufacturing Industries and Construction.

(1) Source : CITEPA
(2) Source: IPCC
(3) Source: EMEP/CORINAIR
(4) Specific study IBGE-BIM [12]-Corinair

Iron and steel sector

For iron and steel plants in Wallonia following CH_4 and N_2O emission factors are used :

Fuel		UNIT	CH_4	N_2O
Coke breeze	Sinter and pelletizing plants	g/GJ	50 (2)	4 (1)
Coke oven gas	Sinter and pelletizing plants	g/GJ	257 (2)	0.1 (1)
natural gas	Blast furnace	g/GJ	2,5 (2)	0.1 (1)
Coke oven gas	Blast furnace	g/GJ	57 (1)	0.1 (1)
blast furnace-gas	Blast furnace	g/GJ	112 (1)	0.1 (1)
Coal	Electric arc furnace	g/GJ	15 (2)	1,4 (1)
Coke breeze	Electric arc furnace	g/GJ	15 (2)	4 (1)
Natural gas	Electric arc furnace	g/GJ	2,5 (2)	0.1 (1)
natural gas	Reheating furnaces steel and iron	g/GJ	2,5 (2)	0.1 (1)

Table 3.6. : CH_4 emissions factors for the different fuels in the iron and steel plants in Wallonia.

(1) Source: IPCC
(2) Source: EMEP/CORINAIR

The consumption of coal not used as a reducing agent in the blast furnace is calculated by a CO_2 balance on the furnace in Wallonia and the emissions are reported in this section. Only CO_2 emissions are calculated.

In Flanders the emissions of CH_4 of the iron and steel sector are allocated in the categories 1.B.1.b (production of cokes) and 2.C.1 (production of sinter) (see these respective sections for more explanation of the methodology used).

Other sectors

Glass industry

The emission factors used in the glass industry in the Walloon region are those proposed in the EMEP/CORINAIR guidebook for CH_4 and the IPCC factors for N_2O as shown in table 3.7.
In the Flemish region the emission factors as shown in table 3.5 are used.

Fuel	UNIT	CH_4	N_2O
Fuel	g/GJ	3	0,6
Diesel oil	g/GJ	1,5	0,6
Natural gas	g/GJ	2,5	0,1

Table 3.7. : Emissions factors per fuel in glass production (EMEP/CORINAIR and IPCC) in Wallonia.

Lime and cement industry

In the lime and cement plants (activities which only take place in the Walloon region), the emissions of CH_4 and N_2O are plant-specific and determined by measurements. Implied emission factors for CH_4 and N_2O are then derived from the energy consumption data and the reported emissions.

3.2.3. Transport (category 1.A.3 and 1.A.5.b)

Road transport

The energy consumption and CO_2 emissions for road transport are based on federal (Belgian) energy statistics. The activity data (combustion figures) represent the amount of fuels sold in Belgium for road transport. These activity data are multiplied with default IPCC emission factors to calculate the CO_2 emissions. Emissions of CH_4 and N_2O are calculated by compiling the emissions of each region based on the use of the specific models used in the 3 regions (based on COPERT III in the Walloon and the Brussels region and on the MIMOSA-model in the Flemish region).

Air transport

In the two regions (Flemish and Walloon region) where air transport is relevant, a slightly different approach was taken in estimating the emissions from air transport.

In Flanders only domestic air traffic is considered for calculating the CO_2 emissions. All kerosene used in the air transport is assigned to the bunker fuels, all gasoline for air transport is allocated to domestic air transport. This approach was chosen because it is not easy to split these fuels otherwise and because, due to the small size of Belgium (and Flanders), most kerosene is used for international transport. A default IPCC emission factor for CO_2 is used to calculate the emissions. CH_4 and N_2O emissions from air transport are calculated for the Landing and Take-Off cycle. The methodology is mainly based on the methodology described in the EMEP/CORINAIR handbook [3]. These emissions are calculated for 3 airports for civil aviation (Antwerp, Ostend and the international airport of Brussels-National) and for 6 airports for military aviation (Kleine Brogel, Brasschaat, Koksijde, Melsbroek, Sint-Truiden (till 1996) and Goetsenhove (till 1996)).

In Wallonia, there are two main airports in Liège and Charleroi. The emissions from aviation are estimated following a very simple methodology described in the EMEP/CORINAIR guidebook [3]. Data on LTO activities and fuel consumption come from the statistics of the two main airports. Airports divide the statistics following domestic and international activities.
In the methodology, a distinction is made between emissions from domestic and international LTO and cruise activities. Emissions factors used to estimate emissions from domestic and international

traffic are based on the table 8.2 in the EMEP/CORINAIR guidebook [3]. The emissions from domestic LTO and cruise activities are reported under the category 1.A.3.a (civil aviation), while emissions from international LTO and cruise activities are reported under "international bunkers : aviation". Kerosene used in international air transport is assigned to the bunker fuels.

Railways

The greenhouse gas emissions from the railway traffic is estimated for the 3 regions in the same way:

In Flanders, the fuel consumption is based on a proportional fraction of fuel used in Belgium for rail transportation. Default IPCC emissions factors are used for CO_2 (table 3.1). The emissions of CH_4 and N_2O are calculated by using the activity data (fuel consumption) of the regional energy balance combined with emissions factors of the EMEP/CORINAIR handbook [3]. These emission factors are the same as the emission factors from the IPCC Revised 1996 guidelines. Other emissions are calculated with the results of a model developed by the Vito [1] and based on the registered kilometres with distinction between different types of trains.

In the Walloon and in the Brussels region the emissions from railways are estimated by multiplying the train's fuel consumption [21 and 11] by the fuel specific emission factors. For CO_2, the emission factors used are those as indicated in table 3.1. For CH_4 and N_2O, the specific emission factors are those described in table 8.1 of the EMEP/CORINAIR guidebook [3]

Navigation

For navigation, fuel consumption is taken from the regional energy balances.

In Flanders statistics are used to calculate the total freight kilometres and to calculate the total amount of fuel used.

Fuel consumption is multiplied with a CO_2 default emission factor (see table 3.1).

During the previous submission the emissions of CH_4 and N_2O in Flanders were optimized by using the results of a so-called susatrans-model which is developed by the Vito [1] and technology-related. This methodology gives a more accurate estimation of the emissions compared to the use of IPCC default emission factors in previous submissions.

The emissions of the other pollutants are calculated in Flanders with this same model developed by the Vito [1] and in the two other regions, the emissions of the non-CO_2 pollutants are calculated by using emission factors of the EMEP/CORINAIR handbook [3].

Other transportation

In this category 1.A.3.e. the energetic emissions originating from the compression activities in the sector storage and transport of natural gas. The emissions of CO2 are estimated by using the default emission factors (see table 3.1). In the Flemish region the emissions of CH_4 en N2O are calculated by using the same emission factors as these used in the sector 1.A.2. 'Manufacturing industry and construction' (see section 3.2.2).

3.2.4 Other sectors (category 1.A.4)

The fuel consumption of the service sector is based on general statistics of natural gas, supplemented with results from surveys for solid and liquid fuels. Agricultural fuel consumption is estimated from statistical information concerning area used, etc., combined with specific energy consumption from literature. The energy consumption of these sectors is published in the regional energy balances. The used default emission factors for CO_2 are listed in table 3.1.

The category 1.A.4.c Agriculture/Forestry/Fisheries is negligible in the Brussels region. As a consequence no greenhouse gases from this sector are taken into account for this region.

In table 3.8 below, the emission factors for CH_4 are listed.

			Flanders	**Wallonia**	**Brussels**
Fuel		**Unit**	**CH_4**		
Coal	Commercial	g/GJ	10 (1)	10 (2)	/
	residential	g/GJ		300 (2)	200(4)
	Agriculture heating	g/GJ	0,3 (1)	-	/
Natural gas	Heating	g/GJ	1 (1)	5 (2)	5 (4)
	Heating agriculture	g/GJ	0,3 (1)		/
Fuel/diesel oil	Heating	g/GJ	3 (1)	10 (2)	7 (4)
	Heating agriculture	g/GJ	0,1 (1)		/
	Farming vehicles.	g/GJ	4 (2)	4 (3)	/
Fuel	Fishing activities	g/GJ	5 (2)	-	/
Heavy fuel	Commercial	g/GJ	3 (1)	-	3 (4)
	residential				
	Agriculture heating		0.1(1)		
Propane/butane/LP		g/GJ	0 (1)	-	0 (1)
Lamp petroleum	Commercial	g/GJ	3 (1)	-	/
	residential				
	Agriculture heating		0.1(1)		
wood		g/GJ	150(1)	300 (2)	300 (4)

Table 3.8. : Emission factors of CH_4 for category 1.A.4 Other sectors (households, service and agriculture sector).

(1) source: Citepa
(2) source: IPCC
(3) EMEP/CORINAIR
(4) Specific study on behalf of IBGE-BIM [12]-Corinair

In table 3.9 below, the emission factors for N_2O are listed.

			Flanders	**Wallonia**	**Brussels**
Fuel		**Unit**	**N_2O**		
Coal	Heating	g/GJ	12 (1)	1,4 (2)	12 (4)
	Agriculture heating	g/GJ	14 (1)	-	/
Natural gas	Heating	g/GJ	2 (1)	0,1 (2)	2 (4)
	Heating agriculture	g/GJ	3 (1)		/
Fuel/diesel oil	Heating	g/GJ	12 (1)	0,6 (2)	12 (4)
	Heating agriculture	g/GJ	14 (1)		/
	Farming vehicles.	g/GJ	30 (2)	30 (3)	/

Fuel	Fishing activities	g/GJ	0,6 (2)	-	/
Heavy fuel	Heating	g/GJ	12 (1)	-	14 (4)
	Agriculture heating		14(1)		
Propane/butane/		g/GJ	3 (1)	-	2 (4)
Lamppetroleum	Heating	g/GJ	12 (1)	-	/
	Agriculture heating		14(1)		
wood		g/GJ	4(1)	4 (2)	4 (4)

Table 3.9. : Emission factors of N_2O for category 1.A.4 : Other sectors (households, service and agriculture sector).

(1) source: Citepa
(2) source: IPCC
(3) EMEP/CORINAIR
(4) Specific study on behalf of IBGE-BIM [12]-Corinair

3.2.5. Other (category 1.A.5.b)

In this section the emissions originating from the military transport (domestic air transport) are included (category 1.A.5.b). These emissions are calculated in the same way as explained in section 3.2.3.
No activities under category 1.A.5.a take place in Belgium.

3.2.6. Fugitive emissions from fuels (category 1.B.1 and 1.B.2)

Solid fuel transformation (category 1.B.1.b)

Emissions during the cokes production are caused by the loading of the coal into the ovens, the oven/door leakage during the coking period and by extracting the coke from the ovens. Emissions of CH_4 originating from the production of cokes were estimated in Flanders until the 2005 submission by using emission factors of CITEPA [2], which are in line with the emission factors of the EMEP/CORINAIR handbook (400 g CH_4/ton cokes).
During the previous submission in 2006 a revision of the emissions of CH_4 was carried out due to the availability of more detailed information of the industry involved. Based on monitoring results carried out in 2001, 2002 and 2004, the emissions of CH_4 were optimized from 1990 on.
In Wallonia and Brussels, the CH_4 emissions are estimated with the emission factor of the EMEP/CORINAIR handbook (400 g CH_4/ton cokes).

Activity data (tons of cokes) are delivered by the corresponding industry.

Petroleum refineries (category 1.B.2.a)

Estimation of the emissions of CH4 and N2O from the sector petroleum refining occurs as mentioned in section 3.2.1.: CH_4- and N_2O-emissions from petroleum refining are calculated using a combination of monitoring results (for the 2 largest companies in the Flemish region) and emission factors of CITEPA [2] for the smaller companies. All CH_4-emissions of this sector are allocated in category 1.B.2.a and all N_2O-emissions are allocated in category 1.A.1.b because of the diffuse character of the CH_4-emissions.

Gas distribution (category 1.B.2.b)

The methodology to calculate the emissions of CH_4 originating from the gas distribution (category 1.B.2.b ii/distribution) is completely optimized since the submission in 2004 for all the regions in Belgium. These emissions are determined on the basis of the length of gas distribution pipelines. The lengths of the main pipelines (exclusive additional pipelines which are pipelines going to households) per public utility board are available. The number of additional pipelines in Flanders is estimated at 1 500 000 for the year 2003 and this with an increase of 24 000 every year. In Wallonia, it's estimated at 588 458 for the year 2002. The length per additional pipeline measures 5 m. In Brussels, the number of additional pipelines is estimated at 183 325 for the year 2003 and the average length is 3m (urban environment).Depending on the material of the pipeline other emission factors are used. In particular 869, 7865, 869 and 95 m^3/y/km for respectively steel, cast iron, fibre cement and synthetic material. The density of methane is 0,716 kg/m^3. The methane content of natural gas distributed is 85 %.
For each material the length of the pipelines is multiplied by its emission factor. This results in de total natural gas emission in m^3 per year. Multiplying this figure by the methane content and the density of methane we obtain the methane emission originating from gas distribution.

Based on the composition of the natural gas, emissions of CO2 from the gas distribution are calculated and added to the inventory (natural gas contains +/- 1% of CO2) in category 1.B.2.bii/distribution.

Emissions of CH_4 (category 1.B.2.b.ii/transmission) originating from the storage and transport of natural gas in Belgium are calculated and added to the inventory since the 2006 submission.
These emissions are estimated on the basis of measurements and calculations (taken into account pressure, distance, volume) carried out. All necessary interventions in case of problems are known and the amounts of gas blown off is registered as accurate as possible.

The activity data reported for the category 1.B.2.b is the annual total natural gas amount, consumed in Belgium.

3.2.7. International bunkers (category Memo Items – International Bunkers)

Information about the marine bunkering comes from the Belgian energy statistics.
The emissions of CH_4 and N_2O of the marine bunkers are calculated by using emission factors of CITEPA [2], the same factors as these used in the category 1.A.2.(see section 3.2.2).

For international air transport, bunkers fuel consumption of the international air transport is given directly by the two Walloon airports. For the airports in Flanders, the reported kerosene fuel is assigned to the bunker fuels and all gasoline for air transport is allocated to domestic air transport (see justification of this approach in the section 3.2.3). Default IPCC emission factors to calculate the CO_2 emissions for all products are used (see table 3.1).

3.2.8. CO_2 emissions from biomass

Emissions of CO_2 from biomass are presented in CRF table 1s2. The emissions of CO_2 reported in this table are estimated as good as possible, depending on the information (activity data) available in the different regions in Belgium. These emissions are probably not complete.

3.2.9. Non-energy use of fuels and related emissions (categories 1.A.2, 2.B and 2.G)

The emissions of non-energy use of fuels and related emissions (emissions from recovered fuels from processes) are reported under categories 1.A.2**,** 2.B.1, 2.B.5 and 2G.

In Flanders, a recalculation of the non-energy use and related CO_2 emissions was performed during the 2005 submission, based on the results of a study conducted in 2003 [43]. The default % of carbon stored in the IPCC Guidelines were considered to be inaccurate in the Flemish situation. The default % of carbon stored in the 1996 IPCC guidelines are not well defined: it is not clear what is included or excluded in these default % (f.i. is the waste phase included or not?). Belgium participated in a European network on the CO_2-emissions from non-energy use (see website http://www.chem.uu.nl/nws/www/nenergy/) and one of the conclusions of this network is that the new IPCC guidelines need to give more information on this subject.

To our opinion, the guidelines are also not very clear on the allocation of the resulting emissions: in the CRF table 1.A(d), as part of the reference approach, a country should specify in the documentation box where these emissions are allocated. This problem of allocation should be tackled also.

Since the petrochemical industry is important in Flanders and Belgium and the emissions from the feed stocks are a key source in the Belgian inventory, the study mentioned above was conducted to get more detailed, country-specific information. A distinction was made between :

1. The use of <u>recovered fuels</u> from cracking units or other processes where a fuel is used as a raw material and where part of this fuel (or transformed product) is recovered for energy purposes. These emissions are reported under category 1.A.2c 'other fuels'. This is the largest source of CO_2 emissions. The involved industry is reporting the CO_2 emissions and PJ for these recovered fuels.
2. CO_2 emissions occurring during <u>chemical processes</u>, for example the production of ammonia based on natural gas or the production ethylene oxide where CO_2 is formed in a side reaction (reported respectively under 2.B.1 and 2B.5 other). The industry involved is reporting these CO_2 emissions directly for these processes.
3. <u>Use of products as solvent or lubricants</u> (reported under 2G as 'non-energy use'). The best possible estimation of emissions of CO_2 is made for this sector. This source is the least important one in order of magnitude.
4. <u>Waste treatment of final products</u> is not included in the study. This is practically impossible due to import/export of plastic products, etc (it is also not clear if the waste phase is included in the default IPCC carbon stored % or not). The emissions of waste incineration are therefore calculated separately and are reported under the sector of waste (category 6.C) or under the sector of energy (category 1.A.1.a), whether or not energy recuperation takes place during the process.

The result of the study made a recalculation possible for all years. The effect of the recalculation was greater in the more recent years because the petrochemical industry has expanded its activities in the beginning of the nineties (that's one of the reasons this sector is a key source).

The resulting emissions are reported under different sections. The first and largest part (<u>recovered fuels</u>) of the resulting emissions is reported under 1.A.2 c, under 'other fuels'. This includes other fuels in the chemical sector, a result of recovered fuels in the steam cracking units in petrochemical industry (approx. 2/3) and other recovered fuels from the chemical industry (approx. 1/3). These recovered fuels are reported directly in the yearly surveys carried out by the chemical federation in cooperation with the Vito [1] to establish a yearly Flemish energy balance. The choice was made to allocate these fuels under 'other fuels' and not 'liquid fuels' or 'gaseous fuels', for transparency reasons.

Another part of the emissions surveyed in the study, are considered to be <u>process emissions</u> and are reported under 2.B. These include the CO_2-emission during the production of ammonia (2.B.1) and other process CO_2 emissions (2.B.5) reported by the chemical industry in Flanders (for example production of ethylene oxide, production of acrylic acid from propene, production of cyclohexanone from cyclo-hexane, production of paraxylene/meta-xylene, etc). These CO_2 emissions result from the same surveys in the chemical sector in Flanders as those reported under 1.A.2.c. In the survey, more sources of emissions from chemical processes are reported than are described in the IPCC 1996 guidelines.

A small part of non-energy use is still calculated using the default IPCC emission factors (mostly use of lubricants and solvents). These emissions are reported under 2.G. and include also the use of these products in some other sectors than the chemical industry. The emissions are based on an estimate of the use of these products in Flanders and in Wallonia, multiplied with an emission factor and the default % of carbon stored of other petroleum products. These emissions are rather small.

3.3.Reference approach

CO_2 emissions from fuel combustion were estimated in accordance with the “Reference Approach” (Tier 1 Approach – IPCC Guidelines). This estimation is based on the national energy balance, which is derived from national statistics of fuel supply. Default values recommended in the IPCC guidelines were adopted for carbon emission factors, fraction of carbon oxidised, and fraction of carbon stored (feed stocks). The details of this estimation are provided in the CRF tables 1.A(b), 1.A(c), 1.A(d)) for all years.

The comparison with the sectoral approach (Table 1.A(c)) shows a differences between -3.23% (in 2005) and +6,76% (in 2000). The difference between the reference approach and the national inventory for all years is visualised in the figure 3.1 below.

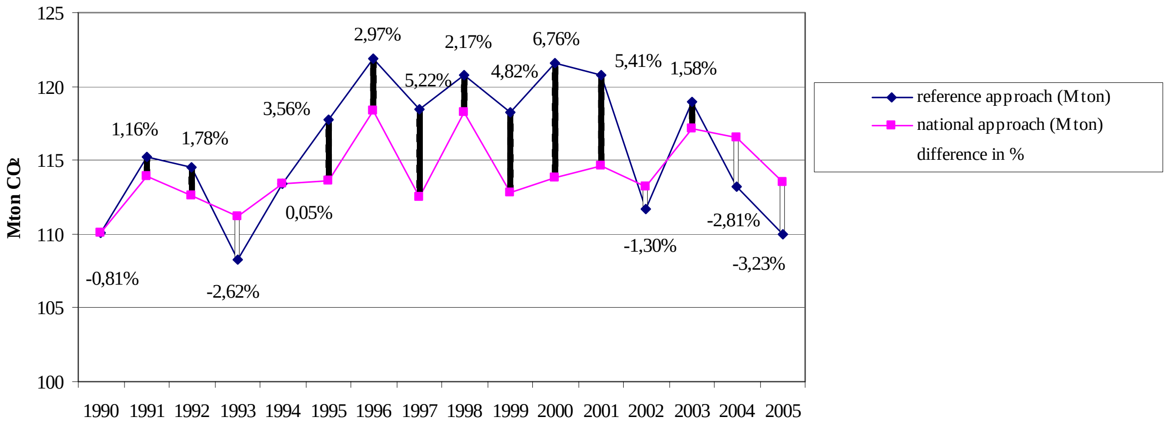


Figure 3.1. : Difference between the Reference approach and the national inventory.

There can be several reasons why there is a difference between the results of the reference approach and the national inventory and also why the difference seams to be getting larger. These differences and their potential reasons have been discussed in previous NIRs. In brief, the same reasons are still valid:

- Reason number 1: the results for the reference approach and the national inventory are based on different data sets (top-down and bottom-up)
- Reason number 2: the effect of calorific values and emission factors of liquid fuels in the reference approach is important for countries with high import of crude oil
- Reason number 3 : emissions from solid fuels are partially located under industrial emissions in the national approach contrary to the reference approach

- Reason number 4: estimations of stored carbon from non-energy use of fuels is completely different in both approaches

A working group under the National Climate Commission is working to improve harmonization of the regional and federal energy balances for the future.

3.4. Recalculations and planned improvements

3.4.1 Recalculations

- In the Flemish region most recalculations in the energy sector of the emission inventory 1990-2005 are performed in the last years (2003 and 2004) because more accurate information became available for these years. The year 2004 has undergone a complete revision because the emissions of 2004 reported last year were reported on a temporary basis. Most important changes (until the year 2003) in the energy balance occurred in the following sectors (with an estimation of the amount of joules changing compared to previous submission):

- Inland navigation in 2003 (sector 1.A.3d, approx. 0,3 PJ)
- Commercial/institutional in 2002 and 2003 (sector 1.A.4a, approx. 2,9 PJ of which most change in redistribution of the electricity consumption between housing and services sector, these changes have no influence on the emissions)
- Industry 2002 and 2003 (chemical industry and other industries) (sector 1.A.2, approx. 0,2 PJ)
- Transport through pipelines for 1999 to 2003 (approx. 0.2 PJ/year)

- Other changes in the Flemish emission inventory are performed because (new) plant-specific CO2-emission factors from 2002 on are obtained from the iron and steel sector in the Flemish region, a recalculation of these emissions since 2002 is performed during this submission.
- Some minor errors are corrected in Wallonia : CO_2 emissions in the category 1.A.2.d. , biomass in the category 1A4a are moved to Energy industries from 1998 until 2004.
-
After EF harmonization with the other regions, the Brussels whole time series has been reviewed for the NOX and SOx emisions of the residential and services sectors.

- - All emissions from road transport (category 1.A.3.b) are recalculated in the Brussels region in this submission for all years from 1995 because of a change in mobility statistical Brussels data from Mobility and Transport Public Federal Service and new data of speed from 2000.
- The Brussels energy balances has been reviewed for 2003. The coal consumption in the domestic sector has been also reviewed from 2001.

3.4.2 Planned improvements

- No specific planned improvements are foreseen in the near future in the estimation of greenhouse gas emissions in Belgium in the energy sector.

CHAPTER 4: INDUSTRIAL PROCESSES

4.1. Overview

4.1.1. Description of the sector

The structure of the industrial sector has undergone profound changes over recent decades. The mining industries have practically disappeared with the closure of the last coalmines. The metallurgy and textile sectors have been relatively stable, after several waves of closures and restructuring. The metallurgy industry nevertheless remains one of the key sectors of Belgian industry, both in terms of employment and turnover. The two other key sectors of industrial activity are the chemical industry and the food processing industry, which contribute respectively 3.8% and 2.5% to the GDP.
In this sector of industrial processes the emissions of industrial activities are included which are not related to the combustion of fossil fuels. Also the emissions of F-gases are included in this sector.

4.1.2. Allocation of emissions

The industrial processes in Belgium are covered by

(1) categories 2.A.1 (cement production) and 2.A.2 (lime production), activities which take place only in the Walloon region and category 2.A.7 (production of glass and ceramics), activities which take place in the Flemish and the Walloon region;
(2) categories 2.B.1 (ammonia production), 2.B.2 (nitric acid production), these activities take place both in the Flemish and the Walloon regions and category 2.B.5 other industrial in the chemical industry in the Walloon region i.e. the production of maleic anhydride and in the Flemish region i.e. the production of caprolactam and other process emissions reported by the chemical industry (f.e. the production of ethylene oxide, acrylic acid, …);

(3) category 2.C.1 (metal production i.e. iron and steel industry), these activities take place both in the Flemish and the Walloon regions;

(4) categories 2.E (production of halocarbons and SF_6) and 2.F (consumption of halocarbons and SF_6);

(5) category 2.G (other industrial processes) i.e. a small amount of emission from the non-energy use of energy carriers used as solvents or lubricants in different (industrial) sectors.

4.2. Methodological issues

The main process emissions of CO_2, CH_4 and N_2O are calculated in Belgium by using production figures, mainly directly originating from the industrial plant, combined with emission factors presented in reference works like CITEPA [2], EMEP/CORINAIR handbook [3], IPCC Guidelines or other specific bibliographies or calculated via measurements carried out by the industrial companies.

4.2.1. Mineral products (category 2.A)

The mineral industry is one of the most important sectors of industrial process emissions in Belgium and contributes to more than 30% (37% in 2005) of greenhouse gas emissions in this sector.

In Belgium, cement production (category 2.A.1) only take place in Wallonia. The activity data is the clinker production collected directly from individual plants following the Tier 2 method.

These emissions are estimated by using a plant-specific emission factor. The emission factor is determined on the basis of the $CaCO_3$ content of raw material (analysis), the CaO produced and the stoechiometric ratio of the equation : $CaCO_3 \rightarrow CaO + CO_2$. The emission factor can be further adjusted taking into account the process efficiency ($CaCO_3$ may be not fully converted into CaO or the CaO produced sometimes contains impurities). Emission factors used in Wallonia are estimated between 464 and 567 kg CO_2/T clinker.

An average emission factor by plant has been estimated in 2002 and is applied on the all time-series 1990-2001. Since 2002, the emission factor varies each year and was calculated directly by the plant. Since 2004, plant data's include information on the CaO content of the clinker and non-carbonate sources of CaO. The CO_2 emission factor is estimated as described for Tier 2 method.

Production of lime also occurs only in the Walloon region of Belgium. These emissions of lime production (category 2.A.2) are estimated by using a plant-specific emission factor (741-839 kg CO_2/T lime ordolomite). This is presented in table 4-1. A part of the lime production is coming from the kraft pulping process : the CO_2 liberated during the conversion of calcium carbonate to calcium oxide in the lime kiln in the kraft pulping process contains carbon which originates in wood. This CO_2 is not included in the net emissions (CO_2 biomass in table 4-1).

The activity data is the lime and dolomite lime production and is collected directly from individual plants. The emission factors are also collected directly from individual plants.

One recalculation was performed concerning errors in the amount of lime produced in 1990, 1991 and 1992.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Lime (kt)	2091	2037	1981	1962	2057	2080	1897	1993	2050	2075	2085	1770	1742	1785	1927	1721
IEF lime (kg CO2/t)	0,75	0,76	0,75	0,75	0,76	0,76	0,75	0,75	0,75	0,75	0,75	0,75	0,74	0,74	0,75	0,78
Dolomite lime (kt)	570	452	408	393	401	374	360	347	385	419	555	823	939	826	851	880
IEF dolomite lime (kg CO2/t)	0,91	0,91	0,91	0,91	0,91	0,91	0.91	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,83
IEF global (kg CO2/t)	0,79	0,78	0,78	0,78	0,78	0,78	0,78	0,78	0,78	0,78	0,78	0,8	0,8	0,8	0,8	0,78
CO2 emissions (kt)	2097	1951	1865	1828	1921	1921	1756	1819	1895	1944	2066	2070	2144	2072	2228	2018
CO2 biomass emissions (kt)	40,9	42,8	42,8	16,6	38,4	30,8	41,9	41,9	45,6	45,6	57,2	48	56,1	61,5	62,3	62,3

Table 4-1 : Lime and dolomite lime production in Wallonia.

The CO_2 emissions in the "limestone and dolomite use" category are mainly reported in others source categories : table 2(I).A-G, under A. Mineral products, 7 "other" (ceramic sector and glass production) and table 2(I).A-G, under C. Iron and Steel production (sinter production). In these sectors, the CO_2-emissions are mostly due to the use of limestone in the production processes. In Wallonia, the CO_2-emissions due to the use of limestone in pollution control are negligible and non-estimated.

Soda Ash production has been occurred in Wallonia until 1993 in Solvay's plant in Couillet. The production of soda ash was discontinued at the end of 1993 and the plant was closed in 1998. The process used was the Solvay process. From stoechiometric considerations, the industrial process emission of CO_2 associated with the Solvay Process is zero. The excess CO_2 emitted from soda ash production originated from coke oxidation is included in the combustion sector.

The production of glass (category 2.A.7) in Belgium takes place in the Flemish and in the Walloon regions. The CO_2 emission factors used in the Walloon region in the glass production (category 2.A.7) for the decarbonation are originating from the joint EMEP/CORINAIR handbook [3] and are 150 kg/ton glass (container glass and glass wool) and 140 kg/ton glass (flat glass). Since 2003, the CO_2 emission factors are calculated by the glass plant. It's difficult to make a recalculation between 1990 and 2002 due to a lack of data's.
In the Flemish region these process emissions of CO_2 from the glass production were newly added in the previous submission for the complete time series after consultation with the industrial companies involved. An emission factor of 125 kg CO_2/ton glass, as proposed by the glass federation, is mainly used in this sector. One company did revise this emission factor in the current of 2006 to 300 kg process CO_2/ton glass. Because of the comparability of the melting process in the production of glass and enamel, both industries are related in Flanders and consequently put under the same category 2.A.7. For the one company involved in the enamel production in Flanders, an emission factor of 650 kg CO_2/ton was used in the previous submission. This emission factor was first given by the company and based on the European BREF-documents (reference document Best Available Technology) and is revised in the current of 2006 to 71,12 kg CO_2/ton glass. The company involved stated that the emission factor of 650 kg CO_2/ton is a combination of process and combustion and consequently a double counting of the emissions of CO_2 occurred.

Also put in the 2005 submission are the process emissions of CO_2 originating from the ceramic sector (category 2.A.7) for the complete time series. In consultation with the federations and companies involved, an estimate is given of the emissions of CO_2. This estimation is calculated in Flanders with the methodology recorded in the monitoring protocol of the companies and is based on production information and the evolution of the gamut of products .
In the Walloon region an average emission factor was established in 2005 by the plants involved.

4.2.2. Chemical industry (category 2.B)

The chemical industry is the most important sector in industrial processes in Belgium and contributes for 39% (in 2005) of greenhouse gas emissions in this sector. The different sectors involved are described below.

4.2.2.1. Ammonia production (category 2.B.1)

Nowadays there is ammonia production in 2 companies in Belgium.
In Flanders the emissions of CO2 originating from the production of ammonia are obtained as a result of the yearly surveys carried out by the chemical federation in cooperation with the Vito [1] (see also section 3.2.9.). In the past the same methodology as in Wallonia was used, nowadays the methodology is adapted because a part of the emissions of CO_2 is recuperated in the plant and no longer emitted.
In the Walloon region, until 2004, the CO_2 emissions were calculated based on the natural gas used as feedstock. 100% per cent of the carbon content of the natural gas was presumed to be emitted; the default IPCC emission factor for CO_2 for natural gas (55,8 kton CO_2/PJ) was used to calculate the total CO_2 emissions. The amount of natural gas used in the process was given directly by the plant. Since 2005, CO_2 emissions have been given directly by the reporting of the plant under the emission trading scheme.

A part of the process CO_2 emissions is used by two other plants and released after use but all the CO_2 emissions are allocated to the ammonia plant.

4.2.2.2. Nitric acid production (category 2.B.2)

The N_2O emissions from the production of nitric acid (category 2.B.2) are estimated in Flanders by using an emission factor of 8 kg N_2O/ton HNO_3 from CITEPA [2]. The three plants involved in Flanders since 1990 agreed with this factor of 8 kg N_2O/ton HNO_3 and give their nitric acid production figures each year. Since 2000 only one plant is still involved in this sector. From 2003 on lower emission factors in this plant are reported, based on monitoring results (approx. 5.6 kg N_2O/ton HNO_3). The use of catalysts reduces these emissions. A further reduction of these emissions will be obtained in the future because of the extension of the use of catalysts in the different installations involved.
Although the closure of 2 plants in the Flemish region, in 1995 and in 2000 respectively, the production of nitric acid increases and the emissions of N2O decreases in time due to undertaken measures. From 2003 to 2005 a more or less stabilization in production and emissions occur.

The producer of nitric acid in the Walloon region provides the N_2O emissions based on their production and on monitoring. There are three installations on the plant. The global emission factor used in this region is 4,5 kg/t in 2005. For the time being , there is only one installation with an abatement technology (SCR) installed in 1996. However, this installation did not lead to a decrease in the N_2O emissions given the strong increase of the production since 1996. .

4.2.2.3. Other (category 2.B.5)

In the other chemical industrial processes, the CO_2 -emissions originate from

(1) the non-energy used of fuels i.e. the use of n-butane for the production of maleic anhydride in the Walloon region. The emissions are estimated by the chemical industry;

(2) the emissions of N_2O originating from the production of caprolactam. Only one company is involved in Belgium in the Flemish region and since 1997 this company offers each year the results of the monitoring carried out. This company estimated the emissions of the previous years from 1990 on as accurate as possible;

(3) other process CO_2 emissions reported by the chemical industry in Flanders (for example production of ethylene oxide, production of acrylic acid from propene, production of cyclohexanone from cyclo-hexane, production of paraxylene/meta-xylene, the emissions of CO_2 of flaring in the chemical industry etc). These CO_2 emissions result from surveys in the chemical sector in Flanders (see also section 3.2.9 for more details).

4.2.3. Metal production (category 2.C)

Metal production, more specific the iron and steel production (category 2.C.1.) is the third most important sector of industrial process emissions in Belgium and contributes to more than 10% (11% in 2005) of greenhouse gas emissions in this sector of industrial processes. These activities are situated in the Flemish and the Walloon regions .

In Flanders, the calculation of the process CO_2 emissions from iron and steel production is based on the production figures of fluid steel and pig iron and on the consumption of electrodes of the only two industrial plants in this sector and with an emission factor approved by these plants (% carbon blown off and an emission factor of 158 kg CO_2/ton pig iron).

In Flanders the emissions of CH_4 originating from the production of sinter are completely revised during the previous submission and based on information in the reference document of the Best Available Techniques of the sector iron and steel and on monitoring results from 2001 on. Emissions of CH_4 are measured in 2001 and because of the switch of cokes grit into anthracite during 2004 and 2005 (because of environmental technical reasons) emissions of respectively 416 and 1964 ton CH_4 are measured in 2004 and 2005. Emissions of CH4 in the remaining years are negligible.

In the Walloon region, iron is produced through the reduction of iron oxides (ore) with metallurgical coke (as the reducing agent) in a blast furnace to produce pig iron. Steel is made from pig iron and/or scrap steel using electric arc or basic oxygen.

The method used is the Tier 2 method.

The emission estimates in this sub-sector include also emissions from the production of steel in basic oxygen type furnaces but not emissions from the combustion of the fuel.

Until 2004, the emission factors in the basic oxygen furnace steel plant are found in table 4-3. The plants approved these emission factors. Until 2002, 100 % of the CO_2 in the pig iron produced the blast furnace has been estimated to be emitted in the basic oxygen furnace due to the lack of data's (purchased pig iron, C in steel produced, C in steel scrap). Following the industry, the amount of C in steel scrap is equivalent of the amount of C in steel produced and so, the amount of C resulting is approximately zero. It was confirmed with the emission trading data's.

Until 2004, the process CO_2 emissions from electric arc furnaces were based on the consumption of electrodes with the following emission factor : 5 kg CO_2/ t steel.

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
C in pig iron (% weight)	4,6	4,6	4,6	4,6	4,6	4,6	4,6	4,6	4,6	4,6	4,6	4,6	4,6	4,66	4,66
CO_2 emission factor (kg/t pig iron)	169	169	169	169	169	169	169	169	169	169	169	169	169	171	171
CO_2 emission factor (kg/t steel) basic oxygen furnace	153	152	154	155	158	158	161	166	165	169	167	164	165	164	162
CO_2 emission factor (kg/t steel) electric arc furnace	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 4-3: Emission factors used in the iron and steel sector in the Walloon region (Source: plant specific /ULG)

Since 2005, CO_2 emissions have been obtained directly by the reporting of the plants under the emission trading scheme.

This sub-sector included a part of the CO_2 emission in the sinter plant. Until 2004, these emissions were calculated by using an IPPC emission factor of 200 kg CO_2/ton sinter. The emissions calculated involved combustion and process emissions. Combustion emissions were reported in the energy sector (fuel consumption x emission factor (table 3-1) and the remaining emissions were reported in the process sector. These process emissions are originating from additive in the furnace as limestone. In the future, it will be difficult to make a recalculation for the complete time series due to the lack of necessary data. Since 2005, CO_2 emissions have been obtaining directly by the reporting of the plants under the emission trading scheme.

CH_4 and N_2O emissions are included in the energy sector (emission factors in table 3-6).

4.2.4. Fluorinated gases (categories 2.E and 2.F)

The emissions of the categories 2.E and 2.F (production and consumption of halocarbons and SF6) contribute to 11% of total greenhouse gas emissions in 2005 in the sector of industrial processes in Belgium.

For estimating the emissions of the F-gases described in Annex A to the Kyoto Protocol (hydrofluorocarbons HFCs, perfluorocarbons PFCs, sulphur hexafluoride SF6), a country-specific methodology was developed by 2 consultancies (ECONOTEC and ECOLAS) in 1999 based on the IPCC Guidelines [34][35][10][28] and since then updated every year and further optimised by ECONOTEC, in collaboration with VITO since 2005 [45].

The present contribution of the F-gases to the total GHG emissions covered by the Kyoto Protocol (1.3 % in 2005) is significantly lower than in 1995 (3.3%), mainly thanks to abatement measures in the chemical industry. From 1999 to 2004, the total F-gas emissions have increased steadily, as a result of the current regulations relating to the substitution of ozone depleting substances. In 2005, they have decreased, which can entirely be explained by the reduction of PFCs in the chemical industry.

No systematic emission inventories of fluorinated greenhouse gases were made for the years 1990-1994 because it is very difficult to obtain reliable information. However Belgium did try to estimate the F-gas emissions for these years as accurately as possible (see CRF-tables): the emissions of the chemical process industry, which represent 87% of the total fluorinated GHG emissions in 1995, are known for the complete time series. For the years 1990-94, the emissions of the remaining sources (13% in 1995) were assumed constant and equal to their level of 1995. As a result, the emission inventory of fluorinated gases from 1995 to 2004 can be considered as time consistent for the complete time series.

2E Production of halocarbons

The emissions of category 2.E (Production of halocarbons) are those of an electrochemical synthesis (electro-fluorination) plant, which emits, or has emitted, SF6, CF4, C2F6, C3F8, C4F10, C5F12 and C6F14, as well as fluorinated greenhouse gases not covered by the Kyoto Protocol (among which CF3SF5, C7F16, C8F18 and C8F16O). This plant produces a broad range of fluorochemical products, which are used as basic chemicals as well as end products (mainly in the electronic industry). The emissions of this key emission source are partly fugitive and partly non-fugitive.

A gas incinerator with HF recovery has been installed in 1997 to reduce the non-fugitive emissions. This has resulted in a drastic reduction of the emissions, which for 2005 are estimated at about 140 kt CO2 equivalents (for the gases covered by the Kyoto Protocol), down from 4.4 Mton CO2 equivalents in 1995.

This process is unique in the EU (there are however some similar plants in the US). This means that there is no readily available documentation on the processes, or reported emission factors. The emissions are calculated by using mass balances in combination with measurements. These measurements are based on EPA Method 320 using FTIR (Fourier Transform Infra Red spectroscopy) and GC/MS (gas chromatography combined with mass spectrometry).

The emission estimates are complicated due to the fact that all emissions come from batch processes and that there are many reactors and process steps. For each process step (around 60 steps for the GHG emissions) an emission factor is reported. The emission factors are combined with detailed specific production data. Due to the complexity and for reasons of confidentiality, the detailed emission calculations cannot be made public.

An external audit was performed on the emission inventory by CH2M HILL. One of the findings was: “CH2M HILL finds that the company has been diligent in its effort to remove scientific uncertainty from the downstream emission estimates, the company has gone above and beyond the expectations outlined in the GHG Protocol in its attempts to reduce uncertainty, and the resulting emission estimates are transparent and provide a basis for consistent reporting of GHG emissions.” (August 2005).

2F Consumption of halocarbons

Emissions of fluorinated greenhouse gases are mainly estimated on the basis of the consumption of the different substances for each application, the consumption of products containing such substances, figures on external trade in substances or products containing substances, as well as on emission modelling by application and assumptions on leakage rates.

For the calculation of the potential emissions the definition and calculation of the potential emissions have been revised during this submission, in particular the impact of recovery and destruction. The bulk potential emissions for the whole period 1995-2005 have been updated accordingly (note that there is no impact for the years 1995-97). See [58] for more details about this methodology.

The actual emissions of HFCs come from the following categories: Refrigeration (industrial & commercial and household refrigerators) and air conditioning equipment (in stationary applications and in vehicles), Foams (closed cell foams, polyurethane cans and foam in refrigerators/freezers), Metered Dose Inhalers (MDI), aerosols other than MDIs and fire extinguishing (fixed installations).

For the refrigeration sector, the consumption and emission of refrigerants are modelled on the basis of an annual inquiry among refrigerant distributors on their national supply by refrigerant mixture, as well as on assumptions on average loss rates. The refrigerant consumption and emissions of the transportation sector are estimated by modelling the number of vehicles and the penetration of air conditioning or refrigerated transport, by category of vehicles.

For the foam sector, the modelling of consumption and emissions of blowing agents is based on an annual inquiry among the foam manufacturers and assumptions on emission rates for manufacturing and product use, as well as on external trade, by type of insulation foam.

The SF6 emissions originate from the production and the stock of soundproof double-glazing and to a minor extent from the electricity sector.

HFC emissions have been gradually increasing (+235 % between 1995 and 2005), as a result of the current regulations relating to CFC and HCFC substitution. HFCs are mainly used in the refrigeration sector and for the production of synthetic foams.

4.2.5. Non-energy use of fuels (category 2.G)

The CO_2 emissions in the category 2.G are calculated using the IPCC default factors of carbon stored during the use of lubricants and solvents in Flanders (mostly in industry).
A factor of 0,75 is used in Wallonia as the fraction carbon stored.
These emissions are relatively small. More explanation about the estimation of these emissions can be found in section 3.2.9.

4.3. Recalculations and planned improvements

4.3.1. Recalculations

- In the Flemish region the process emissions of CO_2 in the glass industry (category 2A7) are revised in 2 companies from 1990 on because more reliable information became available.
- Small amount of process emissions of CH_4 in the chemical industry were included for the first time since 1991 in the flemish region.
- Since 2005, CO_2 process emissions in the Walloon region have been mainly obtaining directly by the reporting of the plants under the emission trading scheme.
- The following changes have been made in the fluorinated gas inventory for the period 1995-2004:
  - The bulk potential emissions have been recalculated, using a revised approach (note that there is no impact for the years 1995-97).
  - Emissions from domestic refrigerators have been re-estimated for all years.
  - Disposal emissions of refrigeration 'installations' have been revised.
  - A certain number of minor mistakes or inconsistencies have been removed. All of them only have a marginal impact on the total emissions.
  - Rounding errors have been removed for all years.

4.3.2. Planned improvements

No specific improvements are planned in the near future in the estimation of greenhouse gas emissions in Belgium in the sector of industrial processes.

CHAPTER 5: SOLVENT AND OTHER PRODUCTS USE

5.1 Overview

In Belgium the emissions of NMVOC in the source category 'Solvent and other product use' include paint application (building industry & households), production of medicines, paints, inks and glues, domestic use of other products (incl. glues and adhesives), coating processes in general (incl. assembly of automobiles), printing industry, wood conservation, treatment of rubber, storage and handling of products, recuperation of solvents and extraction of oil, cleaning and degreasing and dry cleaning.

No estimation of the CO_2 equivalent emissions of the solvent consumption is carried out in Belgium except in the Flemish region where emissions of CO_2 from the non-energy use of lubricants and solvents are reported under category 2.G.

The greenhouse gas emissions in this category 3 in Belgium are related to the use of N_2O as an anaesthetic.

5.2. Methodological issues

The regions in Belgium are using comparable methodologies to estimate the emissions of solvent and other product use in their region.
The emissions of NMVOC in Flanders are estimated by using the results of a study started by the University of Gent in 1998 and continued by the Flemish Environment Agency (VMM).
In Wallonia, the calculation is based on a methodology established by Econotec [39].
In the Brussels region, the emissions are calculated by using the results of the research projects [16], [17] and [20].
Because of the less importance of these emissions in the greenhouse gas story, only a general view of how these emissions are calculated in Belgium is given below.

Broadly speaking, emissions of NMVOC are estimated in Belgium as follows :

- All emissions of category 3.A (NMVOC emissions for Paint Application…), and some of category 3.C (production of paints, inks and glues) as well as some of category 3.D (other domestic use, wood coating, wood conservation, recovery of solvents, treatment of rubber, coating of synthetic material and paper) are estimated based on production figures that are given by the specific industry or professional federations. The emission factors used are mainly the solvent content of the product.

- The remaining emissions of category 3.D (storage and handling of products and assembly of automobiles, extraction of oil seeds, textile coating and printing industry) are estimated based on information gathered in the industrial databases mainly originating from the yearly reporting obligations of the industrial companies.

- The emission calculation for the emission of N_2O from anaesthesia (3D) is based on the number of hospital beds in Belgium and the average consumption of anaesthetics per bed. The emission factor is 10,3 kg N_2O/bed/year. This factor was determined by inquiries carried out in 1995 by an independent consultant agency Econotec [39].

It has been assumed that all of the nitrous oxide used for anaesthetics will eventually be released to the atmosphere. The number of beds used for the emissions calculations was obtained from the DGASS (General Directorate for Health and Social Action) and from the Health Public Federal Service..

- There is no estimation carried out in Belgium of the CO_2 equivalents calculated out of the emissions of NMVOC of the solvent consumption because of the unreliability of this factors proposed in literature.

5.3 Recalculations and planned improvements

5.3.1. Recalculations

No main recalculations of greenhouse gas emissions are made in the sector of solvent and other product use during this submission. However, as with all other sectors, a constant actualization of the inventory is performed. Consequently most recalculations of the emission inventory 1990-2005 are performed in the last years (2003 and 2004) because more accurate information became available for these years.

5.3.2. Planned improvements

No specific improvements are planned in the near future in the estimation of greenhouse gas emissions in Belgium in the sector of solvent and other product use.

CHAPTER 6: AGRICULTURE

6.1. Overview

6.1.1. Description of the sector

The main types of rearing and cultivation business and their numbers are represented in tables 6.1 and 6.2. Those data are available on a yearly basis and are used as one of the activity data for the agricultural sector (see 6.2.1.). Tables 6.1 and 6.2 are presented here to give an overview of the sector in Belgium.

	Belgium	Evolution 2004-2005	Flemish Region	Walloon Region	Brussels Capital region
Number of businesses	51.540	-3,2%	34.410	17.109	21
Agricultural land (ha)	1.385.582	-0,6%	629.684	755.545	353
Grassland (ha)	600.509	-1,1%	226.314	374.054	141
Grains (ha, without maize)	267.975	0,3%	91.397	176.494	83
Maize (ha)	218.081	-0,5%	162.533	55.485	62
Sugar beet (ha)	85.527	-2,5%	32.747	52.765	15
Potatoes (ha)	64.952	-2,7%	40.218	24.712	22
Others (ha)	148.538	1,8%	76.474	72.035	29

Table 6.1. : Main types of cultivation in Belgium (NIS, 2005).

	Belgium	Evolution 2004-2005	Flemish Region	Walloon Region	Brussels Capital region
Bovins (total)	**2.698.649**	**-1,5%**	**1.350.304**	**1.348.032**	**313**
Bovines under 1 year	786.773	-0,3%	434.988	351.696	89
Male bovine between 1 and 2 years	141.814	-5,3%	76.942	64.872	0
Female bovine between 1 and 2 years	378.106	-2,0%	183.612	194.471	23
Male bovine more than 2 years	37.427	-5,2%	18.960	18.465	2
Female bovine more than 2 years	350.601	-1,9%	168.743	181.784	74
Dairy cows	523.281	-3,6%	292.842	230.374	65
Brood cows	480.647	1,3%	174.217	306.370	60
Porcs (total)	**6.318.213**	**-0,6%**	**5.952.518**	**365.693**	**2**
Piglet under 20 kg	1.661.344	-1,0%	1.607.322	54.022	0
Piglet between 20 and 50 kg	1.291.375	-4,6%	1.203.425	87.948	2
Fattening pigs more than 50 kg	2.762.858	1,9%	2.563.978	198.880	0
- Breeding males	10.105	-6,1%	9.482	623	0
Sows	592.531	-1,3%	568.311	24.220	0
Sheep	**152.384**	**1,2%**	**95.976**	**56.392**	**16**
Goats	**26.209**	**2,9%**	**15.984**	**10.215**	**10**
Horses	**33.404**	**4,6%**	**21.684**	**11.659**	**61**
Poultry (total)	**35.569.320**	**-2,6%**	**30.385.744**	**5.182.800**	**776**
laying hens	13.214.955	-1,7%	11.605.059	1.609.723	173
Broilers	21.073.353	-3,1%	17.633.155	3.439.718	480
Others	1.281.012	-2,6%	1.147.530	133.359	123

Table 6.2. : Number of heads in the main livestock categories in Belgium (NIS, 2005).

The land used for agriculture in 2005 extends to 1.385.582 hectares (Table 6.1), or 45.6% of Belgium. In 2005, the number of agricultural and horticultural businesses amounted to 51.540. This number had dropped by 17 % in 5 years, the disappearing of small businesses being a general trend in the sector, also reinforced by the successive crises that have hit the agricultural sector (BSE [*Bovine Spongiform Encephalitis*], dioxin). Additionally in Flanders, this partly can be explained due to the subsidized cut down of the number of cattle. This counted in 2001 and 2002 only for swine, in 2003 also for bovine and poultry. Nevertheless the land area used for agricultural purposes remained identical during this period. In 2005 Wallonia has 55% of the land used for agriculture, but 67% of agricultural businesses are situated in Flanders. The land area used for farming is on average 18 ha per farm in the Flemish region and 44 ha per farm in the Walloon region.

Organic farming and the businesses in transition towards this type of farming only represent 1% of the total. The evolution of the Belgian agricultural sector is of course directly related to the Common Agricultural Policy of the European Union.

6.1.2 Allocation of emissions

Some agricultural sectors such as rice cultivation, prescribed burning of savannahs (categories 4.C and 4.E) and field burning of agricultural residues (category 4.F) are not occurring in Belgium.
The agricultural sector in Belgium covers the categories 4.A, 4.B, 4.D and 4G.

The agricultural activities on the Brussels territory are extremely small compared with the 2 other regions in Belgium. As one can see in table 6.2, the agricultural area or the number of animals in the Brussels region never exceed 0,02 % of the national figure. Keeping in mind the large uncertainty on agricultural emissions, the emissions in the Brussels region are deemed negligible and are not estimated.

6.2. Methodological issues

6.2.1. Data sources

The main activity data are the land-use and the livestock figures. The National Institute of Statistics (NIS) [26] publishes these numbers yearly. All agricultural businesses have to fill in a form each year about the situation at 1 may of that year and sent it to the NIS. Further details on the agricultural census methodology and QA/QC issues can be found on the NIS website: www.statbel.fgov.be.

For nitrogen fertiliser use, data from the Institute for Agricultural and Fisheries Research (the so-called IVLO) are used. The institute conducts surveys on a representative sample of the different types of agricultural businesses and produces yearly weighted average values on the fertiliser use, taking into account manure pressure.

With an average temperature of 9,8 °C (11°C in 2005, www.meteo.be), Belgium as a whole has a "cool" climate.

In Wallonia, the data on sludge spreading on agricultural soils are available on the website of DGRNE (http://www.environnement.wallonie.be/). The allocation of animals to animal waste management system (AWMS) comes from the NIS agricultural census of 1992 and 1996, where those data were collected by animal type. Those data are not collected on a yearly basis by the NIS given their slow pace of change. However, an update of the 1996 data would likely be useful in the near future. So far we have no information about the NIS planning regarding this update.

In Flanders, the N_2O emission calculation model follows IPCC methodology but uses region-specific data wherever available. The allocation of animals to AWMS as well as the detailed data for nitrogen excretion factors and processed animal manure originate from the Manure Bank of the Flemish Land Agency (www.vlm.be) and is based on the regional situation. The nitrogen leaching (N_2O model) is based on the SENTWA model (System for the Evaluation of Nutrient Transport to Water) which is updated yearly [45].

In Wallonia, the emissions are calculated using a model developed by a consultant agency Siterem [30] with recognised experience in this field. Some amendments have been applied on the model in order to better comply with the UNFCCC requirements and to keep only the relevant regional specific emission factors. Different data are used as input in the model which then calculates CH_4, N_2O and NH_3 emissions (NH_3 is used for other mandatory reporting than UNFCCC). Four emissions sources were pointed: animal husbandry, the excreta of agricultural animals deposited in buildings and collected as either liquid slurry or solid manure, application of animal manure to land and mineral fertilisers.

6.2.2. Enteric fermentation

CH_4 emissions from enteric fermentation from animal husbandry are estimated using the Tier 1 methodology described in the IPCC Good Practice Guidance [10]. Although enteric fermentation is a key source , Belgium does not use a Tier 2 methodology because data such as gross energy intake are not available and the use of Tier 2 without reliable activity data does not appear likely to reduce the overall uncertainty of the estimate.

CH_4 emission (ton) = number of animals * emission factor

The IPCC emission factors are used for most animal categories. In Wallonia, the emission factor for dairy cattle, which is the most important subcategory in this sector, is adjusted regarding the increasing milk production. The IPCC 1996 guidelines states that animal size and milk production are important determinants of emission rates for dairy cows. IPCC provides different EF different milk productions, and a similar approach was applied to adjust the EF according to the measured milk production. The resulting EF is very close to the IPCC default, from 100 kg CH4/yr in 1990, with an average milk production of 4021 litres, to 110 kg CH4/yr in 2003, with a milk production of 5222 litres.

Further harmonisation of the emission factors between the regions is carried out during this submission. The classification of the animal categories occurs according to the IPCC methodology.

The emission factors presented in the CRF tables are a weighted average of the emission factors used at the regional level.

6.2.3. Manure management

Flanders

CH_4 emissions from manure management in Flanders are estimated using the Tier 2 methodology. Because of the availability of detailed statistics on livestock composition in Flanders, including data on e.g. slaughter weights, a more extended variant of the IPCC methodology has been applied, integrating country specific data [49]. The integrator used in following formula takes into account the fact that the weight of the cattle over the whole lifetime is not the same as the slaughter weight, and integrates therefore between the weight at birth and the slaughter weight.

Since 1996 Flanders has got a Manure Action Plan (MAP), which foresees in processing of the surplus of manure (based on the Nitrate Directive). A study performed by the Flemish Institute for Technological Research (Vito), indicates that CH_4 emissions during manure processing are negligible. Further studies are undertaken to estimate N_2O losses during manure processing.

CH_4 emission (m³) = number of animals * average adult weight[(1)] (kg) * integrator[(1)] * manure production[(1)] (kg/day/1000kg) * 365/1000 * volatile solid[(2)] (%) * emission potential[(2)] (m³/kg VS) * CH_4 potential[(2)] (m³) [(1) Source : Flemish Land Agency; (2) Source : Casada & Safley [46]].

CH_4 emission (ton) = CH_4 emission (m³) * density (kg/m³)

Category	*Weight (kg)*	*Integrator*	**Manure production (kg/d/1000kg)**	**VS (%)**	**Emission Potential (m³/ kg VS)**	**MCF (%)**
Bovine						
Slaughter calves in stable	160	0,62	86	11.6	0.33	15
Bovine under 1 year						
In stable	300	0,56	86	11.6	0.33	15
On pasture	300	0,56	58	12.4	0.17	10
Bovine from 1 to 2 year						
In stable	400	0,88	86	11.6	0.33	15
On pasture	400	0,88	58	12.4	0.17	10
Bovine more than 2 year						
In stable	500	1	86	11.6	0.33	15
On pasture	500	1	58	12.4	0.17	10
sheep	50	1	40	23	0.19	10
goats	50	1	41	26.6	0.17	10
swine						
Piglet under 20 kg	20	0,75	84	10.1	0.45	20
Piglet between 20 and 50 kg	35	1	84	10.1	0.45	20
Fattening pigs between 50 and 80 kg	65	1	84	10.1	0.45	20
Fattening pigs between 80 and 110 kg	95	1	84	10.1	0.45	20
Fattening pigs more than 110 kg	150	0,87	84	10.1	0.45	20
Breeding male	140	1	84	10.1	0.45	20
Breeding sows and old males and sowes	125	1	84	10.1	0.45	20
Horses	500	1	51	19.6	0.33	10
Mules	250	1	51	20	0.33	10
poultry						
Broilers (for breeding)	2	1	85	19.4	0.32	10
Broilers (for fattening)	1,3	0,52	85	19.4	0.32	10
Laying hens	2	1	85	19.4	0.32	15
Young laying hens	1,3	0,52	85	19.4	0.32	10
Ducks	2,5	0,54	85	19.4	0.32	20

Goose	7,5	0,65	47	19.4	0.30	20
Turkeys	7	0,49	47	19.4	0.30	20
Guinia fowl	1,2	0,55	85	19.4	0.32	20

Table 6.3. : Calculation factors used for the CH_4 emissions from manure management in the Flemish region (Source: Flemish Land Agency, Casada & Safley).

Wallonia

Emission factors for each animal category have been developed by Siterem [30]. Those factors take into account the type and volume of manure produced during the time spent in stables, its density and carbon content, and its carbon volatilisation ratio. The parameters come from studies conducted in Wallonia or in France. The calculation of these EF implies large excel spreadsheets, which cannot be reproduced in the NIR. Those emission factors are multiplied by the number of animals to estimate the total emissions from manure management.

The resulting EF are comparable to the default IPCC EF (table 4-6 of the IPCC 1996 guidelines for western Europe, cool climate) : in 2004, the EF used in Wallonia are 5,18 kg/head.year for non-dairy cattle (IPCC default = 6), 12,47 for dairy cattle (IPCC default = 14) and 2,54 for swine (IPCC default = 3). For non-dairy cattle and swine, the implied EF in the CRF tables for Wallonia is a weighted average of specific EF for further disaggregated animal categories (see table 6.2 for example). For this reason, the EF is changing from year to year, according to the changing proportions of the subcategories of swine and non dairy cattle. The EF for sheep is 0,25 compared to 0,19 in the 1996 IPCC guidelines. It can be pointed that in 2004, sheep represents only 0,16 % of the CH4 emissions from manure management in Wallonia.

6.2.4. Agricultural soils

Methane

Following the centralised review report and in harmony with the IPCC 1996 guidelines the methane emissions from wetlands, unmanaged surface waters and removals in forest soils, grassland and agricultural soils are no longer reported in the national inventory.

Wallonia calculates the CH_4 emissions on the basis of the manure applied during grazing. This source is very small compared to enteric fermentation and manure management.

Nitrous oxide

The N_2O emission estimation depends on two major sources : the manure storage and the emission from agricultural soils (direct and indirect). The N_2O emissions are calculated according to IPCC methodology but uses country or region specific data where available.

The N_2O emission estimation from manure storage is based on the nitrogen excreted by each animal category, estimated through local production factors. The calculation takes into account the number of days in pasture and the ratio of liquid systems and solid storage. In Wallonia. Such factors were first determined for the implementation of the CE Nitrates Directive 91/676 (see annexes of the decree downloadable on http://www.nitrawal.be/pdf/arretenitrates_mb2.pdf, but were representing the nitrogen *after* deduction of the atmospheric losses, so new factors were calculated on this basis for the purposes of estimating atmospheric emissions.

In Flanders, the nitrogen excretion factors were revised during this submission for the time series 1996-2004, taking into account the reduced nutrient content in the animal feed (see table 6.5).

The nitric acid factors are based on the excretion factors as written in the Manure Action Plan II bis (MAP 2 bis) and corrected with 12% for bovines (excl. slaughter calves). Also improved nutrient contents of cattle feed are taken into account [50].

In Belgium, the local excretion factors are more or less comparable to the 1996 IPCC default value, especially if the principle of Table 4.14 of the IPCC Good Practice Guidance is taken into account : adjustment factors for the IPCC 1999 table 4-20 are given according to the age range, and in Belgium, the agricultural census allows a detailed disaggregation in subcategories according to the age or the weight of the animals (see table 6.2).

The IPCC default emission factors for liquid systems and solid storage are then applied (respectively 0,001 and 0,02 kg N- N_2O/kg N excreted).

In Wallonia, the allocation of animals to AWMS comes from the NIS agricultural census of 1992 and 1996, where those data were published by animal type. Those data are not collected yearly by the NIS given their slow pace of change.

In Flanders, the allocation of animals to AWMS comes from the Flemish Land Agency (see table 6.5).

Category	**N ex (kg N/animal/yr)**	**AWMS**
Bovine		
Slaughter calves	10.5	24% liquid storage 36% solid storage 40% pasture
Other bovine under 1 year		
Male	25.76	ditto
Female	36.96	ditto
Bovine from 1 to 2 year		
Male		
for the reproduction	67.08	ditto
other	68.32	ditto
Female		
Fattening cows	68.32	ditto
For replacement of dairy cows	62.72	ditto
Bovine more than 2 year	86.24	ditto
Dairy cows	108.64	39% liquid storage 19% solid storage 42% pasture
Sheep		
Sheep under 1 year	4.36	19% liquid storage

		81% pasture
Sheep more than 1 year and goats	10.5	ditto
Swine		
Piglet under 20 kg	2.51	96% liquid storage 4% daily spreading
Piglet between 20 and 50 kg	12.17	ditto
Fattening pigs between more than 50 kg	15.69	ditto
Breeding pigs more than 50 kg		ditto
Boars	23.36	ditto
Sows	23.18	
coverred sows	23.18	76% liquid storage 24% solid storage
Non-coverred sows	22.73	ditto
Horses		
Horses under 6 months	35	96% pasture 4% other
Farming horse more than 6 months	65	ditto
Other horses more than 6 months	50	ditto
Mules	35	ditto
Rabbit	8.64	ditto
Furred animals	3.22	ditto
poultry		
Broilers (for breeding)	0.94	85% solid storage 15% other
Broilers (for fattening)	0.59	ditto
Laying hens (for breeding)	0.55	44% storage within housing 23% solid storage 33% other
laying hens	0.69	ditto
Breeding cocks	0.69	100% solid storage
Turkeys	1.89	ditto
ostriches	8.6	100% liquid storage
other	0.24	ditto

Table 6.5 : Nitrogen excretion factors and allocation of animals to AWMS for each category in Flanders (2005).

N_2O is also emitted as a by-product during soil nitrification and denitrification processes. There is a very high variability in the emission rates and the estimation methodologies try to take into account local conditions to reduce the uncertainty.

The N_2O direct soil emissions (category 4.D.1) include the N_2O emissions from daily spread, spreading of mineral fertilisers, spreading of organic fertilisers and nitrogen from crop residues.

The N_2O emissions from mineral fertilisers account for the nitrogen volatilised as NH_3 (and NO). The model uses a volatilisation rate from mineral nitrogen to NH_3 (In Wallonia the average rate of 2,3 % based on the default values recommended by IIASA for different types of fertilisers and in Flanders the weighted average for NH_3 and NO volatilisation is 4.4%). The N_2O emissions from organic fertiliser spreading are calculated in the same way than N_2O emission from mineral fertiliser spreading. The N_2O emissions from crop residues can vary according to the preceding culture. The nitrogen residual from soil is estimated by multiplying, for each culture, the cultivated area by the nitrogen residual average quantity for the culture considered. The N_2O emission from these 3 sources is estimated by applying the IPCC default emission factor (0.0125 kg N-N_2O/kg nitrogen).

The nitrogen from grazing is estimated, taking into account the number of days in pasture and the nitrogen excreted by each animal category. Available nitrogen is the difference between the manure nitrogen content and the manure nitrogen volatilisation in NH_3 and NO form. The IPCC default emission factor of 0.02 kg N-N_2O / kg N is then used to estimate the emissions.

In Flanders, during the previous submission the implied emission factor for histosols is updated from 5 to 8 kg N_2O-N / kg N. Also the area histosols has been corrected using region specific data based on an intersection between the CORINE Land Cover Geo dataset from 1990 and the Belgian ‘Soil association map’. The area is held constant for the entire time series [48].

The indirect emission (category 4.D.3) considers the N_2O emissions from atmospheric deposition, leaching and runoff.

The atmospheric deposition is estimated at 10.9 kg N/ha. It is considered that 1 % of this nitrogen is volatilised as N_2O. The N_2O emissions from leaching and runoff are estimated by multiplying available nitrogen quantity in soil (animals excreta from grazing, mineral and organic fertilisers spreading, crop residues decomposition, sludge and atmospheric deposition) by two factors. The first estimates the fraction of nitrogen lost by leaching and runoff, with a value coming from local studies and which falls into the IPCC range (0.17 kg N / kg N available) [51]. The second estimates the volatilisation rate in N_2O form with the IPCC default value (0.025 kg N-N_2O / kg N, table 4.18 of the IPCC Good Practice Guidance).

The category other (4.D.4) consists of N_2O emission from sludge spreading on agricultural soils. It is considered a fixed contribution of 0.1 kg N/ha x year and an emission factor equal to 0.0125 kg N-N_2O/kg N from sludge.

6.2.5. Other (category 2G)

The emissions put in category 2G in the flemish region are the emissions of N2O originating from nature (conifers, deciduous trees and parks). These emissions are calculated using emission factors of CITEPA [2].

6.3. Recalculations and planned improvement

6.3.1 Recalculations

- The methodology to calculate the emissions of fertilizer is adapted in the Flemish region during this submission, the pressure of manure is taken into account.
- Based on a recent study 'Coupling and analyses of the NH_3 field emission measurements in Flanders and the Netherlands' the emission factors of NH_3 for different manure application techniques on grassland were measured. The results of this project were taken into account during this submission in the model of N_2O (N_2O direct and N_2O indirect) used in the Flemish region.

6.3.2. Planned improvements

- Since September 2003 there is an obligation in the Flemish region for all new stables of poultry and pigs to be build in an emission poor way. The results of this action will be taken into account from 2005 on.
- In the Flemish region a study has been carried out to calculate the NH_3-, N_2O- and the CH_4-emissions from outdoor manure storage. The results of this study will be taken into account from 2005 on.
- In the current of 2007 there will be a revision of the model used to calculate the emissions of NH_3. A special attention will go to taken into account the emissions from manure processing, a revision of the emission factors of NH_3 and the N-excretion factors and inventorying fertilizer type and application. The results of this study will also have an impact on the emissions of N_2O.

CHAPTER 7: LAND-USE CHANGE AND FORESTRY

7.1. Overview

Belgium has a temperate maritime climate, with moderate temperature variability, prevailing westerly winds, heavy cloud cover and regular rain.

Belgium decides to adopt the following forest definition for use in accounting for its activities under the Convention, and Article 3.3 and 3.4 of the Kyoto Protocol:

- Minimum tree crown cover: 20 %
- Minimum land area : 0.5 ha
- Minimum height at maturity: 5 m

These choices allow to use the result of the actual and projected regional forest inventories (Wallonia and Flanders) to calculate the C stock of different pools (biomass, dead organic matters and mineral soil). This definition is fully consistent with the official FAO definition and is already reported in the 2005 Forest Resource Assessment (FRA 2005).

The distribution of forests in Belgium is shown in table 7.1. The total productive forest area in Flanders amounted to 144700 ha in 2000, based on the regional forest mapping (Van de Walle *et al*, 2005), while Walloon forests covered 458700 ha (Perrin *et al.*, 2000). Moreover, the non-productive areas as open spaces, roads, rivers etc. in the Flemish and Walloon forests were also excluded from the analysis.

Considering the very small forest area in the Brussels region (0,3 % of the total forested area), no inventory of the emissions has been conducted so far.

Regions	**Total area**	**Forest area**	**Forest cover**	**% of the total**
	(km2)	**(km2)**	**(%)**	**Belgian forest area**
Wallonia	16845	4587	27,2%	75,8%
Flanders	13521	1447	10,7%	23,9%
Brussels Capital	162	20	12,3%	0,3%
Belgium	**30366**	**6054**	**19.9%**	**100,0%**

Table 7-1: Forest cover in Belgium (source: National Institute of Statistics and regional forest inventories, Year 2000)

7.2. Methodological issues

7.2.1 Changes in Forest and Other Woody Biomass Stocks

A. Above and below ground biomass in forest

Forest inventories were conducted both in the Flemish and the Walloon regions using similar sampling techniques. The inventories are drawn up by sampling to determine the surfaces by categories of property (Private or Public: State, Province, Community), type of forest, species, age, size and quality. The sampling points of the regional forest inventories were selected according to a 1.0 km x 0.5 km grid oriented from the east to the west on the National Geographic Institute (NGI) maps at a scale of 1/25000. The rectangular grid had the advantage of going against the orientation of the relief elements oriented along a southwest – northwest axis and against ecological and geological gradients predominant in the N-S orientation. Each grid intersection, located in a forest, represented the centre of a sampling plot. For plots at edges or borders, the plot centre was moved towards the inside of the plantation. The overall impact of changing the plot centre don't conduct to any systematic bias (still a random procedure (Lecomte & Rondeux, 1994; AB&G, 2001).

Sampling plots are circular and of 10 are each. The following information was collected : category of property (private or public : state, region or province), municipality, forest type, stand structure and development stage, commercial quality for broadleaf species with a section exceeding 22 cm circumference, evidence of damage caused by game and the health and condition for harvest (these two last categories are only available for the Walloon forests) (see Figure 7.1.). Topography (exposition and slope), soil texture and drainage class, age (class), canopy closure, tree species, circumference at 1.5 m and total and dominant heights were also collected. Basic information in the Flemish and the Walloon inventories was therefore very similar. Moreover, the same cubage tables were applied to calculate the total solid wood (TSW) volume from tree circumference and tree height. The terminology 'total solid wood' refers to the combination of stem and branches with a circumference exceeding 22 cm (Dagnelie et al., 1999).

The first Walloon forest inventory was completed in 1984. The current permanent systematic sampling started in 1994 and covers each year 10 % of the approximately 11000 sampling points (Lecomte & Rondeux, 1994). In 2000, 50 % of the sample points of the second inventory were measured. In Flanders, 2665 plots were sampled in the framework of the first forest inventory, which was constituted in the period 1997-1999 (AB&G, 2001). This regional inventory is intended to be repeated every 10 years, to allow e.g. the calculation of growth rates in the Flemish forests.

With more than 13000 plots over a territory of 30528 km2, forest inventories in Belgium have one of the highest sampling rates in Europe. Compared to other countries or regions, the Belgian sampling grid, with each sampling point representing 50 ha of forest, is very dense (Laitat et al., 2000). In comparison, one plot represents 2400 ha of forest land in the U.S. (Brown, 2002).

Based on the information of the regional forest inventories, the total solid wood volumes (TSW) of each species, spread over three age classes, were calculated for Flanders and Wallonia, as given in table 7.2. Values for Belgium were calculated by summing up the Flemish and Walloon forest areas and wood volumes.

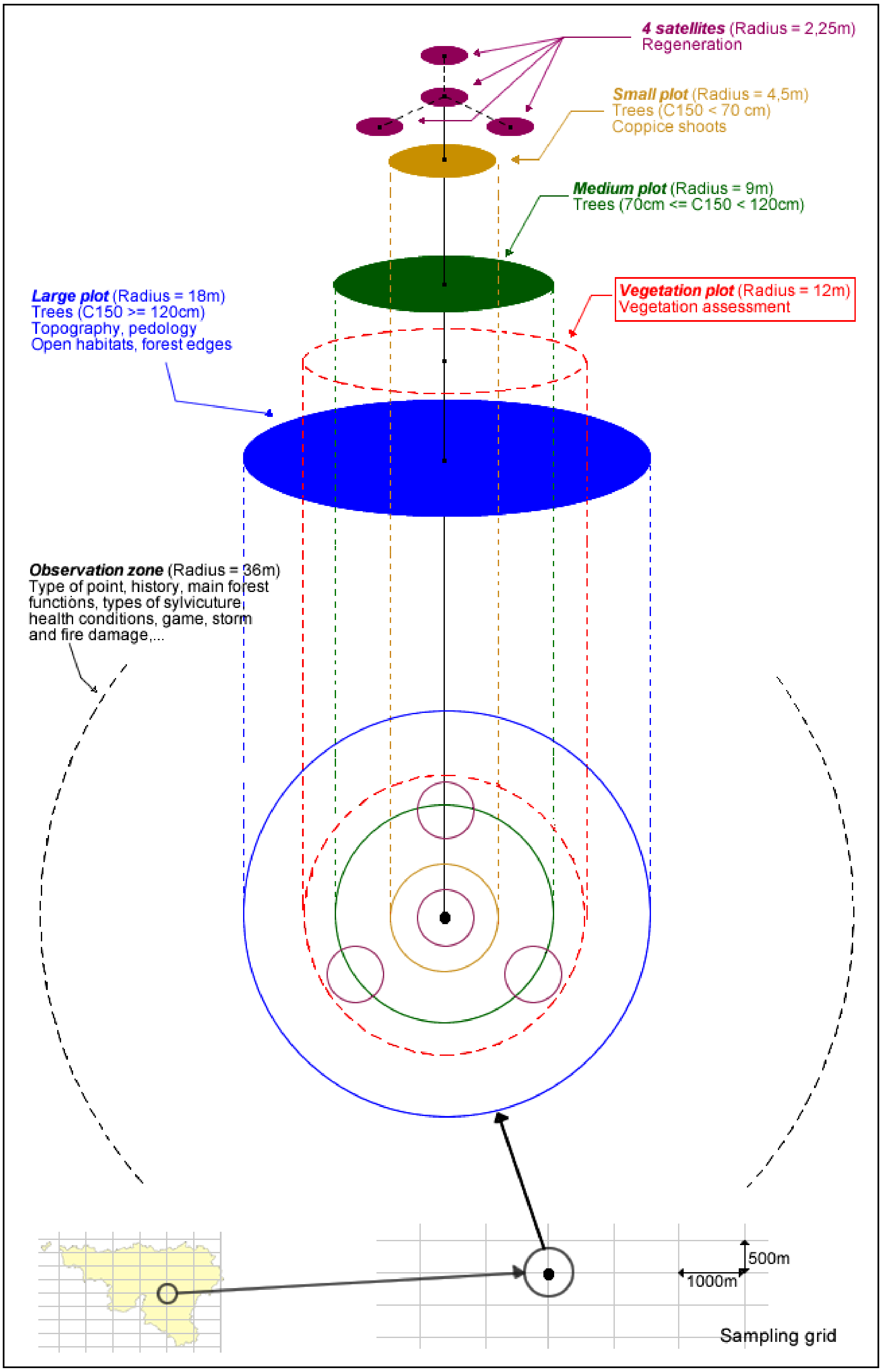


Figure 7.1. : schema of a sampling unit and data collected (Rondeux *et al*, 2005)

Species	Wallonia	Flanders	TOTAL
Picea abies (Norway Spruce)	52,5	0,5	**53,0**
Quercus petraea et Q. robur (Oaks)	25,2	3,6	**28,9**
Fagus silvatica (Beech)	16,3	2,4	**18,7**
Pinus silvestris (Scots Pine)	2,9	8,6	**11,5**
Populus sp (Poplars)	2,8	5,1	**7,9**
Betula sp (Birch)	3,4	1,4	**4,8**
Pinus laricio (Corsican Pine)	0,4	3,9	**4,4**
Fraxinus excelsior (Ash)	3,6	0,4	**4,0**
Larix sp (Larch)	2,6	0,8	**3,4**
Pseudotsuga menziesii (Douglas fir)	2,9	0,4	**3,3**
Other species	13,0	4,5	**17,6**
Total	125,7	31,7	**157,4**

Table 7.2 : volume per specie in the forest inventories (TSW in Mm^3)

The calculation of the amount of carbon stored in the biomass of trees is usually based on biomass expansion factors s.l We converted solid wood volumes into carbon. For each dominant species, we transformed: volumes of solid wood in total dry mass multiplying by the infra-densities (WD); solid wood total dry mass in total above-ground dry biomass (biomass expansion factor 1 or BEF 1); above-ground dry biomass in total dry biomass (roots included, biomass expansion factor 2 or BEF2) and total dry biomass in carbon quantities (carbon content or CC). Some explicit conditions were applied for the selection of biomass expansion factors s.l. from the literature. For the expansion factors s.s., foliage had to be included, in accordance with the IPCC-methodology (IPCC, 2003). The analysis was limited to data reported for Austria, Belgium, Denmark, France, Germany, Great Britain, Ireland and The Netherlands. Values were selected for ‘coniferous’ and ‘deciduous’ species separately, but also for the most important tree species in the Belgian forests: pines (Pinus sp.), Douglas fir (Pseudotsuga menziesii (Mirb.) Franco), larches (Larix sp.), Norway spruce (Picea abies (L.) Karst.), beech (Fagus sylvatica L.), oaks (Quercus robur L. and Q. petraea L.), mixed ‘noble’ species (including maple (Acer pseudoplatanus L.), elms (Ulmus sp.), ash (Fraxinus excelsior L.) and red oak (Quercus rubra L.)) and poplars (Populus sp.). We established the frequency distribution of the values used in neighboring countries and selected the median (see Vandewalle et al, 2005). The selected factors are shown in table 7.3.

Species	Wood density (t.m^{-3})				Carbon content (t.t^{-1})			
	Min	Max	Med	#	Min	Max	Med	#
Spruce	0.34	0.45	0.38	15	0.40	0.51	0.50	5
Pines	0.39	0.60	0.48	13	0.40	0.55	0.50	9
Douglas fir	0.37	0.54	0.45	7	0.50	0.50	0.50	1
Larch	0.41	0.55	0.47	8	0.40	0.50	0.50	3
Other resinous	0.35	0.50	0.40	20	0.40	0.50	0.50	7
Beech	0.55	0.72	0.56	11	0.44	0.51	0.49	10
Oaks	0.50	0.72	0.60	9	0.45	0.50	0.50	3
« Nobles » species	0.52	0.69	0.59	9	0.50	0.50	0.50	1
Poplars	0.34	0.55	0.41	48	0.50	0.50	0.50	1
Other deciduous	0.38	0.77	0.55	34	0.45	0.50	0.50	6
Species	BEF 1 : Total aboveground biomass / Solid wood mass (t.t^{-1})				BEF 2 : Total below ground biomass / total above ground biomass (t.t^{-1})			
	Min	Max	Med	#	Min	Max	Med	#
Spruce	1.14	1.71	1.29	9	0.2	0.2	0.2	
Pines	1.14	1.40	1.32	5	0.16	0.16	0.16	1
Douglas fir	1.18	2.24	1.28	10	0.17	0.17	0.17	1
Larch	1.14	1.36	1.30	3	0.2	0.2	0.2	
Other resinous	1.14	1.71	1.33	5	0.18	0.25	0.20	3
Beech	1.16	2.04	1.34	9	0.23	0.25	0.24	2
Oaks	1.24	1.39	1.32	2	0.2	0.2	0.2	
« Nobles » species	1.29	1.29	1.29	1	0.2	0.2	0.2	
Poplars	1.4	1.4	1.4		0.2	0.2	0.2	
Other deciduous	1.24	1.40	1.32	2	0.20	0.22	0.21	2

Table 7-3 : Conversion factors used to derive forest inventory data for deciduous and coniferous forests in Belgium (METAGE report, 2006)

The geographic distribution of the biomass organic carbon (BOC) stock in Belgian forests in 2000 is shown in Figure 7.2. The high BOC stocks of the broadleaf forest on loam soils in central Belgium are visible, as well as in the Walloon Ardennes. The low BOC stocks on the sand soils of Kempen, Sand Region and the coast region are visible as well.

Figure 7-3 gives the evolution of biomass carbon stock (BOC). For then 1990-2000 simulation, a working hypothesis of a linear trend in forest areas and overall biomass increase was made. A distinction was made between the main deciduous and coniferous species for estimating the annual wood growth. The annual wood harvest is estimated through a comparison of the estimated annual increase of the carbon stock (based on the annual wood growth) with the effective annual carbon stock variation observed in the inventories.

For the 2001-2003 period, a model simulating the evolution of the forest biomass, called EFOBEL which stands for 'Evolutions de la FOrêt BELge' (Trends for Belgian Forest in English) was used (Laitat et al, 2005). EFOBEL is a dynamic .xls spreadsheet using 20 tables. The complete description is done in Perrin (2005). The inputs of the model refer to every grid cells of the Belgian Forest Inventories as published for the year 2000: the solid wood volume and the area of the stands, by species and by age classes. The parameters are the annual growth increment for each species, the revolution, the period between harvest and replanting (also called latency), and the percentage replacement of one species by another according policy rules under implementation by the respective forest administrations. The prediction of BOC result from various scenarios. The most probable scenario is the continuation of the current forestry practices in a scenario "Sylviculture has usual".The parameters relating to such a scenario are obtained either by the inventories themselves, or by literature searches in reference works.

A comparison between the annual wood harvest calculates with the model EFOBEL and the result of forest statistic confirm the accuracy of the methodology.

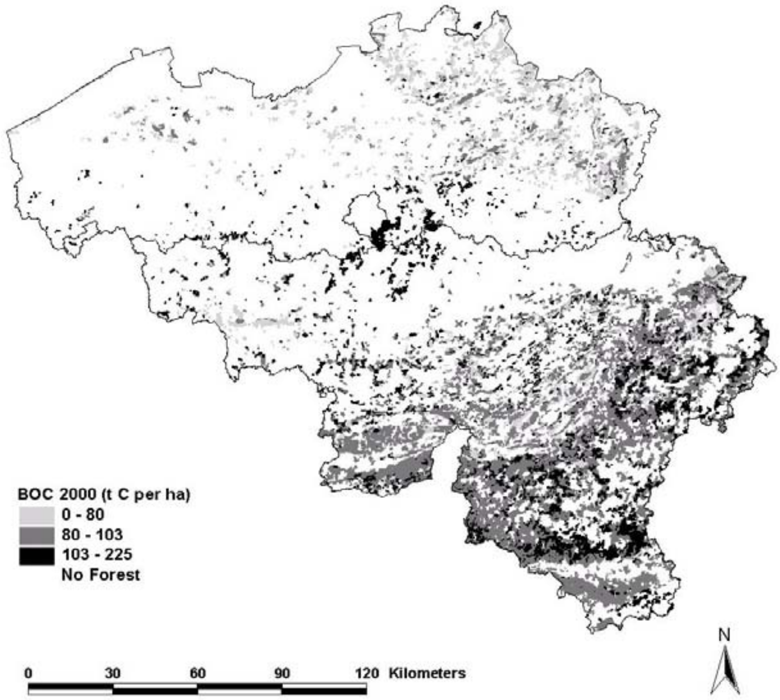


Figure 7.2. Biomass organic carbon (BOC) stock (t C ha-1) in forest in 2000 (Lettens et al, 2003)

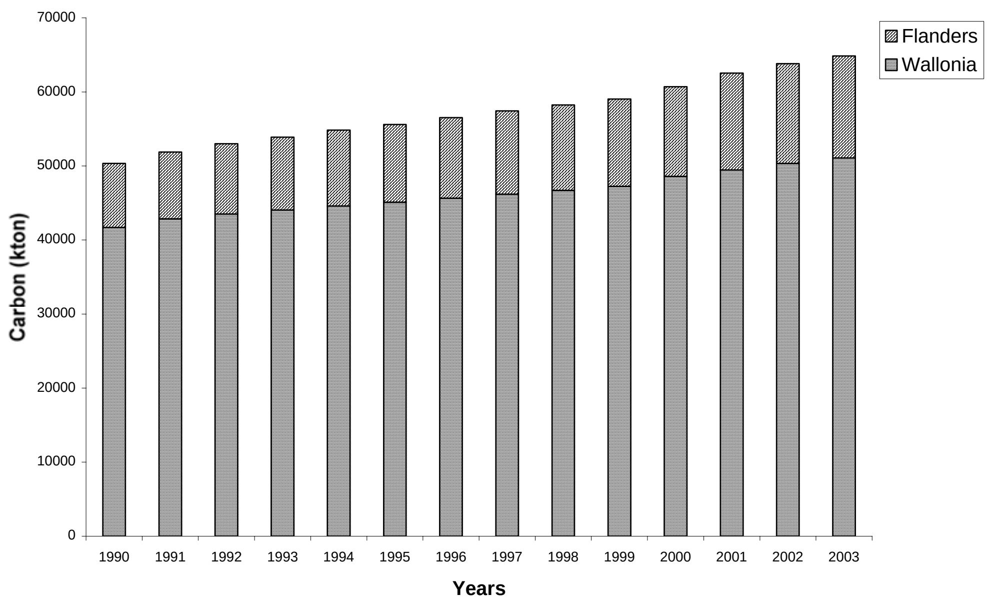


Figure 7.3 : evolution of biomass carbon stock in belgian forest (Perrin 2005)

Belgium use two different methodologies : a linear interpolation for the 1990-2000 period and a mechanistic model for the 2001-2004 period. A significant overestimation of carbon sink in biomass are observed during 2001, 2002 and 2003, due to a underestimation of real harvest (link to the model assumption). After 2003, the model shows a stabilisation of the annual carbon net removals (1300 - 1500 Gg CO2 per year). Belgian will improve the time-series consistency, using the result of a scientific study (Agricultural University of Gembloux) and the actualization of the forest inventories and wood harvest statistics.

The table 7.4. represents the confidence interval (cl 95%) associated with the volume estimation. We combine the error due to the measurement techniques (diameter, height, number of trees per plot) and the error linked to the surface and volume estimation for the whole region (error dependent on the sampling plot number per species).

		Wallonia	Flanders
Spruce	Picea excelsa	2,20%	15,10%
Douglas fir	Pseudotsuga menziesii	13,20%	14,40%
Larches	Larix sp,	9,50%	15%
Pines	Pinus sp	6,80%	6,50%
Other resinous		7,50%	20,20%
Beech	Fagus sylvatica	4,70%	12%
Oaks	Quecus robur and Q. petraea	3%	12,40%
"Noble" broadleaves		4,20%	11,10%
Other broadleaves		5,20%	2,20%
Poplars		17,10%	11,70%

Table 7.4. confidence interval associated with the volume estimation per species (2000 forest inventories)

Solid stem wood volume was converted to carbon as described in the figure at the left with conversion factors preferably selected from COSTE21 publications (Table 7.2.).

A frequency distribution was established for the values used in neighbouring countries, assuming a normal distribution of the selected variable. The relative error could be derived from this frequency distribution. Consecutively a Monte Carlo analysis (10000 simulations) was applied to the calculation of the 2000 stock.

According our calculations, the carbon stock in the biomass averages 59.8 Mton in 2000, with a relative confidence interval (CI95%) on the mean of 10.3%.

B. Carbon in deadwood and litter (forest only)

The definition of deadwood applied in the Inventory's methodology is all standing dead trees and fallen logs and branches. A dead tree is considered as fallen when it tilts at a vertical angle equal or superior to 45°. Veteran trees are taken into account in the living trees section.

The objectives of the collection of deadwood information consist in estimating the volume of standing dead trees and fallen logs and branches, contributing to the estimation of the carbon-stock in Wallonia's forests and estimating biodiversity indicators throughout the importance of deadwood.

The collecting method varies according to the type of deadwood.

Entire dead trees (snags) and broken dead trees (candles) are both taken into account by the Inventory. Trees of different sizes are taken into account in each circular plot according to the same rules as for living trees. This means that a standing dead tree is included in a circular plot according to its circumference. Dead trees under 20 cm of circumference are not taken into account (threshold of the inventory).

Fallen logs and branches are taken into account in a circular plot for which the size varies depending on the average circumference (Caverage) of the living stand. If the unit is located in a clear cut, clearing or impenetrable stands for which no stand measurements are performed, downed deadwood is taken into account in the 9m plot. Logs of at least 1 m long and 20 cm circumference are considered by the Inventory and their volume is estimated by volume functions. Crown (logging residue) is also taken into account (as deadwood) if it is 3 years old. Logs and branches inferior to 20 cm circumference are taken into account by the Inventory and their volume is considered by visual estimation.

For the carbon in deadwood pool, the forestry practices evolve according two contradictory tendencies : increased harvest of the residues in the zones without important constraint of biological conservation (ie bio-energy) and more deadwood left in forest in the zones where dominating conservation of the biodiversity (zones Natura 2000, which represent more than 30% of forest area). We assume that the actual stock (1.38 Mt.C) remains constant.

For the carbon in litter pool, the default IPCC factors are used. The C stock in litter pool was estimated about 13.73 Mt.C. Despite the increase of above and below ground biomass, Belgium consider the stability of the C stock (conservative approach).

C. Soil organic carbon in agricultural and forest mineral soils

Methodology

The Belgian territory was divided into landscape units (LSU) by the topological intersection of the 1990 version of the Corine Land Cover (CLC) geo-dataset (European Commission 1993) and the digitized Soil Association map of Tavernier et al. (1972). The CLC geo-dataset has been produced by manual digitization of printed LANDSAT-images, taking into account a minimal mapping unit of 25 hectares. The 34 of the 44 possible classes of the original legend that occur in Belgium were aggregated into the 11 broader classes: (i) cropland, (ii) grassland (both permanent and temporary), (iii) broadleaf forest, (iv) coniferous forest, (v) mixed forest, (vi) fallow land, (vii) heath land, (viii) inland marshes, poplar in pasture, rush and reed vegetation, (ix) clay pits, mineral extraction sites and excavated soils, (x) peat bogs, (xi) not specified. The Soil Association map (1:500,000) represents broad zones with similar topsoil texture and drainage conditions in 64 soil associations. The overlay of both geo-datasets resulted in 567 landscape units (LSU), each characterized by one soil association and one land use class, scattered over 101,376 polygons.

Due to the generalised nature of the CLC geo-dataset and the Soil Association map, LSUs are pseudo-homogeneous with respect to soil and land use composition. This is especially true in highly fragmented landscapes, as those present in major parts of Belgium, and is illustrated by the fact that according to CLC, there is 1,782,028 ha of arable and grassland in Belgium while official net land use statistics show 1,400,300 ha (NIS, 2000). Moreover, a CLC compatible geo-dataset for 1960 and 2000 is not available. Therefore, LSUs derived from CLC-1990 are used for 1960 and 2000 as well. Hence, spatially explicit land use changes between 1960, 1990 and 2000 are not accounted for and no data can be generated on the effect of land use change on SOC stocks as derived from multi-temporal assessments. This assumption of absent land use changes may be fairly realistic with regard to the overall delineation of the LSUs. The total agricultural area for example, increased by less than 3% between 1990 and 2000, as indicated by agricultural statistics (NIS, 1990). However, the increase of within-LSU heterogeneity of land use, e.g. the obvious growth of rural residential areas, mostly at the expense of agricultural land fragments, is disregarded.

The methodology uses the stock change method for estimating CO_2 fluxes from the LSUs i.e. soil organic carbon (SOC) stocks of different years are compared. It is assumed that the per-LSU and total CO_2 flux is equal to the observed change in SOC stock in CO_2 equivalents over a certain time span and that the per-LSU-fluxes can be aggregated to yield total fluxes at regional or national levels. SOC stocks for LSUs are computed for the years 1960, 1990 and 2000. The SOC estimations are based on a number of heterogeneous databases and modelling efforts. Three cases can be distinguished when computing per-LSU SOC values.

When elementary point measurements are available, they are attributed to the LSU in a process called matching (Van Orshoven et al., 1993). Through matching, points are attributed to the LSU either based upon their location within the boundaries of the LSU ("geomatching") or based upon corresponding soil and land use characteristics as the LSU ("class matching"). Class matching may be completely independent of the point's location. In our approach class matching was restrained by a stratification by soil association.

With regard to agriculture, a number of data sources provide an average SOC-percentage per municipality or other type of administrative unit. These data can be considered to be indirectly geo-referenced to the administrative units, functioning as alternative LSUs (further termed ALSU) that do not correspond spatially with the LSUs to which we want to attribute the data. Therefore, the measurements are first disaggregated to the intersection of the ALSU and the LSU and then re-aggregated to the LSU.

For LSUs for which no measurements are available, the stocks can be estimated using a mechanistic model (YASSO for forest soils, ROTH C for agricultural soils). This has been done for the 1990-stocks of forested LSUs.

Result

Due to the absence of forests in the 1990 assessment, the SOC content of only 130 agricultural LSU can be compared between the years 1990 and 2000 by means of a pair-wise comparison. The SOC stock in the 0-20 cm layer of 87 LSUs (74% of the total agricultural area) decreased between 1990 and 2000. For 25 (48% of the total agricultural area) of these LSU, the decrease is significant at the 95% confidence level. Those LSUs are mostly under cropland and all of them occur in northern or central Belgium. Most of the remaining 43 LSUs (26%) with increased SOC content are situated in southern or central Belgium. Also the 1 LSU (3%) that shows a significant increase of SOC content is located in southern Belgium.

On average, the SOC content of both the land use type grassland and cropland decreased significantly between 1990 and 2000. Grassland SOC decreased from 64 t C ha^{-1} in 1990 to 60 t C ha^{-1} in 2000 (0-20 cm). Cropland soils stored 38 t C ha^{-1}in 1990 and 36 t C ha^{-1} in 2000. If only the soil associations are considered, 39 of the 65 associations have lost SOC between 1990 and 2000. They are situated in the coastal zone and in northern and central Belgium. The 16 associations with a significant decrease in SOC are restricted to northern and central Belgium. The 4 associations with a significant increase in SOC are all situated in southern Belgium.

Finally, the total SOC stock in agricultural land was compared between 1990 and 2000. In 1990 this stock amounted to 178 Mt C in the upper 100 cm and for 2000 it decreased to 169 Mt C. This decrease is significant at the 95% confidence level (Figure 7.4.).

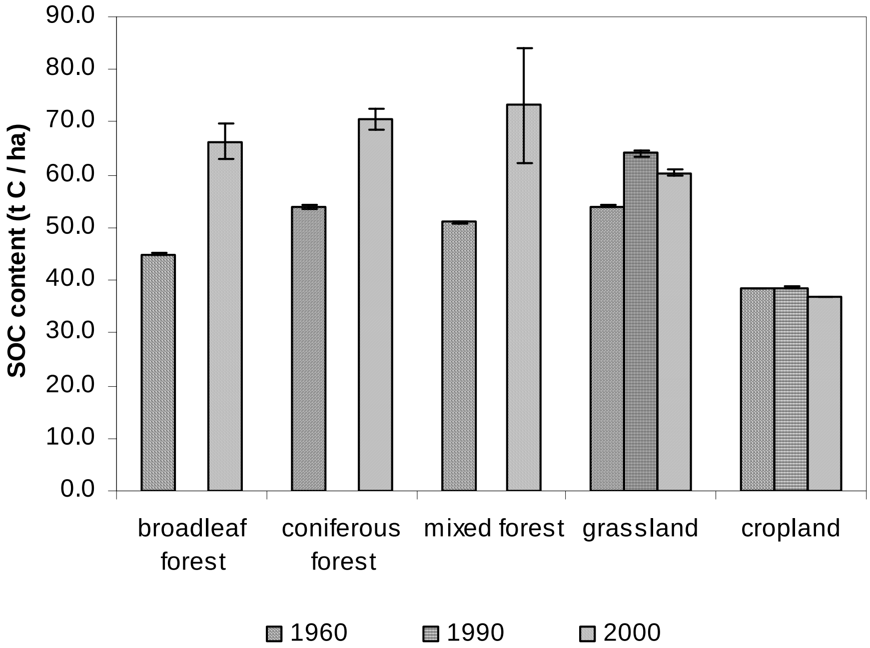


Figure 7.4. : Average SOC content and 95% confidence intervals (t C ha-1) for 0-20 cm for the land use types broadleaf forest, coniferous forest, mixed forest, grassland and cropland for 1960, 1990 and 2000 (Lettens et al, 2003)

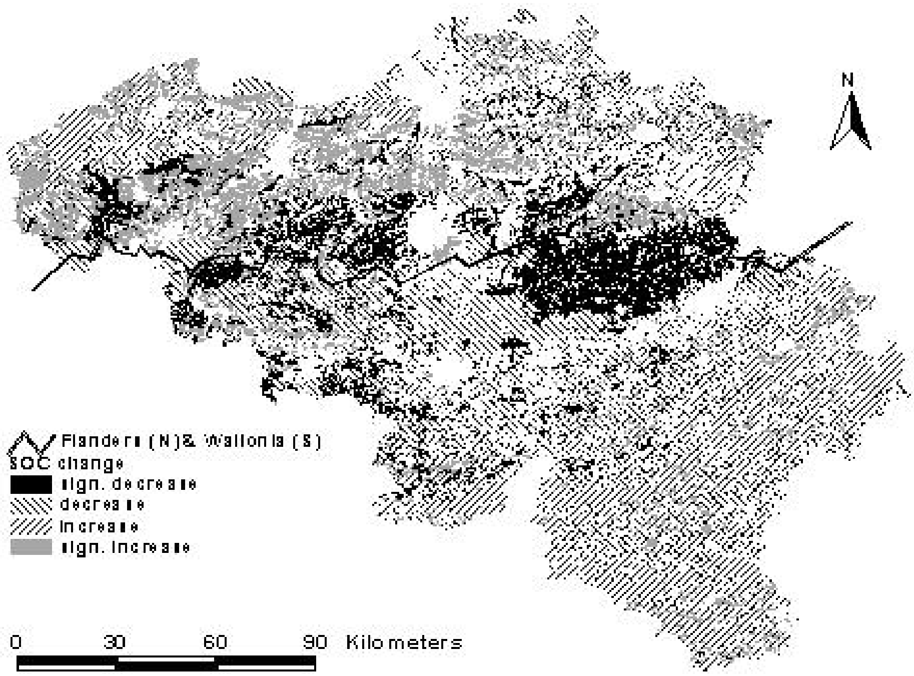


Figure 7.5 : SOC change of landscape units in Belgium between 1960 and 2000 in the upper 20 cm of mineral soil. Hatched areas represent non-significant changes (Lettens et al, 2003)

7.2.2 Land-use change

Agricultural land occupies the largest part of the national territory (Table 7.5). Its total area has declined since 1990 (-4.7%), while built-up areas grew nearly 18% during the same period. Forests occupy nearly 20% of the national territory, down slightly from 1990 (-0.6%). For the time being, Belgian considered a negligible impact of land-use changes on carbon stock.

Land-use	% total area	Evolution 1990-2005
Total agricultural land (1)	57,1%	-4,7%
Forest and woodlands	19,9%	-0,6%
Built-up and related areas (2)	19,2%	17,8%
Miscellaneous (3)	3,0%	1,4%
Water (4)	0,8%	0,0%

(1) including idle land

(2) except for scattered farm buildings

(3) fens, heaths, marshes, waste ground, rocks, beaches, dunes

(4) OECD estimate

Source: I.N.S. and Ministry of Finance (land register). I.N.S. calculations based on OECD / Eurostat definitions

Table 7.5. Land use – relative figures (% of total surface area, 2005) and evolution (1990-2005)

7.3. Recalculations and planned improvement

7.3.1. Recalculations

Since the previous submission, all categories of the land-use change and forestry are covered in the Belgian greenhouse gas inventory.

7.3.2. Planned improvements

Regarding the category "forest land remaining forest land", Belgian will improve the time-series consistency when the update of the forest inventory will be available.

CHAPTER 8: WASTE

8.1. Overview

8.1.1. Description of the sector

The production of waste arising from the residential sector and from commercial activities (‘municipal waste’) amounted to 535 kg per inhabitant in 1999, 52% of which was not recycled. Manufacturing industry is the largest source of waste (13.8 Mt). The three regions have implemented waste management plans.
The objectives and actions of the Flemish region for waste are defined in the report *MiNa [Flemish Environmental Policy Plan 2003-2007]*. For further information the website www.ovam.be of the institute responsible for waste management in Flanders (OVAM) can be consulted.
The *Wallonia waste plan ‘Horizon 2010’*, adopted in 1998, contains a series of 70 actions targeted on the prevention, the recycling and the recovery of energy, and the elimination of waste. The *Waste Prevention and Management Plan in Brussels-Capital Region 2003-2007* also subscribes to this double strategy of waste prevention and recovery.

In addition, a body (FOST Plus) has been created by the private sector to finance, co-ordinate and promote the selective collection, the sorting and recycling of household packaging waste. FOST Plus was created to enable industry to respond in a global and concrete way to the legislation on packaging and, more specifically, to the introduction of European Directive 94/62/EC of 20/12/1994, and the Co-operation Agreement between the Regions of March 1997 relating to the prevention and management of waste from household packaging. The recovery of used materials is becoming a major industry in Belgium and creates plenty of employment. The industries most intensive in manpower are textile recycling, the recycling of paper and of construction materials.

8.1.2.Allocation of emissions

The waste emission inventory in Belgium covers categories 6.A, 6.B, 6.C and 6.D.

Category 6.A.1.contains the emissions of CH_4 originating from the solid waste disposal sites in Belgium. No waste disposal sites are located in the Brussels region in Belgium.

Emissions originating from the treatment of industrial wastewater (category 6.B.1) are not estimated because a lack of data. Only emissions from the treatment of domestic wastewater are calculated for the time being (category 6.B.2).

CH_4 emissions from the production of compost are put under category 6.D Waste/Other.

The waste incineration category (category 6.C) includes incineration of municipal and industrial waste, incineration of hospital waste and the incineration of corpses. Emissions originating from flaring activities are allocated partly to the sectors 1.B.2.c (refineries) and 2.B.5. (Flemish region, see section 4.2.2.3 for further information) and partly to the sector 6.C (Walloon region).

In Brussels only category 6.B (municipal wastewater treatment plant since half 2000) and 6.C (waste incineration) are relevant in this waste section. The municipal waste incineration occurs with energy recuperation and is allocated under 1.A.1.

8.2. Methodological issues

8.2.1. Solid waste disposal on land

The methodology used to calculate the emissions from solid waste disposal on land differs between the 2 regions in Belgium where these sites are located (Flanders and Wallonia).

Flemish region

CH_4 emissions from solid waste disposal on Land (category 6.A.1) were studied by the Vito [1] in 1994 [8]. The data available for Flanders are specific and accurate, what allows a more refined methodology than the one proposed in the IPCC Guidelines.
Since 1994 waste policies in Flanders (cfr. Ladder of Lansinck which prefers waste burning over waste dumping) have made some results. The amount of waste of households dumped decreased since 1994 and from 1998 on, more waste is burned than dumped. A real moratorium in dumping organic waste is set up since 2000.
In the Flemish region a combination of 2 models is used: a multiphase model for the estimation of emissions of the sites which are permitted and a first order decay model for all other, old waste disposal sites which are no longer permitted to dispose but where still emissions occur after the ban of disposal on these sites (these are the solid waste disposal sites in after-care).
In the course of 2005 all data used in the models and originating from the OVAM (public waste agency in the Flemish region) are checked with the responsible people of OVAM and optimized if necessary.
A short presentation of the 2 models is given below:

1) The first order decay model takes into account residential and industrial waste. Data for these sites are available from 1981 on. It has been assumed that the ratio of waste land filled to waste produced in the period 1970 to 1980 is the same as for the year 1981. An assumption is made that the waste decomposes during a period of 25 years. With respect to the waste composition a biodegradable fraction of 18% is assumed, conform to studies carried out in the Netherlands [46]. In an other study conducted in the Netherlands [47] methane emissions at 3 land fills sites have been measured and a mean degradation coefficient of k of 0,1/year calculated. An active lifetime is assumed of 25 years for the Flemish landfills, including an aerobic period of 1 year and an anaerobic period of 24 years. The formula used to calculate the emissions of methane in solid waste disposal sites is:

St = a*Qi*Bo*k*exp-kt (first order kinetic approach of waste gas production S on time t after disposal) based on biodegradation of $C_6H_{10}O_4$

$$C_6H_{10}O_4 + 1.5\ H_2O = 2.75\ CO_2 + 3.25\ CH_4 \text{ (Parken \& Owen, 1986)}$$

With a = conversion 1m^3 waste gas originates from 1 kg organic waste (based on the reaction above)
St = waste gas production on time t after disposal (in m^3)
Qi = the amount of disposed biodegradable waste on time t=0 (in ton)
Bo = the initial concentration of biodegradable material in the disposed waste (in kg/ton)
k = the first order velocity constant of biodegradation (in year-1)

The biogas contains 55% of methane (see reaction of Parken & Owen) and an oxidation of methane of 10% in the upper layer is assumed.

2) The multiphase model treats 15 solid waste disposal sites (category II) which are permitted in Flanders and contains mainly domestic waste. This domestic waste is divided into residential, rough and urban waste. Because a different interpretation of different local authorities, urban waste is supposed to be similar to domestic waste.
This model uses velocities of gas production that are more accurate compared to first order models. The model assumes that the gas production starts 1 year after disposal and goes immediately to a maximum.
The following biodegradation rates are used:

Quick biodegradation: k_1=0.173 (t1/2=4)
Average biodegradation: k_2=0.069 (t1/2=10)
Slow biodegradation : k_3 = 0.023 (t1/2 = 30)

The amounts of organic matter for different kinds of waste categories originates from literature.
The biodegradable fractions of rough waste on the solid waste disposal sites are:
paper and carton: 3%
trim wood (from gardening): 10%
wood (construction & demolition, furniture): 20%
textile: 6%

The amount of organic C in each phase of biodegradation rate of domestic waste (dw) and rough waste (rw) are presented in table 8.1.

Biodegradation rate	w_{dw} (…-1990)	w_{dw} (1991-…)	w_{rw}	d	o	c
quick	0.44	0.49	0.00	0.44	0.51	0.45
average	0.24	0.17	0.13	0.70	0.85	0.45
slow	0.09	0.10	0.26	0.77	0.73	0.45

Tabel 8.1: Characteristics for the determination of the fraction of organic carbon in each phase of biodegradation rate of domestic waste (dw) and rough waste (rw).

The calculation of organic carbon in the category II industrial waste uses other w-values. Following characteristics could be defined:
Process waste: 36%
Non-process waste: 36%
Recycled residues: 3%
Sludge: 9%
Medical waste: 1%
Inert rest: 15%

Biodegradation rate	c_{iw}	w_{iw}
quick	$c_{0,1}$ = 49 kg/ton	0.52
average	$c_{0,2}$ = 8 kg/ton	0.03
slow	$c_{0,3}$ = 18 kg/ton	0.05

Tabel 8.2: Characteristics for the determination of the fraction of organic carbon in each phase of biodegradation rate of industrial waste (iw)

The fraction of biodegradable material is assumed to be 77%.

The biogas contains 50% of methane and an oxidation of methane of 10% in the upper layer is assumed.

The production of waste gas Q_g in the year t (in m^3/year) is calculated as:

$$Q_g = \zeta\, a \left[\sum_{j=0}^{m} \sum_{i=1}^{n} A_j\ k_i\ C_{o,i,j}\ e^{-k_i(t-j)}\right]_{domesticwaste} + \zeta\, a \left[\sum_{j=0}^{m} \sum_{i=1}^{n} A_j\ k_i\ C_{o,i,j}\ e^{-k_i(t-j)}\right]_{roughwaste}$$

$$+ \quad \zeta\, a \left[\sum_{j=0}^{m} \sum_{i=1}^{n} A_j\ k_i\ C_{o,i,j}\ e^{-k_i(t-j)}\right]_{industry}$$

with a the factor to transfer the amount of carbon to the amount of waste gas (1,87 m^3/kg C)
with A_j the amount of waste disposed in year i (in ton/year)
with the biodegradation rate k_i of each phase of biodegradation rate (in 1/year) with the total amount of phases = 3 (quick, average and slow)
with $C_{0,i,j}$ the amount of organic carbon in each phase
with ζ a formation factor for the reduction of waste gas in some parts of the disposal site (because of local unfavourable conditions of micro-organisms. This factor corrects for uncertainties such as level of humidity, pH, temperature, … and indicates how much gas is really formed. In practice this factor is assumed to be more or less 0,6.

The **recoverable amount of waste gas Q_r** is determined by the recovering efficiency η:

$$Q_r(t) = \eta\ Q_g(t) \qquad (8)$$

The recovering efficiency η is determined by the ratio of the disposed volume out if which the waste gas is recovered effectively and the total disposed volume and can be improved by an extension of the amount of sources and/or the placement of impenetrable over- or undercovering.

Walloon region

The CO_2 and CH_4 emissions from solid waste disposal on land are calculated with a model that considers separately the emissions of industrial and municipal waste. The model, developed by the Vito [24], acknowledges the fact that methane is emitted over a long period of time. A first order decay model is used to take into account the various factors that influence the rate and extent of methane generation and release from landfill.

The model calculates the biogas emissions using the following relation :

$S_{P,Y} = Q_Y * DOC * k * C* \exp^{(-k * \Delta t)}$

$S_{P,Y}$ = biogas generation rate at year P (m^3)
Q_Y = the quantity of waste disposed year Y (Ton)
DOC = initial degradable organic carbon (kg/Ton)
k = biodegradation rate constant (% / year)
C = % of DOC really degraded (%)
Δt = the time since initial disposal (Y-P) (year)

In order to estimate the current biogas emissions from waste placed in all years, the equation is solved for all values of Q_Y and the results summed. The methane production is then calculated taking into account the biogas composition and an oxidation factor of 10% in the upper layer. The overall methodology follows the Tier 2 IPCC methodology (equation 5.1, IPCC Good Practice Guidance [10]). The constants used for household and industrial waste are presented in the table 8.3.

Constant	Municipal waste	Industrial waste
DOC(x) (in kg C/tonne waste)	180 (before 1986) 170 (1986-1990) 142,9 (1995) 112,5 (2000)	26,8 (1970-1995) 23,6 (2000)
K	10	10
DOCf	77	77

Table 8.3. : Solid waste disposal on land. Constants used in the model in Wallonia. For DOC, linear interpolation is used to estimate the intermediate values.

The model assumes that :

- the waste decompose during 25 years
- there is a aerobic period of 1 year where there is no methane production
- the landfill gas contain 55 % of CH4 and 45 % of CO_2
- there is a CH_4 oxidation in the upper layer (10 %)
- the DOC reduction reflects the increased sorting of municipal waste

The model provides, for each year, estimation for the range of CH_4 and CO_2 production. The biogas CO_2 emissions are not reported in the CRF tables 6.A as it is from biogenic source.

The CH_4 recovered is subtracted from total emissions. This CH_4 is assumed to be completely converted into CO_2 through the combustion process. In previous submissions, this CO_2 emission was included in national totals. The CO_2 produced by the biogas recovery is not reported anymore in the CRF tables 6.A, according to footnote 4 on page 5.10 of the IPCC Good Practice Guidance [10].

CH4 recovery started in 1993 and largely increased since that year, by gradually equipping more and more disposal sites. It is the main driver of the reduction of the net emissions in this sector.

In Wallonia, the quantity of waste disposed comes from the statistics of OWD (Walloon Waste Office). It publishes each year the industrial and municipal waste disposed, based on the taxes declaration forms covering 50 solid waste disposal sites of various sizes. The data are classified according to 12 main categories (119 subcategories), thus allowing an accurate calculation of the amounts of waste and its degradable organic carbon content (IPCC Good Practice Guidance [10] equation 5.4, page 5.9), which are used as an input in the model. Those statistics are available on a yearly basis since 1994. The calculation involves large excel spread sheets which cannot be reproduced in the NIR. For the years before, the amounts have been estimated using available data and OWD expert judgement assumptions. The evolution of the ratio of biogenic waste in the waste incineration sector reflects the implementation of the Wallonia Waste Plan, as the "green waste" are increasingly sorted by the citizens and collected for compost production, thus decreasing the ratio of biogenic waste deposited in solid waste disposal sites.

The DOC value for municipal waste lies in the default value range from IPCC revised 1996 Guidelines and was chosen according to national expert judgement. The value for industrial waste was estimated calculated using the detailed waste types from OWD and the IPCC Good Practice Guidance methodology (equation 5.4, page 5.9). This detailed estimation led to a complete recalculation, as the new estimated DOC were much lower than the default value previously used.

The biodegradation rate constant and the rate of DOC really degraded also come from the revised 1996 IPCC Guidelines and the IPCC Good Practice Guidance [10]. The new default value of 0,5-0,6 for DOCf , proposed in the IPCC Good Practice Guidance if lignin is included in the DOC value, has been tested in the model. It leads to a major problem in the sense that from 2002 and on, the biogas recovery (measured in volume and CH4 fraction, thus appearing to be reliable estimate) becomes larger that the emissions as estimated by the model. Consequently, the former default value of 0,77 has been deemed more suited to the walloon context and kept in the model.

Each year, all the landfills with CH_4 recovery (12 in 2002) are contacted to collect data on the amount and CH_4 content of the biogas recovered (flaring or energy purposes). The CH_4 content is measured by landfill owners as it determines the possible use of the biogas (only "rich" biogas" is used in engines, the rest is flared). Following a 1997 legal decree, a contract with the ISSEP (Scientific Institute for Public Service in Wallonia) also organises a close follow up of the environmental impacts of the Solid Waste Disposal Sites on Air, Water and Health. Seven main sites are followed for the time being and the report includes biogas analysis. Details can be found on the website of DGRNE.

8.2.2. Wastewater treatment

The CO_2 emissions from municipal wastewater treatment plants are not included in the Belgian greenhouse gas inventory in this category of domestic and commercial wastewater handling (category 6.B.2) because the carbon derives from biomass raw materials, In this category, two sources of methane emissions are taken into account, the municipal wastewater treatment plant and the sceptic tanks.

The methodology for the septic tanks is based on an article (Vasel, 1992) [32] which describes the characteristics and parameters of individual septic tanks. The IPCC default value of 0.6 kg CH_4/kg BOD is used. Each habitant produce 60 g BOD/day, whose 60 % eventually settles (IPCC fraction that readily settle). It is considered that only 25 % of the BOD loading is anaerobically degraded (60*0.6*0.25), because the septic tanks are regularly emptied and consequently the sludge is then treated aerobically. The annual emission factor becomes 1,971 kg CH_4/inhab*year (60*60%*25%*0,6gCH4/kg BOD). This is the emission factor used in the Walloon region. In the Flemish region the old factor of 1,5 kg CH_4/inhab*year is still used. The CH_4 emissions are estimated by multiplying these emission factors by the number of inhabitants not connected with a municipal wastewater treatment plant.

In the Walloon region, after discussion with the regional responsible for municipal wastewater treatment plants, it appears that most of the plants are conducted aerobically. Those who use anaerobical digestion of the sludge recover the CH4 for energy purpose. Consequently, no CH4 emissions are accounted in this subcategory.
In the Brussels region, the municipal wastewater treatment plant is conducted aerobically; no CH4 emissions are then estimated for this subcategory.
In the Flemish region the emissions of CH_4 of the municipal waste water treatment plants are estimated by using the methodology as described in the EMEP/CORINAIR guidebook [3]. An emission factor of 0,3 kg/inhabitant*year is used to calculate these emissions.

The N_2O emissions are estimated by using the methodology described in the IPCC Guidelines. The default values for N fraction in protein and N_2O emission factor are 16 % and 0.01 kg N-N_2O / kg protein. The figures of protein consumption originates from the FAO statistics (32,3 kg protein/person in 2005). The population figures comes from the National Institute of Statistics.

8.2.3. Waste incineration

N_2O emissions from domestic waste incineration are calculated using activity data known from the individual companies involved combined with the emission factor of CITEPA [2], which is 60 g N_2O/ton waste. CH_4 emissions are not relevant here, as IPCC Good Practice Guidance [10] states on page 5.23: "Emissions of CH_4 are not likely to be significant because of the combustion conditions in incinerators (e.g. high temperatures and long residence time)".

For CO_2 emissions, each region applies its own methodology according to the available activity data (see below).

The emissions of CO_2 from the flaring in the chemical industry are reported in category 6.C according to the IPCC Guidelines (Walloon region). In the Flemish region the emissions of CO_2 from the flaring activities in the chemical industry are allocated to the category 2.B.5. instead of category 6.C (as described in the IPCC Good Practice Guidance) because these emissions are also included in the surveys which are carried out in this region on a yearly basis by the chemical federation in cooperation with the Vito and because it's difficult to sort these emissions.

Flanders

In Flanders, only the fraction of organic-synthetic waste is taken into consideration (assuming that organic waste does not give any net CO_2 emissions). For the municipal waste, the institute responsible for waste management in Flanders (OVAM) is given the analysis of the different fractions in the waste. Based on this information, the amount of non-biogenic waste (excluding the inert fraction) is determined. The carbon emission factor is based on data from literature for the different fractions involved. For industrial waste, the amount of biogenic waste is considered to be the same as in municipal waste. The remaining amount is considered to be the non-biogenic part in which no inert fraction is present. For industrial waste, it is more difficult to determine the content of C and therefore the results of a study carried out by the Vito 'Debruyn en Van Rensbergen 'Greenhouse gas emissions from municipal and industrial wastes of October 1994' are used. This study gives a content of C of the industrial waste of 65,5 %.

Wallonia

In Wallonia, following a legal decree in 2000, the air emissions from municipal waste incineration are measured by ISSEP and the results are validated by a Steering Committee . These results allow a crosscheck with the results of measurements directly transmitted by the incinerators to the environmental administration. From 1990 to 2000 CO_2 emissions of municipal waste incineration are reported assuming that 68 % of the waste is composed of organic material. This is based on the average garbage composition in Wallonia and the use of IPCC equation on organic content of the various materials. Since 2000, more precise data are reported by the waste incineration plants in the context of their environmental reporting. In 2005, the average organic content is 31 %. These emissions are now reported in the energy sector, according to IPCC guidelines.

There is a distinction between the emission from municipal waste incineration and hospital waste incineration. CO_2 emissions from hospital waste incineration are measured by the Walloon incinerators and are fully reported.

Brussels

The emission factors for the incineration of hospital and municipal waste and corpses are estimated by measurements in situ in connection with EPA and EMEP/CORINAIR emission factors.

8.2.4. Others

CH_4 emissions from compost production are estimated using regional activity data combined with a default emission factor of 2,4 kg CH_4/ton compost. The emission factor of 2,4 kg CH_4/ton compost is used after consultation of our colleagues in the Netherlands who uses this factor as a result of measurements carried out. This monitoring program was carried out in the Netherlands and the Ministry as well as the waste sector were involved. The monitoring was not a random indication of emissions but was carried out over a longer period.

8.3. Recalculations and planned improvements

8.3.1. Recalculations

General

- No main recalculations are carried out in the Belgian greenhouse gas inventory in the waste sector. As with all other sectors a constant actualization of the inventory is performed (mostly in most recent years) from the moment more accurate data become available.
- In the Flemish region an actualization of the multiphase model used to calculate the emissions of the permitted waste disposal sites is done from 1994 on because more accurate information of flaring activities on these sites became available.
- The municipal waste incineration emissions are now in the Walloon region allocated under 1A, Energy, in the categories "other fuels" and "biomass" taking into account the organic content of the waste.
- Some minor corrections for the years 2000 and 2003 have been made in this submission on the activity data of Brussels waste incineration .

8.3.2. Planned improvements

No specific planned improvements are foreseen in the near future in the waste sector.

CHAPTER 9: RECALCULATIONS AND PLANNED IMPROVEMENTS

9.1. Recalculations and achieved improvements

The specific recalculations and methodological improvements achieved since the last submission are presented in the respective chapters of this report.
Most important recalculations (with a major impact on the total emissions) on the Belgian inventory were carried out during the previous submission.
No main recalculations were carried out in the Belgian greenhouse gas inventory during this submission. A constant actualization of all sectors of the inventory is performed (mostly in most recent years) from the moment more accurate data become available. However, no recalculation at all has been or will be applied to the 1990 inventory nor to the emissions of fluorinated gases of 1995 as these emissions have been used for the determination of the Belgian assigned amount under the Kyoto Protocol.

In all regions, the emissions were completely updated for the time series 1990-2004 and provisional emissions are calculated for 2005.
On the technical side, all the national sectoral tables have been fulfilled in this submission.

The results of the draft centralized review report of the 2005 greenhouse gas inventory submission of Belgium are taken into account as much as possible in the Belgian submission.

9.2. Implication on emission levels and trends

No major implications on emission levels and trends of greenhouse gases in Belgium took place during this submission.

9.3. Planned improvements

- As explained in section 1.5, independent audits are realised in the 3 regions in Belgium. However, some identified gaps, such as the lack of human resources, have not been adjusted so far, despite the signals sent by the inventory agencies.
- A working group has been established in order to improve the consistency of the energy balances available at different levels (regional, national, Eurostat). Some main gaps have already been identified and solved but because their correction requires changes in the data collection system at different levels more time is needed to implement the results of this project. This long-term work is still ongoing (see also section 3.3).
- The efficiency of the institutional arrangements for the preparation of the inventory still has to be improved. Given various changes in the personal involved in the inventory preparation, some adaptations of the NIS are foreseen and will be discussed by the end of this year.

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Note : Some National Inventory Reports from other Annex I Parties are referenced in this report. All these are downloaded on www.unfccc.int.

ANNEXES

Annex 1 : Key sources analysis

Level assessment

IPCC Source Categories[a]	Direct Greenhouse Gas	Sector	Base Year Estimate (1990)	Current Year Estimate (2005)	Level Assessment (2005)	Cumulative Total
			(Gg CO_2 eq.)			
1.A.3.b. Road Transportation	CO2	energy	19270	24928	17,3%	17,3%
1.A.1.a. Public Electricity and Heat Production	CO2	energy	23420	24624	17,1%	34,4%
1.A.4.b. Residential	CO2	energy	20213	22166	15,4%	49,9%
1.A.2.a. Iron and Steel	CO2	energy	14213	9470	6,6%	56,4%
1.A.2.c. Chemicals	CO2	energy	6311	7781	5,4%	61,8%
1.A.2.f. Other (Manufacturing Industries and Construction)	CO2	energy	8069	7158	5,0%	66,8%
1.A.4.a. Commercial/Institutional	CO2	energy	4272	5958	4,1%	71,0%
1.A.1.b. Petroleum Refining	CO2	energy	4299	4656	3,2%	74,2%
4.A.1. Cattle	CH4	agriculture	4301	3606	2,5%	76,7%
2.B.2. Nitric Acid Production	N2O	industrial processes	3562	3066	2,1%	78,8%
2.A.1. Cement Production	CO2	industrial processes	2824	2934	2,0%	80,9%
1.A.4.c. Agriculture/Forestry/Fisheries	CO2	energy	2730	2394	1,7%	82,5%
4.D.1. Direct Soil Emissions	N2O	agriculture	2471	2198	1,5%	84,1%
1.A.2.e. Food Processing, Beverages and Tobacco	CO2	energy	2998	2190	1,5%	85,6%
2.A.2. Lime Production	CO2	industrial processes	2097	2018	1,4%	87,0%
2.C.1. Iron and Steel Production	CO2	industrial processes	1946	1535	1,1%	88,1%
4.B.8. Swine	CH4	agriculture	1432	1347	0,9%	89,0%
2.B.1. Ammonia Production	CO2	industrial processes	694	1330	0,9%	89,9%
2.F.1. Refrigeration and Air Conditioning Equipment	HFCs	industrial processes	74	1190	0,8%	90,8%
4.D.3. Indirect Emissions	N2O	agriculture	1184	929	0,6%	91,4%
4.B.1. Cattle	CH4	agriculture	1131	913	0,6%	92,0%
2.B.5. Other (Chemical Industry)	CO2	industrial processes	224	911	0,6%	92,7%
1A.3. Transport	N2O	energy	352	837	0,6%	93,3%
6.A.1. Managed Waste Disposal on Land	CH4	waste	2630	823	0,6%	93,8%
4.D.2. Animal Production (2)	N2O	agriculture	941	807	0,6%	94,4%
1A.4. Other Sectors	N2O	energy	789	793	0,6%	94,9%
4.B.12. Solid Storage and Dry Lot	N2O	agriculture	897	792	0,6%	95,5%
1.A.2.d. Pulp, Paper and Print	CO2	energy	637	605	0,4%	95,9%
2.A.7. Other (Mineral Products)	CO2	industrial processes	414	500	0,3%	96,3%
1.A.2.b. Non-Ferrous Metals	CO2	energy	624	478	0,3%	96,6%
1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	CO2	energy	2144	429	0,3%	96,9%
1.B.2.b. Natural Gas	CH4	energy	519	389	0,3%	97,2%
2.B.5. Other (production of caprolactam)	N2O	industrial processes	372	344	0,2%	97,4%
1.A.3.d. Navigation	CO2	energy	267	334	0,2%	97,6%
2.G. Other (industrial processes)	CO2	industrial processes	416	318	0,2%	97,8%
4.B. Wastewater Handling	N2O	waste	270	272	0,2%	98,0%
3.D. Other (Use of N2O for Anaesthesia)	N2O	solvent	246	249	0,2%	98,2%
1A.2. Manufacturing Industries and Construction	N2O	energy	388	237	0,2%	98,4%
1A.1. Energy Industries	N2O	energy	209	218	0,2%	98,5%
4.A.8. Swine	CH4	agriculture	211	199	0,1%	98,7%
2.F.4. Aerosols/ Metered Dose Inhalers	HFCs	industrial processes	35	151	0,1%	98,8%
1.B.2.c. Venting and Flaring (Fugitive Emissions from Fuels)	CO2	energy	84	145	0,1%	98,9%
2.E. Production of Halocarbons and SF6	PFCs	industrial processes	1753	141	0,1%	99,0%
1.A.3.e. Other Transportation	CO2	energy	196	131	0,1%	99,1%
1.A.3.c. Railways	CO2	energy	202	115	0,1%	99,1%
6.C. Waste Incineration	CO2	waste	337	115	0,1%	99,2%
4.B.9. Poultry	CH4	agriculture	104	106	0,1%	99,3%
2.F.2. Foam Blowing	HFCs	industrial processes	324	101	0,1%	99,4%
1.A.5. Other (Fuel Combustion)	CO2	energy	166	95	0,1%	99,4%
1.A.4. Other Sectors	CH4	energy	129	90	0,1%	99,5%
Total			143393	143118	99,5%	
[a] LUCF is not included in this analysis						

Trend assessment

IPCC Source Categories[a]	Direct Greenhouse Gas	Sector	Base Year Estimate (1990)	Current Year Estimate (2005)	Trend Assessment	Contribution to Trend	Cumulative Total
			(Gg CO_2 eq.)				
1.A.3.b. Road Transportation	CO2	energy	19270	24928	0,042	17,5%	17,5%
1.A.2.a. Iron and Steel	CO2	energy	14213	9470	0,032	13,5%	31,1%
1.A.4.b. Residential	CO2	energy	20213	22166	0,016	6,6%	37,7%
6.A.1. Managed Waste Disposal on Land	CH4	waste	2630	823	0,012	5,3%	42,9%
1.A.4.a. Commercial/Institutional	CO2	energy	4272	5958	0,012	5,2%	48,1%
1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	CO2	energy	2144	429	0,012	5,0%	53,1%
2.E. Production of Halocarbons and SF6	PFCs	industrial processes	1753	141	0,011	4,7%	57,8%
1.A.2.c. Chemicals	CO2	energy	6311	7781	0,011	4,6%	62,4%
2.E. Production of Halocarbons and SF6	SF6	industrial processes	1559	0	0,011	4,6%	67,0%
1.A.1.a. Public Electricity and Heat Production	CO2	energy	23420	24624	0,011	4,5%	71,5%
2.F.1. Refrigeration and Air Conditioning Equipment	HFCs	industrial processes	74	1190	0,008	3,3%	74,8%
1.A.2.f. Other (Manufacturing Industries and Construction)	CO2	energy	8069	7158	0,006	2,4%	77,2%
1.A.2.e. Food Processing, Beverages and Tobacco	CO2	energy	2998	2190	0,005	2,3%	79,5%
2.B.5. Other (Chemical Industry)	CO2	industrial processes	224	911	0,005	2,0%	81,5%
2.B.1. Ammonia Production	CO2	industrial processes	694	1330	0,005	1,9%	83,4%
4.A.1. Cattle	CH4	agriculture	4301	3606	0,004	1,9%	85,3%
1A.3. Transport	N2O	energy	352	837	0,003	1,5%	86,8%
2.B.2. Nitric Acid Production	N2O	industrial processes	3562	3066	0,003	1,3%	88,1%
1.A.1.b. Petroleum Refining	CO2	energy	4299	4656	0,003	1,2%	89,3%
2.C.1. Iron and Steel Production	CO2	industrial processes	1946	1535	0,003	1,1%	90,5%
1.A.4.c. Agriculture/Forestry/Fisheries	CO2	energy	2730	2394	0,002	0,9%	91,4%
4.D.1. Direct Soil Emissions	N2O	agriculture	2471	2198	0,002	0,7%	92,1%
4.D.3. Indirect Emissions	N2O	agriculture	1184	929	0,002	0,7%	92,8%
2.F.2. Foam Blowing	HFCs	industrial processes	324	101	0,002	0,6%	93,4%
6.C. Waste Incineration	CO2	waste	337	115	0,002	0,6%	94,1%
4.B.1. Cattle	CH4	agriculture	1131	913	0,001	0,6%	94,7%
2.A.1. Cement Production	CO2	industrial processes	2824	2934	0,001	0,4%	95,1%
1A.2. Manufacturing Industries and Construction	N2O	energy	388	237	0,001	0,4%	95,6%
1.A.2.b. Non-Ferrous Metals	CO2	energy	624	478	0,001	0,4%	96,0%
1.B.2.b. Natural Gas	CH4	energy	519	389	0,001	0,4%	96,3%
4.D.2. Animal Production (2)	N2O	agriculture	941	807	0,001	0,4%	96,7%
2.F.4. Aerosols/ Metered Dose Inhalers	HFCs	industrial processes	35	151	0,001	0,3%	97,0%
4.B.12. Solid Storage and Dry Lot	N2O	agriculture	897	792	0,001	0,3%	97,3%
2.G. Other (industrial processes)	CO2	industrial processes	416	318	0,001	0,3%	97,6%
2.A.7. Other (Mineral Products)	CO2	industrial processes	414	500	0,001	0,3%	97,9%
1.A.3.c. Railways	CO2	energy	202	115	0,001	0,3%	98,1%
1.A.3.d. Navigation	CO2	energy	267	334	0,000	0,2%	98,3%
1.A.5. Other (Fuel Combustion)	CO2	energy	166	95	0,000	0,2%	98,5%
4.B.8. Swine	CH4	agriculture	1432	1347	0,000	0,2%	98,7%
1.B.2.c. Venting and Flaring (Fugitive Emissions from Fuels)	CO2	energy	84	145	0,000	0,2%	98,9%
1.A.3.e. Other Transportation	CO2	energy	196	131	0,000	0,2%	99,1%
2.F. Consumption of Halocarbons and SF6	SF6	industrial processes	103	43	0,000	0,2%	99,3%
2.A.2. Lime Production	CO2	industrial processes	2097	2018	0,000	0,2%	99,4%
2.C.1. Iron and Steel Production	CH4	industrial processes	0	41	0,000	0,1%	99,5%
1.A.3. Transport	CH4	energy	102	63	0,000	0,1%	99,6%
1.A.4. Other Sectors	CH4	energy	129	90	0,000	0,1%	99,8%
6.D. Other (composting)	CH4	waste	7	41	0,000	0,1%	99,9%
1.A.2.d. Pulp, Paper and Print	CO2	energy	637	605	0,000	0,1%	99,9%
2.B.5. Other (production of caprolactam)	N2O	industrial processes	372	344	0,000	0,1%	100,0%
Total			143336	141467	0,24	1	
[a] LUCF is not included in this analysis							

Annex 2: GHG emission trends in the three Regions

Introductory note: Greenhouse gas emissions follow very different patterns in the three regions of Belgium (Flanders, Wallonia, Brussels-Capital), due to the different structure of the sectors, and to local circumstances. Emission trends of the main greenhouse gases and for the main sectors are for the three Regions presented in this annex.

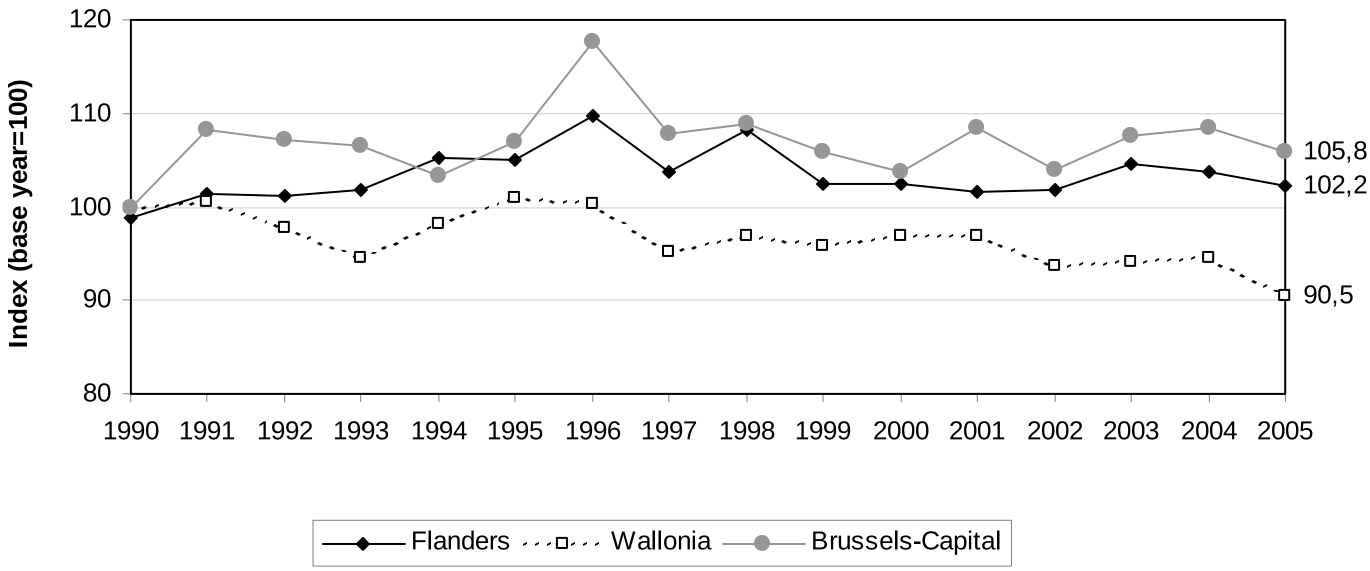


Figure 1. GHG emissions 1990-2005 in the three regions (excl. LUCF).

Unit: Index point (base year emissions = 100).

Note: For the fluorinated gases, the base year is 1995; as the y-axis refers to the base year, the index value for the year 1990 is not necessarily 100.

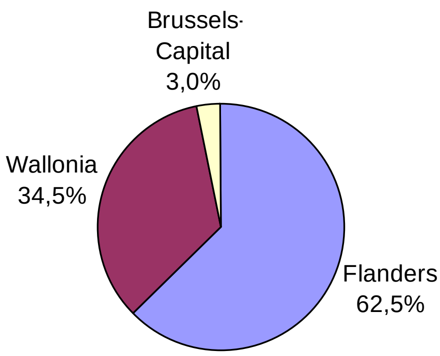


Figure 2. GHG emissions : share of emissions between the three regions (2005).

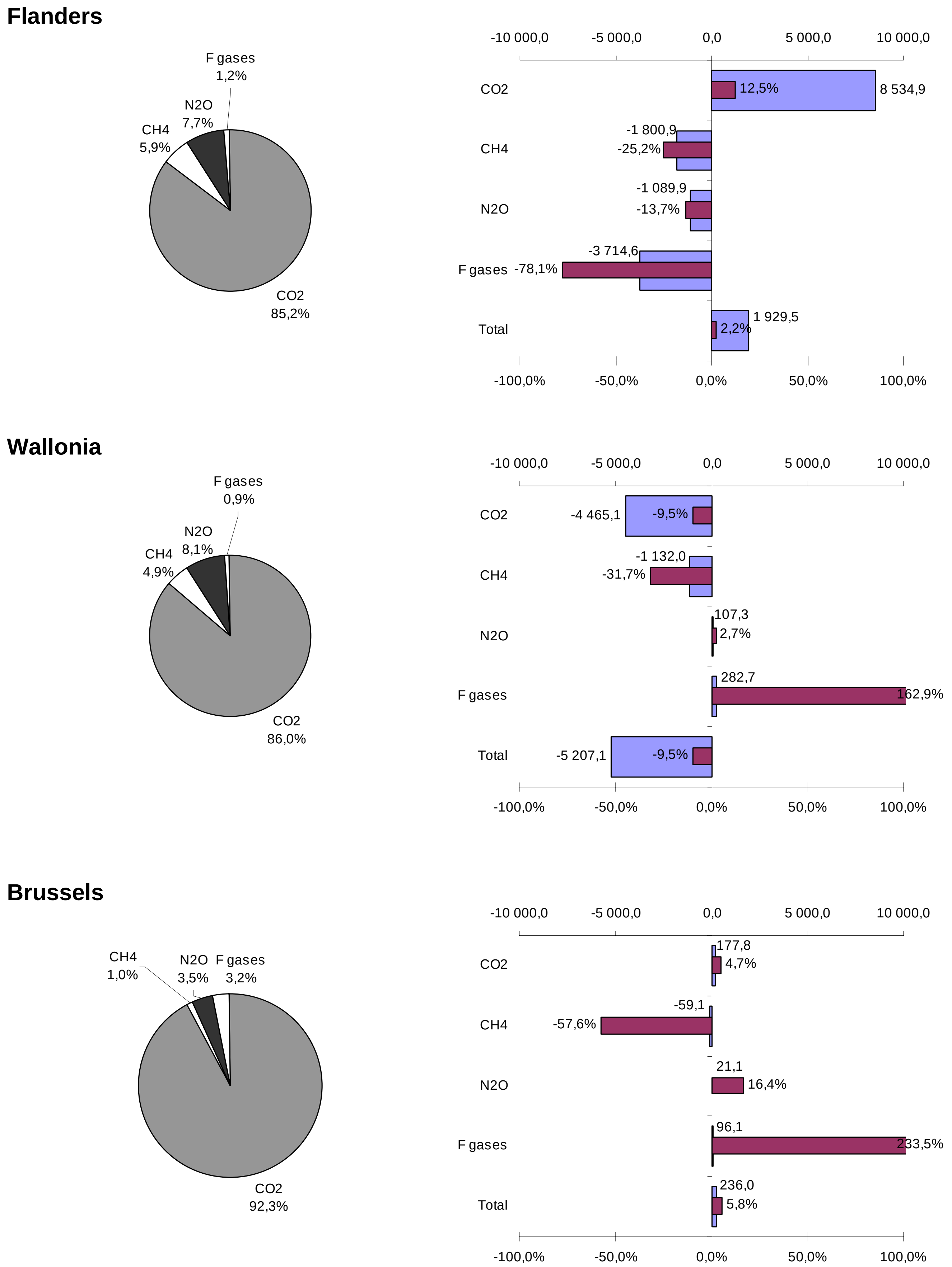
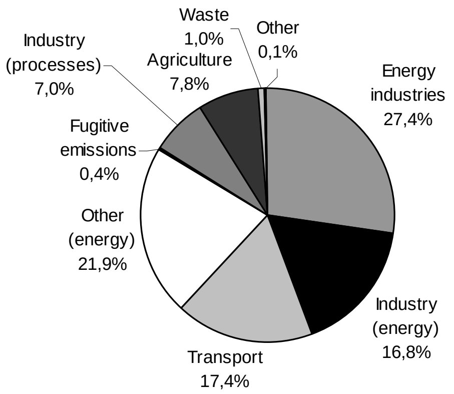
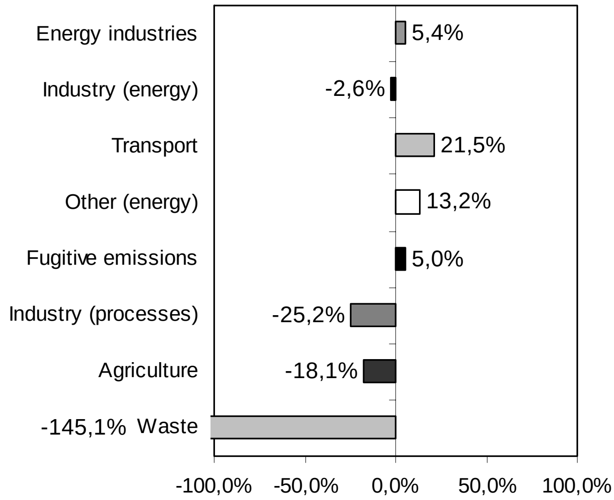


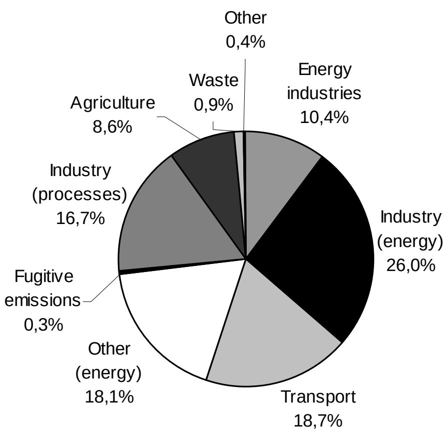
Figure 3. Share of greenhouse gases in the three regions (2005), and changes compared to base year (1990 for CO_2, CH_4 and N_2O; 1995 for F gases) (in ktonne CO_2 eq. and in %).

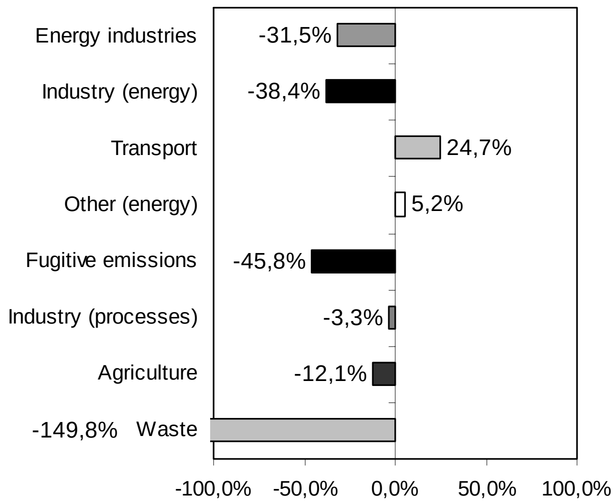
Flanders



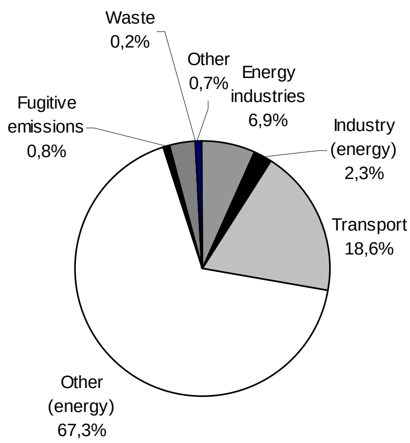


Wallonia





Brussels



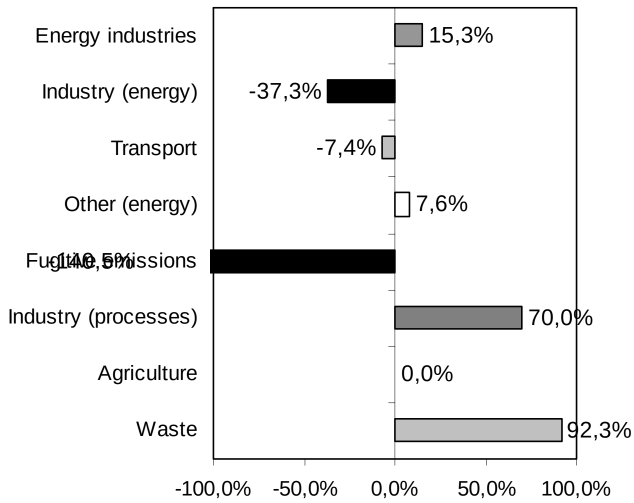


Figure 4. GHG emissions : share of main sectors (2005) in the three regions & changes 1990-2005 (in %)

Annex 3. Uncertainty analysis