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Executive Summary

ES.1. Background Information

As a Party to the United Nations Framework Convention on Climate Change (*UNFCCC*), Luxembourg is required to produce and regularly update national greenhouse gas (*GHG*) inventories. To date, such inventories have been produced for the years 1990 to 2007.

With decision 18/CP.8 (see document FCCC/CP/2002/8/Add.2), the Conference of the Parties (*COP*) adopted the UNFCCC guidelines on reporting and reviewing (FCCC/CP/2002/8). According to this decision, Parties shall submit a National Inventory Report (*NIR*) containing detailed and complete information on their inventories, in order to ensure its transparency (paragraph 38 of FCCC/CP/2002/8).

This report is the fourth version of the National Inventory Report (NIR) submitted by Luxembourg. It is an update of the previous NIR submitted in 2008.[1] It is based on data submitted to the UNFCCC in the Common Reporting Format (*CRF*) on 23 May 2009: submission 2008v1.4.[2] Besides being a submission under the UNFCCC, submission 2009v1.4 is also a voluntary submission under the Kyoto Protocol.

The structure of this NIR follows as much as possible the arrangement suggested in Annex I of document FCCC/SBSTA/2006/9. First, there is an Executive Summary that gives an overview of Luxembourg's GHG inventory. Chapters 1 and 2 provide general information on the inventory preparation process, summarize the overall trends in GHG emissions and describe specific national circumstances that influence Luxembourg's GHG emission trends and structure. Comprehensive information on the activity data, emission factors and methodologies used for estimating Luxembourg's GHG emissions is presented in Chapters 3 to 8 – each chapter dealing with one CRF sector. Chapters 3 to 8 also depict actions planned to further improve the inventory and changes made (recalculations) for each CRF sector. These planned improvements and recalculations are summarized in Chapter 9.

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1 Luxembourg's National Inventory Report of 19 July 2008 (covering inventory years 1990 to 2006)

2 Submission 2009v1.4 can be downloaded from:
a) the Central Data Repository of the European Environment Information and Observation Network (EIONET) of the European Environment Agency (EEA): http://cdr.eionet.europa.eu/lu/eu/ghgmm/envshq85a;
b) the UNFCCC web site: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/4771.php.

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

In 2007, carbon dioxide (*CO_2*) was the main source of GHG in Luxembourg (Table 0-1). This source counted for 91.7% of the total GHG emissions calculated in CO_2 equivalents (*CO_2e*) – total excluding land-use, land-use change and forestry (*LULUCF*). The second source of GHG was nitrous oxide (*N_2O*) with about 4.1% of the total emissions excluding LULUCF. Methane (*CH_4*) was the third source with 3.5%. Fluorinated gases (*F-gases*) only accounted for 0.7% of the total emissions excluding LULUCF, with hydrofluorocarbons (*HFCs*) representing 0.68% of the total and sulphur hexafluoride (*SF_6*) representing 0.04% of the total. There were no known sources of perfluorocarbons (*PFCs*) in Luxembourg.

In 2007, total GHG emissions amounted to 12.914 Mio. t CO_2e, 1.56% below their level for the base year.[3] For the different GHG, trends over the period 1990-2007 were as follows:

- CO_2: .... -2.41%
- CH_4: .... -2.68 %
- N_2O: .... + 5.28 %
- F-gases: .... +431.59 %

For carbon dioxide, the relatively close values estimated in 1990 and 2007 respectively hide a U-shape evolution over the period as well as important changes in the sources of CO_2 emissions: declining emissions in industrial and thermal power plant combustion, increasing emissions from transport and for natural gas fired power.

Methane emissions have declined over the period due to the conjunction of reduced methane emissions in agriculture (-3.2%) and in waste management (-33.5%) and with growing emissions in energy use (+30.7%), the latter being due to an upward trend for fugitive emissions from natural gas distribution and use.

Nitrous oxide emissions development is closely linked to an increase of liquid fuels related emissions in both other manufacturing industries and road transportation (gasoline and diesel oil) that could not be balanced by declining emissions from the agriculture sector.

Finally, with regard to F-gases, HFCs emissions were 6 times higher in 2007 than in the base year, whereas SF_6 emissions showed a 35.4% increase.

3 The base year for CO_2, CH_4 and N_2O is 1990. For the F-gases, the base year is 1995. However, due to lack of data on F-gases for the first half of the 1990s, 1995 emission estimates are equalled to 1990 emission estimates (see Table 2-7).

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

Table 0-2 splits up total GHG emissions of Luxembourg for the 7 CRF sectors to be included in the inventories. In 2007, the energy sector accounted for almost 88% of the total CO_2e GHG emissions, excluding LULUCF. Two sectors represent between 5.5% and 6% of the total emissions, excluding LULUCF: industrial processes (6.1%) and agriculture (5.5%). The remaining sectors[4] (solvent and other product use, waste[5]) were not even reaching 1% of the total GHG emitted in Luxembourg in 2007.

For the different sectors, trends over the period 1990-2007 were as follows:

- Energy: .... +6.60%
- Industrial Processes: .... -51.41%
- Solvent and Other Product Use: .... -21.29%
- Agriculture: .... -8.34%
- Waste: .... -12.94%

Emission reductions observed in all sectors but one could not balance the growth of energy use and production related emissions whose contribution to total GHG emissions, excluding LULUCF, ranged from 80% to 90% over the period 1990 to 2007. Within the energy sector, the fastest growing sub-sector was transport (1A3): +142% between 1990 and 2007 with, as a result, a share in the total energy related GHG emissions rising from 26% to 59%. For the other sub-sectors, the observed trends between 1990 and 2007 are +2% for energy industries (1A1), -66% for manufacturing industries (1A2), +3% for the other sectors (1A4) and +176% for fugitive emissions from fuels (1B).[6]

The second largest sector in Luxembourg with regard to GHG emissions, i.e. industrial processes, shows a declining trend between 1990 and 1998, then a relative stabilisation. This evolution was mainly driven by process changes that occurred in the steel industry (recorded under 2C1), which moved from blast to electric arc furnaces between 1994 and 1998. As a consequence, steel industry emissions in CO_2e decreased by 79% since 1990.

4 The sector “other” is not reported for Luxembourg.

5 The waste sector covers only landfilled waste, wastewater handling and composting activities. Waste incineration, which is the main treatment method for municipal waste in Luxembourg, is carried out in the sole incinerator of the country where energy is recovered. Consequently, waste incineration related emissions are accounted for in CRF sector 1 – Energy (details in Chapters 3 and 8 respectively).

6 Fugitive emission growth is closely linked to natural gas use in Luxembourg.

Trends in agriculture were also favourable between 1990 and 2007: declining GHG emissions were observed for the 3 categories for which emissions are recorded in Luxembourg: enteric fermentation (4A: -9%), manure management (4B: -2%) and agricultural soils (4D: -10%).

In the waste sector, the main source of GHG was solid waste disposal on land (6A), but its weight decreased over the period 1990-2007 due to the combination of reduced amounts of landfilled waste and of increased emissions arising from composting activities (6D). However, GHG emission reduction for solid waste disposal on land (-48% between 1990 and 2007) still drove a reduction for the overall waste sector despite composting rising emissions (wastewater handling emissions (6B) remained stable throughout the period with a 0.1% increase).

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From this analysis, it is obvious that the biggest challenge Luxembourg is facing, with regards to GHG emissions reduction, is to limit emissions from the energy sector, and more particularly from the transportation sector. Detailed explanations on the very high shares of both CO_2 and the energy sector will be provided in Chapter 2, when analysing trends in Luxembourg's GHG emissions. Also, specific national circumstances are to be kept in mind when appreciating GHG emissions trends and composition in Luxembourg. These circumstances will be exposed in Chapter 2 as well.

ES.4. Emission Estimates and Trends of Indirect GHG and SO_2

Some indirect GHG – NO_x, CO, NMVOCs – and SO_2 emissions are recorded in the inventory. Nevertheless, they need to be re-evaluated in the light of the revision of the inventories Luxembourg is compiling for the UNECE Convention on Long-Range Transboundary Air Pollution (*CLRTAP*). Consequently, these emissions will not be discussed in this NIR and generating better emission estimates for these gases are part of our planned improvements.

Table 0-1 – Luxembourg's GHG emissions and removals – overview by main gases: 1990-2007

Gg (1000 t.) CO_2 equivalent	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2	12136,02	12611,07	12360,09	12486,04	11632,18	9384,52	9428,70	8803,73	7970,95	8364,31	8897,31	9239,90	10300,82	10770,93	12204,39	12330,88	12245,75	11844,04
	92,52%	92,67%	92,42%	92,52%	92,15%	90,32%	90,16%	89,45%	88,40%	88,79%	89,23%	89,88%	90,85%	91,48%	91,86%	92,09%	92,05%	91,72%
CH_4 (1)	466,01	475,88	463,74	465,70	460,77	470,12	476,75	471,99	472,24	481,39	476,10	470,18	468,92	459,22	458,41	458,63	456,11	453,54
	3,55%	3,50%	3,47%	3,45%	3,65%	4,52%	4,56%	4,80%	5,24%	5,11%	4,77%	4,57%	4,14%	3,90%	3,45%	3,42%	3,43%	3,51%
N_2O (2)	498,65	504,33	532,50	527,26	512,45	518,20	529,12	537,23	538,97	534,31	551,20	515,54	505,83	473,82	544,79	514,88	511,26	524,96
	3,80%	3,71%	3,98%	3,91%	4,06%	4,99%	5,06%	5,46%	5,98%	5,67%	5,53%	5,01%	4,46%	4,02%	4,10%	3,85%	3,84%	4,07%
HFCs (3)	14,21	14,21	14,21	14,21	14,21	14,21	19,97	25,73	31,49	37,25	43,01	50,92	58,82	66,73	74,63	82,54	87,04	87,04
	0,11%	0,10%	0,11%	0,11%	0,11%	0,14%	0,19%	0,26%	0,35%	0,40%	0,43%	0,50%	0,52%	0,57%	0,56%	0,62%	0,65%	0,67%
PFCs (3)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6 (3)	2,91	2,91	2,91	2,91	2,91	2,91	3,03	3,15	3,28	3,40	3,52	3,57	3,62	3,68	3,73	3,78	3,86	3,94
	0,02%	0,02%	0,02%	0,02%	0,02%	0,03%	0,03%	0,03%	0,04%	0,04%	0,04%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%
Total GHG excluding LULUCF	**13117,79**	**13608,40**	**13373,44**	**13496,11**	**12622,52**	**10389,96**	**10457,57**	**9841,83**	**9016,93**	**9420,67**	**9971,14**	**10280,11**	**11338,01**	**11774,37**	**13285,95**	**13390,71**	**13304,02**	**12913,52**
	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%

Source: Environment Agency and Ministry of the Environment.

Notes:

(1) the methane emissions are converted in CO_2 equivalents by multiplying the emissions by 21, i.e. the global warming potential (GWP) value for methane based on the effects of GHG over a 100-year time horizon.

(2) the nitrous oxide emissions are converted in CO_2 equivalents by multiplying the emissions by 310, i.e. the global warming potential (GWP) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

(3) the F-gases are those not covered by the Montreal Protocol, i.e. the HFCs, PFCs and SF6 expressed in CO_2 equivalents using the the global warming potential (GWP) values based on the effects of GHG over a 100-year time horizon.

Table 0-2 – Luxembourg's GHG emissions and removals – overview by main CRF Sectors: 1990-2007

Gg (1000 t.) CO_2 equivalent	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	10642,61	11206,87	11040,68	11193,10	10437,03	8542,38	8650,90	8140,36	7471,07	7831,63	8349,84	8744,46	9795,25	10330,46	11745,22	11882,12	11740,68	11345,27
	81,13%	82,35%	82,56%	82,94%	82,69%	82,22%	82,72%	82,71%	82,86%	83,13%	83,74%	85,06%	86,39%	87,74%	88,40%	88,73%	88,25%	87,86%
2. Industrial Processes	1612,68	1535,59	1465,61	1445,58	1352,51	992,16	942,47	839,46	686,29	729,84	761,99	713,53	737,19	686,27	735,85	736,22	793,78	783,66
	12,29%	11,28%	10,96%	10,71%	10,72%	9,55%	9,01%	8,53%	7,61%	7,75%	7,64%	6,94%	6,50%	5,83%	5,54%	5,50%	5,97%	6,07%
3. Solvent and Other Product Use	23,90	22,98	21,88	20,85	19,57	19,74	19,42	19,00	17,88	17,30	15,81	16,54	16,76	16,80	18,80	18,47	17,88	18,81
	0,18%	0,17%	0,16%	0,15%	0,16%	0,19%	0,19%	0,19%	0,20%	0,18%	0,16%	0,16%	0,15%	0,14%	0,14%	0,14%	0,13%	0,15%
4. Agriculture	775,27	781,29	785,20	776,84	754,92	778,38	788,82	786,47	784,10	785,24	782,18	749,90	737,40	686,65	732,56	699,54	695,54	710,64
	5,91%	5,74%	5,87%	5,76%	5,98%	7,49%	7,54%	7,99%	8,70%	8,34%	7,84%	7,29%	6,50%	5,83%	5,51%	5,22%	5,23%	5,50%
5. LULUCF	208,44	31,41	-339,23	-450,77	-281,28	-384,86	-559,10	-600,74	-345,22	-470,04	-471,37	-542,13	-546,19	-559,06	-518,00	-493,42	-388,69	-390,64
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	63,34	61,67	60,07	59,74	58,49	57,30	55,97	56,53	57,60	56,66	61,32	55,69	51,42	54,19	53,52	54,36	56,14	55,14
	0,48%	0,45%	0,45%	0,44%	0,46%	0,55%	0,54%	0,57%	0,64%	0,60%	0,62%	0,54%	0,45%	0,46%	0,40%	0,41%	0,42%	0,43%
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total GHG including LULUCF	**13326,23**	**13639,81**	**13034,21**	**13045,34**	**12341,23**	**10005,10**	**9898,47**	**9241,09**	**8671,71**	**8950,63**	**9499,77**	**9737,98**	**10791,82**	**11215,31**	**12767,95**	**12897,29**	**12915,33**	**12522,88**
	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
Total GHG excluding LULUCF	**13117,79**	**13608,40**	**13373,44**	**13496,11**	**12622,52**	**10389,96**	**10457,57**	**9841,83**	**9016,93**	**9420,67**	**9971,14**	**10280,11**	**11338,01**	**11774,37**	**13285,95**	**13390,71**	**13304,02**	**12913,52**
	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%

Source: Environment Agency and Ministry of the Environment.

Notes:

Percentages are relative to the total GHG emissions, excluding LULUCF.

The land-use change and forestry emissions are covering CRF categories 5A, 5B &5C only.

1 Introduction

The updated UNFCCC Reporting Guidelines on Annual Inventories following incorporation of the Provisions of Decision 14/CP.11 that was published on 18 August 2006,[7] reproduces the Guidelines for the preparation of National Communications by Parties included in Annex I to the Convention. This document indicates, in paragraph 38, that "Annex I Parties shall submit to the COP, through the Secretariat, a National Inventory Report (NIR) containing detailed and complete information on their inventories".

The present NIR documents Luxembourg's GHG emission inventory in accordance with the updated UNFCCC reporting guidelines on annual inventories. It is aimed at complying with decisions 11/CP.4, 3/CP.5, 18/CP.8 and 14/CP.11 of the COP, and with European Parliament and Council Decision 280/2004/EC concerning a mechanism for monitoring Community GHG emissions and for implementing the Kyoto Protocol. It 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.

This report is an update of the previous NIRs submitted in 2008.[8] It is based on data submitted to the UNFCCC in the Common Reporting Format (*CRF*) on 23 May 2009: submission 2009v1.4.[9] Besides being a submission under the UNFCCC, submission 2008v1.2 is also a voluntary submission under the Kyoto Protocol.

The GHG inventory reviewed in the present NIR covers the period 1990-2007 and contains information on anthropogenic emissions by sources and removals by sinks for direct GHG (CO_2, CH_4, N_2O, PFCs, HFCs, and SF_6). With regards to indirect GHG (CO, NO_x, NMVOCs) and SO_2, though recorded in the inventory, they need to be re-evaluated in the light of the revision of the inventories Luxembourg is compiling for the UNECE CLRTAP. Consequently, indirect GHG and SO_2 emissions will not be discussed in this NIR and generating better emission estimates for these gases are part of our planned improvements.

7 Document FCCC/SBSTA/2006/9.

8 Luxembourg's National Inventory Reports of 19 July 2008 (covering inventory years 1990 to 2006)

9 Submission 2008v1.2 can be downloaded from:
a) the Central Data Repository of the European Environment Information and Observation Network (EIONET) of the European Environment Agency (EEA): http://cdr.eionet.europa.eu/lu/eu/ghgmm/envshq85a;
b) the UNFCCC web site: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/4771.php
CRF tables relating to this submission are not reproduced in this document since they can easily be accessed and printed out from these two web sites.

1.1 Institutional Arrangement for Inventory Preparation

1.1.1 Obligations for Luxembourg

Some obligations are directly linked with GHG emission reporting:

- annual obligations under Decision 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community GHG emissions and for implementing the Kyoto Protocol (known as the "Monitoring Decision") and Commission Decision 2005/166/EC of 10 February 2005 laying down rules implementing Decision 280/2004/EC;
- obligations under the UNFCCC. Relevant COP Decisions and Guidelines are:
  - Decision 3/CP.5 – Guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, Part I: UNFCCC Reporting Guidelines on Annual Inventories (referring to Document FCCC/CP/1999/7) revised with Decision 18/CP.8 (referring to Document FCCC/CP/2002/8);
  - Decision 4/CP.5 – Guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, Part II: UNFCCC Reporting Guidelines on National Communications (referring to Document FCCC/CP/1999/7) revised with Decision 19/CP.8 (referring to Document FCCC/CP/2002/8);
  - Document FCCC/CP/1999/7 – Review of the Implementation of Commitments and of other Provisions of the Convention – UNFCCC Guidelines on Reporting and Review revised with Document FCCC/CP/2002/8;
  - Decision 11/CP.4 – National communications from Parties included in Annex I to the Convention;
  - Document FCCC/CP/2001/13/Add.3 – Report of the Conference of the Parties on its seventh session, held at Marrakech from 29 October to 10 November 2001, Addendum, Part two: Action taken by the Conference of the Parties, Volume III (Decision 20/CP.7: Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol; Decision 21/CP.7: Good practice guidance and adjustments under Article 5, paragraph 2, of the Kyoto Protocol; Decision 22/C.7: Guidance for the preparation of the information required under Article 7 of the Kyoto Protocol; Decision 23/CP.7: Guidelines for review under Article 8 of the Kyoto Protocol).

Some provide, indirectly, information that can be used to produce GHG inventories:

- annual obligations under the UNECE Convention on Long-Range Transboundary Air Pollution (*CLRTAP*) and its Protocols (1979) comprising the annual reporting of national emission data on SO_2, NOx, NMVOCs, NH_3, CO, TSP, PM_{10}, and $PM_{2.5}$ as well as on the heavy metals Pb, Cd and Hg and persistent organic hydrocarbons (*PAHs*), dioxins and furans and hexachlorobenzene (*HCB*);

- annual obligations under Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, (known as the "NEC Directive") comprising the annual reporting of national emission data on SO_2, NOx, NMVOCs and NH_3;
- obligations according to Article 15 of the European IPPC Directive 1996/61/EC is to implement a European Pollutant Emission Register (EPER). EPER was displaced and upgraded by Regulation (EC) 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register (E-PRTR). EPER and E-PRTR are associated with Article 6 of the Aarhus Convention (United Nations: Aarhus, 1998) which refers to the right of the public to access environmental information and to participate in the decision-making process of environmental issues.
- obligations under the framework of the European Union Emission Trading Scheme (*EU-ETS*) established by Directive 2003/87/EC of the European Parliament.

1.1.2 National Inventory System

A Grand-Ducal Regulation[10] designates a Single National Entity, the National Inventory Compiler and the National GHG Inventory Focal Point. It also defines and allocates specific responsibilities for the realization of the GHG Inventories both within the Single National Entity and within the other administrations and/or services that will be involved in the inventory preparation in the future.

1.1.2.1 Single National Entity and other cross-cutting roles

The previously cited regulation designates the Environment Agency (*Administration de l'Environnement*)[11] as the "Single National Entity with overall responsibility for the GHG Inventory". Overall management of the Single National Entity is assigned to one staff member of the Environment Agency that is nominated GHG Inventory Focal Point. The Agency also acts as "Na-

10 Règlement grand-ducal du 1er août 2007 relatif à la mise en place d'un Système d'Inventaire National des émissions de gaz à effet de serre dans le cadre de la Convention-cadre des Nations Unies sur le Changement Climatique, Mémorial A-N° 130 du 7 août 2007, pp. 2318-2320 : see http://www.legilux.public.lu/leg/a/archives/2007/1300708/1300708.pdf.

11 The Environment Agency is directly linked to the Ministry of the Environment and works under its supervision: see http://www.environnement.public.lu/functions/apropos_du_site/mev/attributions_MEV/index.html and the assignments of the Environment Agency: http://www.environnement.public.lu/functions/apropos_du_site/aev/Missions_aev.html (in French).

tional Inventory Compiler" compiling and checking the information and GHG emission estimates coming from sector experts working in other administrations or services (see Table 1-1).

The Environment Agency has therefore the "technical" knowledge and responsibility for the GHG Inventories, but the "political" responsibility is staying with the Ministry of the Environment acting as UNFCCC National Focal Point. Thus, it is the Ministry that officially submits the inventories and their related reports to the UNFCCC Secretariat and the European Commission (see Article 8 of the Regulation).

1.1.2.2 Specific responsibilities for the GHG Inventory compilation and development process

Article 3 of the Regulation presents the tasks of the Single National Entity. In a few words, the Single National Entity – i.e. the Environment Agency – provides sector experts for all the IPCC Sectors except Agriculture, LULUCF and Wastewater Handling (see Table 1-1). It is also the Agency that:

- manages the NIS and coordinates the work on GHG Inventories by informing the experts of any changes and evolutions in the Guidelines;
- as National Inventory Compiler, compiles the GHG emissions estimates produced by sector experts;
- prepares the NIR (notably on the basis of chapters received from the sector experts), including the Key Source Analysis (*KSA*) and the calculation of the uncertainties;
- prepares and defines work plans to secure timely data supply;
- assists sector experts in their assignments and their training;
- defines and approves, together with sector experts, activity/background data (*AD*), emission factors (*EF*), methods to estimate GHG emissions;
- archives the relevant information on the inventories and the NIS;
- implements recommendations from the quality assurance/quality control (*QA/QC*) annual exercise (see Section 1.6).

Article 4 describes the tasks that fall to sector experts:

- choice of the best methods to evaluate GHG emissions, using IPCC Guidelines (these methods have to be approved by the Single National Entity as indicated above);
- collection of the necessary AD and EFs;
- calculation of emission estimates;

- recalculation of emission estimates when possible and desirable: new AD sources, new parameters, new methods, etc.;
- proceeding with first quality checks (using, inter alia, tools embedded in CRF Reporter that allow to verify completeness and consistency);
- preparation of the NIR relevant chapters.

Finally, Article 5 indicates that activity/background data providers have to transmit quality AD using formats, and respecting the deadlines, defined by the Single National Entity.

Table 1-1 – CRF Sector responsibilities within the NIS

CRF Sector	AD	Choice of EFs	Emissions estimation methods
Energy, excl. road transportation – CRF 1 except 1A3b	AEV – DEN – STATEC	AEV	AEV
Road transportation – CRF 1A3b	AEV – ADA – DEN – SNCT	AEV	AEV
Industrial Processes – CRF 2	AEV	AEV	AEV
Solvent and Other Product Use – CRF 3	AEV	AEV	AEV
Agriculture – CRF 4	ASTA – SER	ASTA – SER	ASTA – SER
LULUCF – CRF 5	AEF – MEV – SER – ASTA - AEV	AEF – SER – ASTA	AEF – SER – ASTA – AEV
Waste – CRF 6A, 6B & 6D	AEV (Waste Division)	AEV (Waste Division)	AEV (Waste Division)
Wastewater Handling – CRF 6B	AGE	AGE	AGE

Abbreviations used in Table 1-1:

Ministry of Agriculture:

ASTA = Agriculture Technical Services Administration (*Administration des Services Techniques de l'Agriculture*): http://www.asta.etat.lu/

SER = Agriculture Economic Service (*Service d'Economie Rurale*): http://www.ser.public.lu/

Ministry of Economic Affairs & External Trade:

DEN = Energy Directorate (*Direction de l'Energie*): http://www.eco.public.lu/index.html

STATEC = National Statistical Institute: http://www.statec.public.lu/fr/index.html

Ministry of the Environment (MEV): http://www.emwelt.lu/:

AEF = Water & Forestry Administration (*Administration des Eaux et Forêts*)

AEV = Environment Agency (*Administration de l'Environnement*)

Ministry of Finance:

ADA: Customs & Excises Administration (*Administration des Douanes et Accises*): http://www.do.etat.lu/

Ministry of Internal Affairs and Spatial Planning:

AGE = Water Agency (*Administration de la Gestion de l'Eau*): http://www.eau.public.lu/

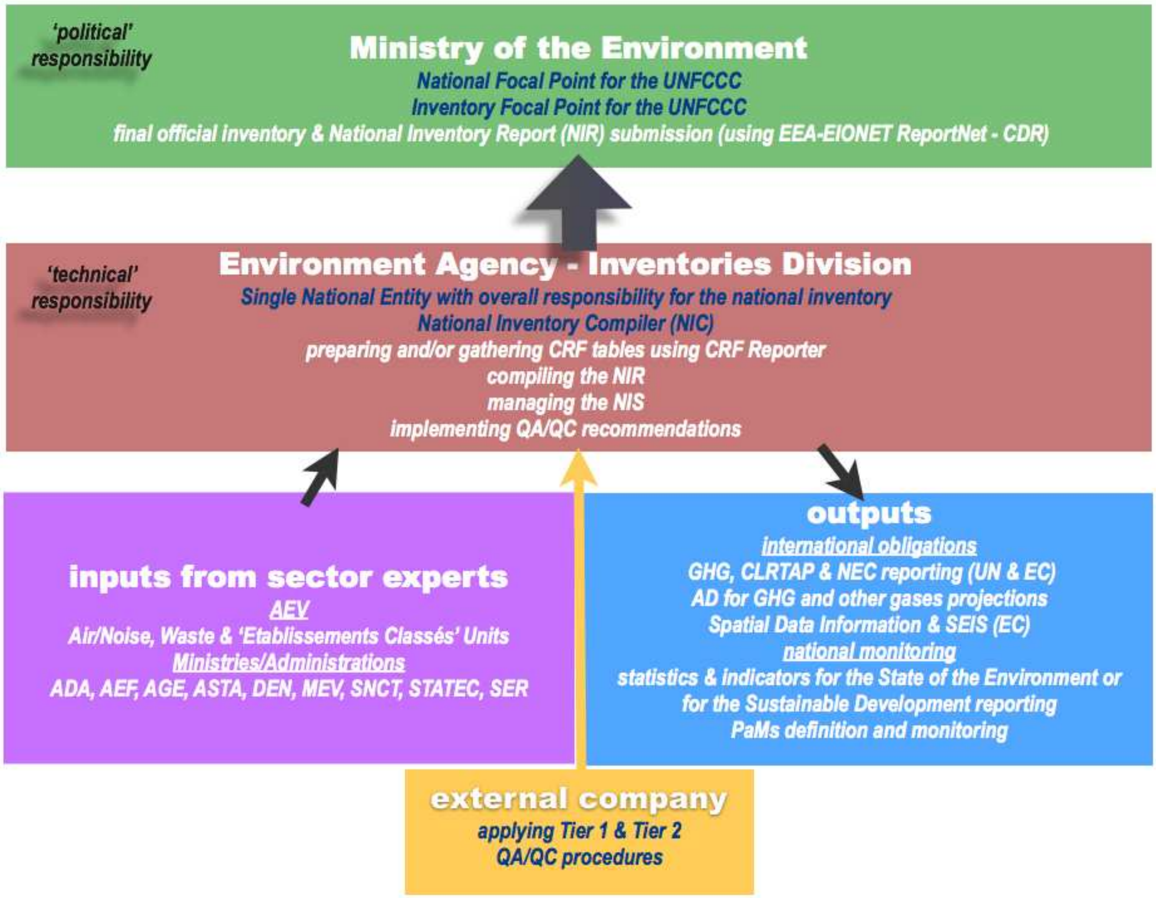
Ministry of Transport:

SNCT = Vehicles Check Administration (*Société Nationale de Contrôle Technique*): http://www.snct.lu/snct/home.nsf

1.1.2.3 GHG reporting

Figure 1-1 summarizes the organization of the GHG reporting in Luxembourg in accordance with the national Regulation for the setting-up of a National Inventory System (NIS).

Figure 1-1 – Luxembourg's NIS according to the Regulation of 1st August 2007



It is worth noting that the Inventories Division of the Environment Agency, a Division part of the Air/Noise Unit of this Agency, is not only dealing with GHG reporting but also with reporting under the UNECE CLRTAP and under the "NEC Directive".

Luxembourg has, thus, adopted an "integrated approach" to avoid redundant and overlapping activities in different administrative services. This concentration of air emissions reporting in one department also allows an improved consistency between different reporting schemes. As an example, indirect GHG and SO_2 emissions that are to be recorded in the GHG inventory – and that, as indicated previously, need to be re-evaluated in the light of the revision of the inventories Luxembourg is compiling for the UNECE CLRTAP and under the "NEC Directive" – will be extracted and adapted from the CLRTAP/NEC reporting schemes.

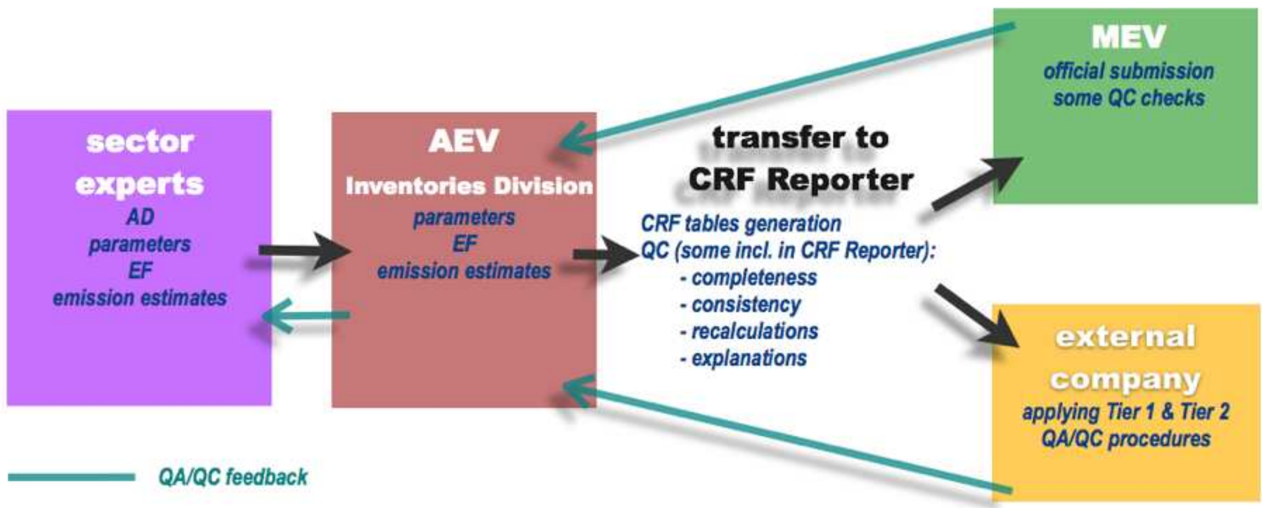
With regard to inputs for the monitoring of GHG emissions, having E-PRTR and EU-ETS managed by the Air/Noise Unit of the Environment Agency ensures easy access to facilities' reported fuel and/or emissions that are subsequently integrated in GHG emissions calculations. The Environment Agency also gathers information from establishments and installations subordinated to a operational permits to carry out certain activities, the so-called "*établissements classés*". There, too, valuable information for the inventories is found. More details on these AD and, sometimes, EF sources are presented in Section 1.4.

With regards to outputs from the Inventory Division, not only are they used for the various inventory reporting obligations (GHG, CLRTAP, NEC), but also for other reporting activities, such as those linked to Spatial Data Information (such as the EC INSPIRE Directive[12]) and under the Shared Environmental Information System.[13] Of course, these are also used for various national publications, as well as, for defining policies and measures (*PaMs*).

Finally, although the national regulation, setting up the NIS, only indicates that an agent, belonging to the Environment Agency, should develop, implement and maintain a QA/QC plan, it has been decided that QA/QC activities should be performed by an external company so to guarantee an independent review process (see Section 1.5).

Figure 1-2 goes over the data flow process that is implied by the setting-up of the NIS. The Inventories Division of the Environment Agency not only collects and validates AD, EF, parameters and emission estimates from sector experts – to whom the Environment Agency belongs too (see Table 1-1 above) – but also produces emission estimates. This flexibility is introduced in Luxembourg's system to ensure a better quality for the reporting of GHG emissions.

Figure 1-2 – Theoretical data flow according to Luxembourg's NIS



12 See http://inspire.jrc.it/

13 See http://ec.europa.eu/environment/seis/index.htm

1.2 Inventory Preparation Process

1.2.1 Overview

Submission 2009v1.4 is the first submission to be produced under the provisions of the National Regulation for the setting-up of a NIS in Luxembourg. That means, that the 3 usual stages for a GHG inventory preparation – i.e. (i) inventory planning, (ii) inventory preparation and (iii) inventory management – were grossly observed.

An inventory timeline has been worked out to ensure submission in time (Figure 1-3).

A centralised data management and archiving system (based on the European Data Exchange and Storage System CIRCA) has been implemented (Figure 1-4). This system is hosted by the National IT Administration, and access is password protected. This system enables sector experts to quickly and easily exchange and store data between administrations, which are not connected through a single network.

An official approval process has been established between the Single National Entity (SNE, Environment Agency) and the UNFCCC National Focal Point (NFP, Ministry of Environment).[14] Thus, the SNE notifies the NFP, in writing, that the inventory has been compiled according to the rules established by the UNFCCC and uploads the submission onto the CIRCALUX data archive. The NFP informs the Minister of Environment accordingly. Upon acceptance, the NFP uploads the submission from the CIRCALUX archive onto the UNFCCC submission portal and to the European Commission.[15]

However, some cross-cutting issues have been identified, and are being dealt with in the next annual submission[16]:

- establishment of a decision making body for relevant decisions;
- improvement of the QA/QC system (Section 1.5);
- prioritization of inventory improvements.

14 ARR 2008, § 31(b)

15 See also article 8 of the Grand-Ducal Regulation of August 1st, 2007 relative to the implementation of the NIS.

16 ARR 2008, § 24

Figure 1-3 – Inventory preparation timeline

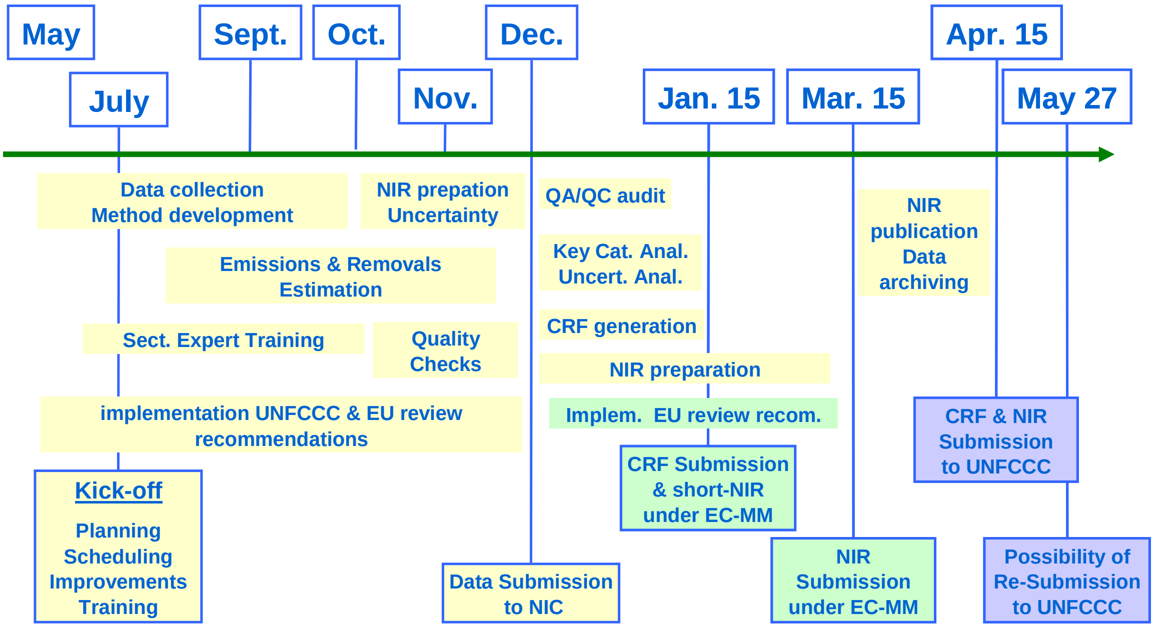
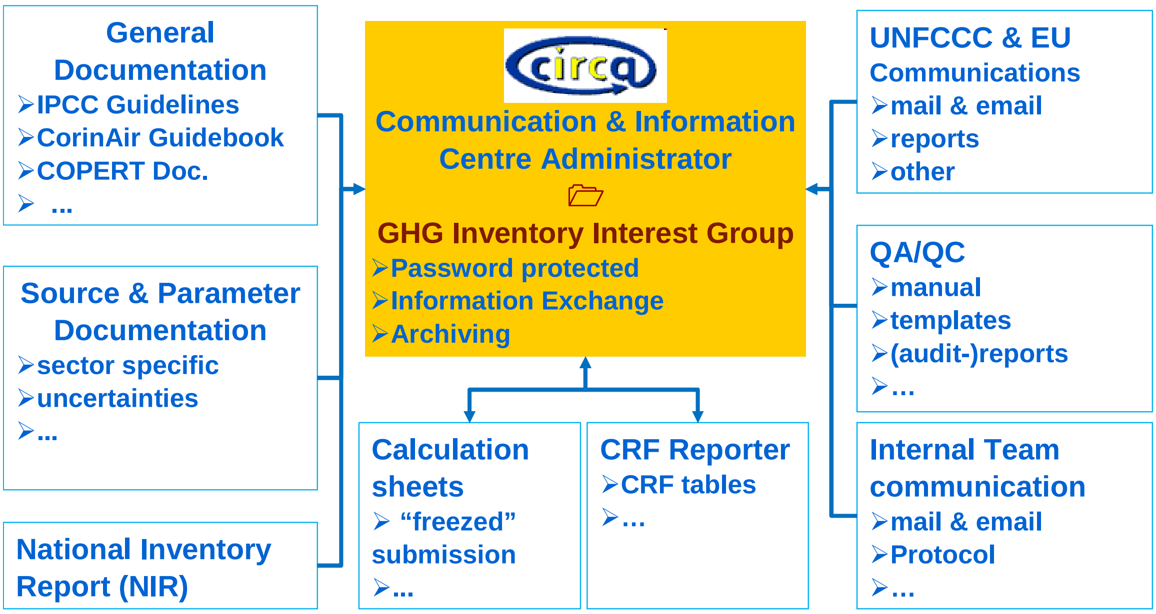


Figure 1-4 – Data management and archiving system (CIRCALUX)



1.2.2 Preparation Process

Luxembourg's inventory submission 2009v1.4 has been prepared using the latest version of CRF Reporter, i.e. version 3.2.3. It covers the inventory years 1990 to 2007.

A large number of GHG source categories are not occurring in Luxembourg. Consequently, for one inventory year, values – other than notation keys – to be included in CRF Reporter amount to around one hundred. This is why, so far, CRF Reporter has been "manually" populated by having recourse to "copy-paste" from Microsoft Excel™ inventory work files.

However, with the increasing number of LULUCF data, which needs to be transferred to the CRF Reporter, this manual data transfer becomes prone to errors. Therefore, it is foreseen to use some specific software tools for the preparation and the compilation of air emission inventories and estimates (GHG, emissions in the framework of the CLRTAP) from which it might be envisaged to develop automated routines for transferring emission estimates directly to CRF Reporter for the next submission (in 2010).[17] Nevertheless, this is not an absolute "must do" for Luxembourg since, as underlined above, yearly data to be included in CRF Reporter are not numerous. Furthermore, "manually" populating CRF Reporter offers concrete advantages compared to automated operations: mistakes and missing values can be directly identified, recalculations cross-checked, explanations for notation keys or recalculations not forgotten and documentation boxes filled accordingly when needed.

For preparing submission 2009v1.4, Luxembourg did refer to the note by the Secretariat FCCC/SBSTA/2006/9 of 18 August 2006 on updated UNFCCC Reporting Guidelines on Annual Inventories following incorporation of the Provisions of Decision 14/CP.11. IPCC Guidelines have been applied as much as possible. These Guidelines are:

- the Revised 1996 IPCC Guidelines for National GHG Inventories (1996 IPCC-GL);
- the 2000 IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000 IPCC-GPG);
- the 2006 IPCC Guidelines for National GHG Inventories (2006 IPCC-GL);
- the 2003 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (2003 IPCC-GPG-LULUCF).

Information on the methods and sources used for preparing the inventory are presented in each of the Chapters 3 to 8 dealing with a CRF sector. They are also summarized in section 1.3 of this chapter.

For estimating GHG emissions reported in submission 2009v1.4, Luxembourg mostly used Microsoft Excel™ spreadsheets (Table 1-2).

[17] ARR 2008, § 27

Table 1-2 – Programs and software used for generating submission 2009v1.4

CRF Sector	Emissions calculated using …
Energy, excl. road transportation – CRF 1 except 1A3b	MS Excel 2000
Road transportation – CRF 1A3b	COPERT IV 6v1 and MS Excel 2000
Industrial Processes – CRF 2	MS Excel 2000
Solvent and Other Product Use – CRF 3	MS Excel 2000
Agriculture – CRF 4	MS Excel 2000
LULUCF – CRF 5	MS Excel 2000
Waste – CRF 6	MS Excel 2000

As Table 1-2 shows that emission calculations are mainly carried out using Microsoft Excel™ spreadsheets. This way of proceeding is offering a very flexible system that can be easily adjusted to new requirements. It is only for the estimation of road transportation emissions, where a dedicated computer program developed for the European Environment Agency (*EEA*) is employed:

COPERT IV v6.1 is a Microsoft Windows™ software tool for the calculation of emissions from road transport.[18] The emissions calculated include all major pollutants (CO_2, CO, CH_4, NO_x, VOC, PM) and several more (N_2O, NH_3, SO_2, ...). Data produced is then transformed, using MS Excel spreadsheets, into the UNFCCC CRF, according to the IPCC Guidelines, to comply with the reporting obligations under the UNFCCC.

More precisely, with the help of our partner – the Umweltbundesamt of Austria –, emissions have been calculated by the institutions indicated in Table 1-3.

Table 1-3 – CRF Sector responsibilities for submission 2009v1.4

CRF Sector	AD	Choice of EFs	Emissions estimation methods
Energy, excl. road transportation – CRF 1 except 1A3b	AEV, DEN, STATEC	AEV	AEV
Road transportation – CRF 1A3b	DEN, ADA, SNCT	AEV	AEV
Industrial Processes – CRF 2	AEV	AEV	AEV
Solvent and Other Product Use – CRF 3	AEV	AEV	AEV
Agriculture – CRF 4	ASTA, SER	MEV	MEV
LULUCF – CRF 5	MEV, ASTA, SER, AEF	ASTA, SER, AEF	ASTA, SER, AEF, AEV
Waste – CRF 6A, 6B & 6D	AEV, STATEC	AEV	AEV
Wastewater Handling – CRF 6B	AGE	AGE	AGE

Note: for the abbreviations used, see Table 1-1 above.

GHG estimates produced by those different contributors have been centralized and verified by the SNE (Environment Agency). The data have then been "manually" transferred to CRF Reporter, by

18 Chariton Kouridis, Leonidas Ntziachristos and Zissis Samaras, *COPERT III - Computer programme to calculate emissions from road transport - user manual (version 2.1)*.Technical Report N°50, European Environment Agency, Copenhagen, 2000.

the SNE. Consequently, for submission 2009v1.4, it is the SNE (Environment Agency) that acted as the National Inventory Compiler.

Quality assurance, control and plausibility assessments of the estimates have been performed through an internal audit covering all sectors, by the SNE[19] in collaboration with its external QA/QC manager. In addition, various checking procedures, included in CRF Reporter, were undertaken. It is worth noting that all the checks included in CRF Reporter have been passed successfully by submission 2009v1.4. In other words, submission 2009v1.4 is consistent through time[20] and is complete: all the cells/entries have been filled; all the notation keys and recalculations are fully documented.

1.3 Methodologies and Data Sources Used

The following table briefly presents the AD sources, the types of EFs used, as well as the methods applied for estimating GHG emissions reported in submission 2009v1.4. A much more detailed table – based on the table in Annex I of Commission Decision 2005/166/EC, which itself is an expansion of CRF table Summary 3 – is provided in Annex II of this report.

Table 1-4 – Methodologies, data sources and EFs used by Luxembourg for submission 2009v1.4 – main CRF Sectors

CRF Sector	CO_2			CH_4			N_2O		
	method applied	*AD*	*EF*	*method applied*	*AD*	*EF*	*method applied*	*AD*	*EF*
Energy, excl. road transportation – CRF 1 except 1A3b	Tier 1 Tier 2	NS PS Q TÜV	D CS PS	Tier 1	NS PS Q TÜV	D	Tier 1	NS PS Q TÜV	D
Road transportation – CRF 1A3b	CIV	NS ADA	D OTH	CIV	NS ADA	D OTH	CIV	NS ADA	D OTH
Industrial Processes – CRF 2	Tier 2 CS	NS PS	CS PS	NA	NO	NA	NA	NO	NA
Solvent and Other Product Use – CRF 3	CS	NS PS	CS	NA	NA	NA	CS	NS PS	CS
Agriculture – CRF 4	NA	NA	NA	Tier 1 Tier 2	EJ NS	CS D OTH	Tier 1	EJ NS	D
LULUCF – CRF 5	Tier 1 Tier 2	NS EJ	CS D	NA	NA	NA	Tier 1	NS EJ	D
Waste – CRF 6	NA	NA	NA	Tier 1 Tier 2	NS Q PS	CS D	Tier 1	NS Q PS	PS D

Note: for F-gases (IPCC Category 2F) methods applied = CS; AD = NS & Q; EF = CS.

19 And its partner, the Umweltbundesamt in Austria.

20 For those big yearly changes (in %) that were identified as outliers by CRF Reporter procedures, Luxembourg can provide an explanation.

Abbreviations:

C = CORINAIR CS = Country Specific CIV = COPERT IV D = IPCC Default
EJ = Expert Judgement NS = National Statistics OTH = Other PS = Plant Specific Data
Q = Specific Questionnaire/Survey TÜV = TÜV Rheinland, *Emissionskataster für das Großherzogtum Luxemburg*, Köln, 1990

Detailed information on data sources for activity and emission data, as well as for EFs used by sector, can be found in the Chapters 3–8. A few general comments are, however, presented in the next two sub-sections.

1.3.1 Activity and background data

Data used to produce the annual air emission (including GHG) inventories are mainly:

- taken from official statistics published by the National Statistical Institute (STATEC);
- coming from information supplied directly by facilities;
- extracted from statistical information received from other ministries (Ministry of Economic Affairs and External Trade for energy (IEA Joint Questionnaires), Administrations under the authority of the Ministry of Agriculture for agriculture, etc.);
- on occasion, from specific surveys or questionnaire and from expert judgements.

For large point sources – and after careful assessment of data plausibility – activity data that are reported by facilities are preferably used. Indeed, these data usually reflect the actual consumptions better than aggregated national statistics data, because the facility is supposed having the best information about its own emissions. Such plant specific data have been used for CRF sectors 1 and 2. Luxembourg's planned improvement for the future foresees to considerably extent the use of consumption and emission data provided by facilities either in the framework of the EU-ETS and of the E-PRTR in its inventories.

Besides plant specific data collected under EU legal requirements, national obligations are also a source of activity and emission data for single facilities. This is the case under the law for "*établissements classés*"[21] that imposes regular reporting obligations to those units – the "*établissements classés*" – which, by their activities, could represent a risk with regards to security, public health and convenience for both the citizens and the workers occupied in these units, as well as regards the environment.[22] These "*établissements classés*" could be public or private industrial or commercial establishments and craft industries, as well as single specific equipments or processes within an installation.

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21 See http://www.environnement.public.lu/etablissements_classes/index.html (in French).

22 "Permitting activities", i.e. activities subordinated to a permit.

Most of the plant specific data, whether they are collected for EU or national obligations, are actually transmitted and managed by the Environment Agency which eases a more systematic use of data provided directly by facilities. Thus, a more systematic use of facilities' data is currently being implemented. In particular, it is investigated whether it will be feasible, both technically and legally, that facilities would report only once for various purposes – such as EU-ETS, E-PRTR, permitting activities, etc. – in order to avoid extra and unnecessary burden for them.

1.3.2 Emission factors

For EFs, besides plant specific factors derived from emission data transmitted by facilities (see above), it is mainly made use of default IPCC values published in the Revised 1996 or the 2006 IPCC Guidelines, as well as in the 2000 IPCC-GPG. Other sources for EFs are the EMEP/CORINAIR Guidebook and national studies or calculations leading to country specific EFs.

1.4 Key Category Analysis

The identification of key categories is described in the 2000 IPCC-GPG, Chapter 7 and in the 2003 IPCC-GPG-LULUCF, Chapter 5.4. It stipulates that a key category is one that is prioritised within the National System because its estimate has a significant influence on a country's total inventory of GHG in terms of the absolute level of emissions or removals, the trend in emissions or removals, or both. Actually, any category meeting the 95% threshold in any year of the Level Assessment (*LA*) or in the Trend Assessment (*TA*) is considered a key category. Then, whenever a method used for the estimation of emissions/removals of a key category is not consistent with the requirements of the 2000 IPCC-GPG, the method will have to be improved in order to reduce uncertainty, which is considered in the emission inventory improvement programme (see Chapter 9).

All notations, descriptions of identification and results for key categories included in this section are based on the 2000 IPCC-GPG and the 2003 IPCC-GPG-LULUCF. The identification includes all reported GHG CO_2, CH_4, N_2O, HFC, PFC and SF_6, and all IPCC categories.

The key category analysis was performed by the Ministry of the Environment on the basis of submission 2009v1.4 to the UNFCCC. It comprises a level assessment for all years between 1990 and 2007, as well as a trend assessment for the trend of the year 2007 with respect to base year emissions, i.e. 1990. Key source categories have been first identified excluding LULUCF categories and then repeated for the full inventory including LULUCF categories, since submission 2009v1.4 includes for the first time more detailed, yet not complete, emissions/removals estimates for the LULUCF sector.

1.4.1 Key categories for Luxembourg – submission 2009v1.4

This sub-section presents the results of Luxembourg's key category analysis, once excluding LULUCF categories, once including them. The methodology is described in sub-section 1.4.2.

1.4.1.1 Key categories analysis – excluding LULUCF

The identified key categories are listed in Table 1-5. The key source categories comprise 12 517.49 Gg CO_2e in the year 2007, which is a share of 96.9% of Luxembourg's 2007 total GHG emissions, excluding LULUCF.

Table 1-5 – Key categories excluding LULUCF based on emission data recorded in submission 2009v1.4

IPCC	IPCC source category	Fuel	Gas	2007 emissions Gg CO_2e	Share in 2007 national total GHG emissions (excl. LULUCF)
1A1a	Public Electricity and Heat Production	gaseous	CO_2	1291.59	10.00%
1A1a	Public Electricity and Heat Production	other	CO_2	65.68	0.51%
1A1a	Public Electricity and Heat Production	solid	CO_2	NO	NO
1A2a	Iron and Steel	gaseous	CO_2	562.10	4.35%
1A2a	Iron and Steel	liquid	CO_2	6.38	0.05%
1A2a	Iron and Steel	solid	CO_2	NO	NO
1A2c	Chemicals	gaseous	CO_2	167.77	1.30%
1A2c	Chemicals	liquid	CO_2	3.19	0.02%
1A2f	Other	gaseous	CO_2	467.05	3.62%
1A2f	Other	liquid	CO_2	247.85	1.92%
1A2f	Other	other	CO_2	49.69	0.38%
1A2f	Other	solid	CO_2	214.13	1.66%
1A3b	Road Transportation	diesel oil	CO_2	5201.88	40.28%
1A3b	Road Transportation	gasoline	CO_2	1362.02	10.55%
1A3b	Road Transportation	diesel oil	N_2O	70.94	0.55%
1A3b	Road Transportation	gasoline	N_2O	27.95	0.22%
1A4a	Commercial/Institutional	gaseous	CO_2	312.73	2.42%
1A4a	Commercial/Institutional	liquid	CO_2	368.31	2.85%
1A4b	Residential	gaseous	CO_2	312.73	2.42%
1A4b	Residential	liquid	CO_2	352.37	2.73%
1A5b	Other – Mobile	liquid	CO_2	6.38	0.05%
2A1	Cement Production	-	CO_2	426.27	3.30%
2A7	Other – Glass Production	-	CO_2	62.92	0.49%
2C1	Iron and Steel Production	-	CO_2	203.49	1.58%
2F	Emissions of F-gases	-	F-gases	90.98	0.70%
4A1	Enteric Fermentation – Cattle	-	CH_4	240.69	1.86%
4B1	Manure Management – Cattle	-	CH_4	62.55	0.48%
4D1	Agricultural Soils – Direct Soil Emissions	-	N_2O	166.38	1.29%
4D2	Agricultural Soils – Pasture, Range & Paddock Manure	-	N_2O	55.12	0.43%
4D3	Agricultural Soils – Indirectl Emissions	-	N_2O	118.36	0.92%

Table 1-6 indicates which source categories have been identified as key categories for every reported year from 1990 to 2007.

Table 1-6 – Key categories excluding LULUCF (qualitative) of submission 2009v1.4: 1990-2007

IPCC	IPCC source category	Fuel	Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007
				LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	TA
1A1a	Public Electricity and Heat Production	gaseous	CO_2						X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A1a	Public Electricity and Heat Production	other	CO_2									X	X	X	X	X	X	X			X	
1A1a	Public Electricity and Heat Production	solid	CO_2	X	X	X	X	X	X	X	X											
1A2a	Iron and Steel	gaseous	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A2a	Iron and Steel	liquid	CO_2		X	X	X	X	X		X	X	X									X
1A2a	Iron and Steel	solid	CO_2	X	X	X	X	X	X	X	X											
1A2b	Non-Ferrous Metals	gaseous	CO_2																			X
1A2c	Chemicals	gaseous	CO_2	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A2c	Chemicals	liquid	CO_2	X	X	X	X	X	X	X	X											X
1A2f	Other	gaseous	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A2f	Other	liquid	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A2f	Other	other	CO_2																X	X		
1A2f	Other	solid	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A3b	Road Transportation	diesel oil	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A3b	Road Transportation	gasoline	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A3b	Road Transportation	diesel oil	N_2O																X	X	X	X
1A3b	Road Transportation	gasoline	N_2O							X	X	X	X	X	X	X						
1A4a	Commercial/ Institutional	gaseous	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A4a	Commercial/ Institutional	liquid	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A4b	Residential	gaseous	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A4b	Residential	liquid	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A5b	Other – Mobile	liquid	CO_2									X										
2A1	Cement Production	-	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2A7	Other – Glass Production	-	CO_2	X		X	X	X	X	X	X	X	X	X	X		X	X			X	
2C1	Iron and Steel Production	-	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2F	Emissions of F-gases	-	F-gases										X	X	X	X	X	X	X	X	X	X
4A1	Enteric Fermentation – Cattle	-	CH_4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
4B1	Manure Management – Cattle	-	CH_4		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
4D1	Agricultural Soils – Direct Soil Emissions	-	N_2O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

IPCC	IPCC source category	Fuel	Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007
				LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	TA
4D2	Agricultural Soils – Pasture, Range & Paddock Manure	-	N_2O	X	X				X	X	X	X	X	X	X							
4D3	Agricultural Soils – Indirectl Emissions	-	N_2O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

1.4.1.2 Key categories analysis – including LULUCF

The identified key categories are listed in Table 1-7. The key source categories comprise 11 803.32 Gg CO_2e in the year 2007, which is a share of 94.3% of Luxembourg's 2007 total GHG emissions, including LULUCF.

Table 1-7 – Key categories including LULUCF based on emission data recorded in submission 2009v1.4

IPCC	IPCC source category	Fuel	Gas	2007 emissions Gg CO_2e	Share in 2007 national total GHG emissions (excl. LULUCF)
1A1a	Public Electricity and Heat Production	gaseous	CO_2	1291.59	10.31%
1A1a	Public Electricity and Heat Production	solid	CO_2	NO	NO
1A2a	Iron and Steel	gaseous	CO_2	562.10	4.49%
1A2a	Iron and Steel	liquid	CO_2	0.01	0.00%
1A2a	Iron and Steel	solid	CO_2	NO	NO
1A2c	Chemicals	gaseous	CO_2	167.77	1.34%
1A2c	Chemicals	liquid	CO_2	3.19	0.03%
1A2f	Other	gaseous	CO_2	467.05	3.73%
1A2f	Other	liquid	CO_2	247.85	1.98%
1A2f	Other	solid	CO_2	214.13	1.71%
1A3b	Road Transportation	diesel oil	CO_2	5201.88	41.54%
1A3b	Road Transportation	gasoline	CO_2	1362.02	10.88%
1A4a	Commercial/Institutional	gaseous	CO_2	312.73	2.50%
1A4a	Commercial/Institutional	liquid	CO_2	368.31	2.94%
1A4b	Residential	gaseous	CO_2	312.73	2.50%
1A4b	Residential	liquid	CO_2	352.37	2.81%
2A1	Cement Production	-	CO_2	426.27	3.40%
2A7	Other – Glass Production	-	CO_2	62.92	0.50%
2C1	Iron and Steel Production	-	CO_2	203.49	1.62%
4A1	Enteric Fermentation – Cattle	-	CH_4	240.69	1.92%
4B1	Manure Management – Cattle	-	CH_4	62.55	0.50%
4D1	Agricultural Soils – Direct Soil Emissions	-	N_2O	166.38	1.33%
4D2	Agricultural Soils – Pasture, Range & Paddock Manure	-	N_2O	55.12	0.44%
4D3	Agricultural Soils – Indirectl Emissions	-	N_2O	118.36	0.95%
5A1	Forest Land Remaining Forest Land	-	CO_2	|396.18|	|3.16%|

Table 1-8 indicates which source categories have been identified as key categories for every reported year from 1990 to 2007.

Table 1-8 – Key categories including LULUCF (qualitative) based on emission data recorded in submission 2009v1.4: 1990-2007

IPCC	IPCC source category	Fuel	Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007
				LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	TA
1A1a	Public Electricity and Heat Production	gaseous	CO_2													X	X	X	X	X	X	X
1A1a	Public Electricity and Heat Production	solid	CO_2	X	X	X	X	X	X	X	X											
1A2a	Iron and Steel	gaseous	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A2a	Iron and Steel	liquid	CO_2		X																	
1A2a	Iron and Steel	solid	CO_2	X	X	X	X	X	X	X	X											
1A2b	Non-Ferrous Metals	gaseous	CO_2																			X
1A2c	Chemicals	gaseous	CO_2									X	X	X				X		X		X
1A2c	Chemicals	liquid	CO_2	X	X																	X
1A2f	Other	gaseous	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A2f	Other	liquid	CO_2	X	X							X	X	X	X				X	X	X	X
1A2f	Other	solid	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
1A3b	Road Transportation	diesel oil	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A3b	Road Transportation	gasoline	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A3b	Road Transportation	diesel oil	N_2O																			X
1A4a	Commercial/ Institutional	gaseous	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A4a	Commercial/ Institutional	liquid	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A4b	Residential	gaseous	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1A4b	Residential	liquid	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2A1	Cement Production	-	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2A7	Other – Glass Production	-	CO_2	X																		
2C1	Iron and Steel Production	-	CO_2	X	X	X	X	X	X	X	X	X								X	X	X
2F	Emissions of F-gases	-	F-gases																			X
4A1	Enteric Fermentation – Cattle	-	CH_4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
4B1	Manure Management – Cattle	-	CH_4		X																	
4D1	Agricultural Soils – Direct Soil Emissions	-	N_2O	X	X	X		X	X			X	X	X	X							
4D2	Agricultural Soils – Pasture, Range & Paddock Manure	-	N_2O	X	X																	
4D3	Agricultural Soils – Indirectl Emissions	-	N_2O	X	X			X	X													

IPCC	IPCC source category	Fuel	Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007
				LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	TA
5A1	Forest Land Remaining Forest Land	-	CO_2	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

1.4.2 Description of methodology

The identification of key source categories follows the Tier 1 method - quantitative approach described in the 2000 IPCC-GPG, Chapter 7 (Methodological Choice and Re-calculation) and in the 2003 IPCC-GPG-LULUCF, Chapter 5.4 (Methodological Choice – Identification of key categories).

The analysis includes all GHG reported under UNFCCC: CO_2, CH_4, N_2O, HFC, PFC and SF_6. All IPCC categories are included.

As indicated above, key categories were identified for the inventory excluding LULUCF and, then, including LULUCF. Therefore, the identification of key categories consisted of four steps:

a) identifying categories;
b) Level Assessment excluding/including LULUCF;
c) Trend Assessment excluding/including LULUCF;
d) qualitative considerations.

The qualitative criteria considered were: mitigation techniques, high expected growth of emissions/removals and unexpected low or high emissions/removals. No additional key source categories were identified with those qualitative criteria.

1.5 Quality Assurance and Quality Control (QA/QC)

The overall responsibility for the establishment and existence of a Quality Management System (QMS), in order to prepare the national inventory of greenhouse gases and air pollutants, lies with the Environment Agency (Administration de l'Environnement, AEV).

Being designated by a grand-ducal regulation[23] as the single national entity (SNE), the AEV, has the overall technical responsibility for the national GHG Inventory. Political responsibility lies with the Ministry of the Environment (MEV). Within the AEV, the Air/Noise Division is responsible for the following tasks:

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23 Grand-Ducal Regulation (règlement grand-ducal du 1 août 2007)

The National Inventory Compiler (NIC):

- supervises the inventory preparation process for various obligations as outlined below;
- is the national inventory focal point to the Ministry (MEV).

The national, European and international obligations are:

- UNECE Convention on Long Range Transboundary Air Pollution and its protocols
- UNFCCC & Kyoto Protocol
- European Union:
    - EU GHG Monitoring Mechanism (280/2004/EC & 2005/166/EC)
    - NEC Directive (2001/81/EC)
    - Ambient Air Quality Directive (2008/50/EC).

1.5.1 Quality Policy

The quality policy is the central aspect of a Quality Management System. It defines the understanding of quality in relation to all topics of inventory preparation and specifies its basic principles.

The single national entity has:

- to establish and maintain the quality policy and quality objectives regarding GHG Inventories;
- to promote the quality policy and quality objectives regarding GHG Inventories throughout the organisation to increase awareness, motivation and involvement;
- to ensure focus on the fulfilment of the Kyoto Protocol and the requirements of the IPCC GPG Chapter 8 QA/QC;
- to ensure that appropriate processes are implemented to enable requirements of the IPCC GPG Chapter 8 QA/QC (and other interested parties) to be fulfilled and quality objectives to be achieved;
- to ensure that an effective and efficient QMS is established, implemented and maintained in order to achieve these quality objectives;
- to ensure the availability of necessary resources;
- to review the Quality Management System periodically;
- to decide on actions regarding the quality policy and quality objectives regarding GHG Inventories;
- to decide on actions for the improvement of the Quality Management System;
- to decide on actions for the improvement of national GHG inventories.

1.5.2 Quality Management System Build-up

The build-up of the Quality Management System (*QMS*) of the GHG emission reporting is currently outsourced and supervised by SEG Umwelt-Service GmbH[24].

Luxembourg's QMS follows a Plan-Do-Check-Act-Cycle (PDCA-cycle)[25], which is an accepted model for pursuing a continual improvement of performance according to international standards and is in line with procedures described in decision 19/CMP.1 and in the IPCC Good Practice Guidance.

Due to Luxembourg's clear extent, its QMS deals with a manageable quantity of documents. Following are the specifications of Luxembourg's Quality Management System:

- firm build-up with a quality manual consisting of a chart with all relevant documents, handling instructions and deadlines for check (Figure 1-5);
- good manageability (instead of a complex system);
- usable and effective quality control procedures (user-friendly, clearly arranged).

Since the QMS has been implemented in the year 2008, it needs further development and improvements. The QMS framework exists and needs to proof its efficiency during the following years.

The QMS shall ensure and continuously improve the quality (measured by transparency, accuracy consistency, comparability, completeness (TACCC) and timeliness) of Luxembourg's GHG Inventory in order to fulfil the party's obligations according to articles 3, 5 and 7 of the Kyoto Protocol. The QMS therefore supplies procedures to:

- check integrity, correctness and completeness of data;
- identify errors and omissions;
- reduce uncertainties of emission estimates;
- document and archive inventory calculation sheets and background data.

1.5.3 QMS Structure

Luxembourg's Quality Management System (QMS) of the GHG Inventory is organised in three layers (Figure 1-5):

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24 SEG Umwelt-Service GmbH, Auf der Haardt 2, D – 66693 Mettlach, http://www.seg-online.de

25 http://www.asq.org/learn-about-quality/project-planning-tools/overview/pdsa-cycle.html

a) Performance processes

Performance processes directly concern the compilation of the GHG Inventory. They comprise input data, data acquisition, calculations, and generation of CRF tables and NIR as well as quality control checks and the outcomes of the NIR and CRF-tables.

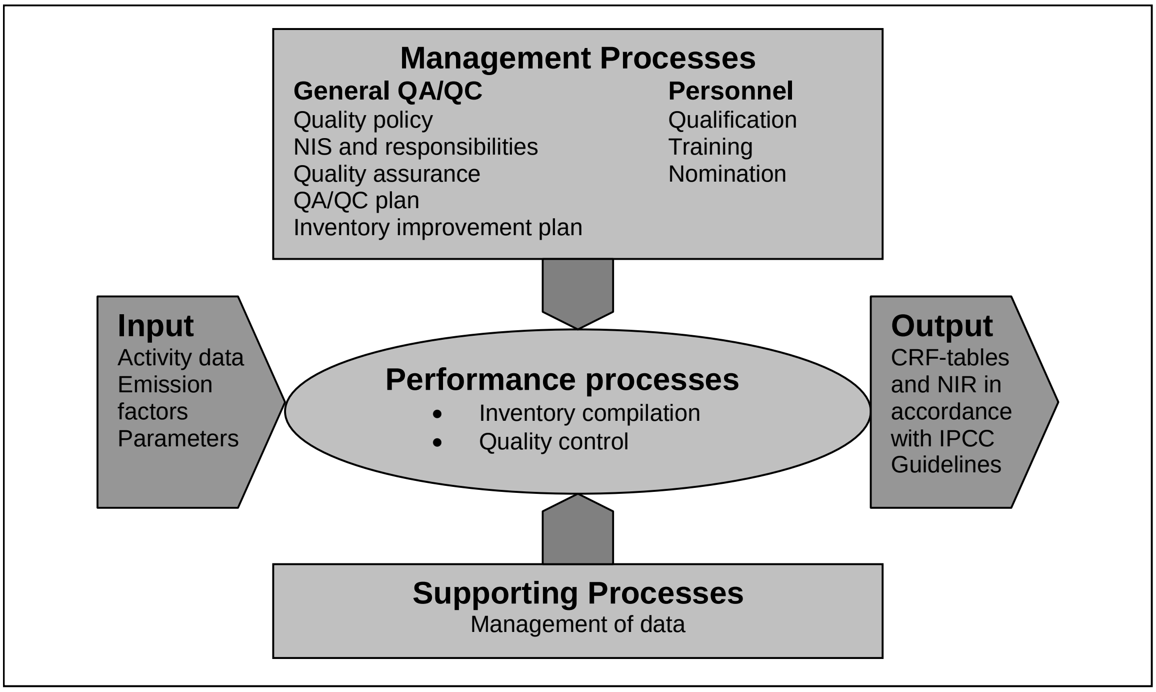
b) Management processes

Management processes control the system's performance by defining quality objectives, responsibilities, quality assurance procedures, improvement plans and the personnel's qualifications and obligations.

c) Supporting processes

Supporting processes assist the system's performance by providing technical requirements and standards.

Figure 1-5 – QMS structure



1.5.4 Quality Manual

The applied quality manual adopts the structure of the QMS and is divided in management, performance and supporting processes.

For each process, a list of related documents exists with information on content, handling, interval of document check and planned improvement. An extract of the quality manual is given below (Figure 1-6).

Figure 1-6 – Extract of QA/QC Manual

	QA/QC procedure	purpose	document	content	handling	interval of document check	planned improvement
management processes	quality policy	basis of the implemented quality management system	quality policy	...	...	...	...
	general QA/QC	organisation of inventory work	definitions and list of abbreviations	...	...	...	...
			Luxembourg's National Inventory System	...	...	...	...
			responsibilities	...	...	...	...
	personnel		nominations	...	...	...	...
			job specification and obligation for secrecy	...	...	...	...
			personal file	...	...	...	...
	quality assurance	to support and complete quality control measures	internal audit programm	...	...	...	...
		check of formal aspects	internal audit report	...	...	...	...
		check of applicability & comparisons	external audit report	...	...	...	...
			audit list	...	...	...	...
			inconsistencies	...	...	...	...
	QA/QC plan	list of objectives and proposed actions in order to improve inventory's quality	QA/QC plan	...	...	...	...
performance processes	inventory		inventory timetable	...	...	...	...
			calculation sheets	...	...	...	...
			documentation standard operating procedure	...	...	...	...
			NIR and crf-tables	...	...	...	...
	quality control	activities to assess and maintain the quality of the inventory being compiled	data validation	...	...	...	...
pporting ocesses	data manageme	definition of data naming and archiving	data flow	...	...	...	...
			management of input data for multiple use	...	...	...	...

1.5.5 Inventory Timetable

The inventory timetable gives several schedules to control the performance of inventory compilation, quality control and quality assurance procedures, implementation of inventory improvements and inventory publication (see also Figure 1-3).

In addition, there are summaries of deadlines regarding EU and UNFCCC submissions.

1.5.5.1 Timetable for inventory planning and preparation

This schedule refers to general inventory work:

- Yearly meetings of the inventory work group and the decision making body
- Key category analysis
- Uncertainty analysis
- Generation of CRF-tables
- NIR preparation and finalisation
- NIR and CRF submission
- Publication and archiving of NIR
- Consideration and implementation of EU review recommendations
- Consideration and implementation of UNFCCC review recommendations
- Internal and external training
- Documentation and archiving

1.5.5.2 Sector specific timetable for inventory planning and preparation

This schedule refers to sector specific compilation work and quality control checks:

- Collection of activity data, emission factors and other parameters
- Calculation of emissions and removals
- Quality check of data, comparison with previous years, documentation of calculations and assumptions
- Uncertainty analysis
- Completion of checklists and other QC activities
- Documentation and archiving

1.5.5.3 QA/QC timetable

This schedule especially refers to QA procedures:

- Internal audit
- Implementation of internal review recommendations
- Yearly meetings of the inventory work group and the decision making body
- QA/QC training for the National Inventory Compiler and the sector experts.

1.5.6 Quality Control and Quality Assurance procedures

The first steps to implement quality control and quality assurance procedures have already been undertaken but need further improvement. The current status and planned improvements are described in the following sub-sections.

Figure 1-7 – QA/QC Procedures

does NOT require knowledge of the emission source category	requires knowledge of the emission source category
general	source specific
QC procedures sector experts (1st party) performed throughout preparation of inventory	
TIER 1	**TIER 2**
data validation, calculation sheet (check of formal aspects)	preparation of NIR, comparison with Guidelines (check of applicability, comparisons)
QA procedures quality manager (2nd or 3rd party; staff not directly involved, preferably independent) performed after inventory work has finished	
TIER 1 basic, before submission	
	Internal audit / EU 'Initial check' (Expert Peer Review)
	evaluate if TIER2 QC is effectively performed (check if methodologies are applicable)
TIER 2 extensive	
System audit by Umweltbundesamt (Audit)	**ICR by UNFCCC (Expert Peer Review)**
evaluate if TIER 2 QC is effectively performed	evaluate if TIER 2 QC is effectively performed (Check if methodologies are applicable)

1.5.6.1 Quality Control procedures

The following Quality Control procedures are conducted:

Meeting of the inventory group twice a year (the inventory group consists of the head of the AEV, the National Inventory Compiler, the sector experts and the quality manager) in order to appoint responsibilities, priorities and schedules of inventory work.

Checklists for validation of data that have to be completed by sector experts until data are transmitted to the National Inventory Compiler. An example of a data validation checklist is given in Figure 1-8.

Figure 1-8 – Data Validation Checklist

Data:	1990 - 20															**Tier 1 Checklist**
Source:	CRF			Snap												
	Activity data			**check done**			**Emission factor**			**check done**			**Emissions**			**check done**
Greenhouse gas	CO2	CH4	N2O	Remarks	Date	Person	CO2	CH4	N2O	Remarks	Date	Person	CO2	CH4	N2O	Remarks
Content check																
Trend checks																
For each category, current inventory estimates should be compared to previous estimates, if available. If there are significant changes or departures from expected trends, re-check estimates and explain any differences																
Data plausible in comparison to other references																
Check time series consistency																
For each category check input data for temporal consistency in time series																
Check methodological and data changes resulting in recalculations																
Check that the effects of mitigation activities have been appropriately reflected in time series calculations																
Check completeness																
Confirm that estimates are reported for all categories and for all years from the appropriate base year to the period of the current inventory																
For subcategories, confirm that entire category is being covered																
Provide clear definition of „Other" type categories																
Check that known data gaps that result in incomplete estimates are documented, including a qualitative evaluation of the importance of the estimate in relation to total emissions																
Uncertainty estimation of data existent																
data relying on a legal reporting commitment																
Formal check																
Collection of data is understandable																
Check that assumptions and criteria for the selection of data are documented																
Assumptions and criteria for the selection of data are documented																
Cross-check descriptions of activity data, emission factors and other estimation parameters with information on categories and ensure that these are properly recorded and archived																
Check for transcription errors in data input and reference																
data correctly entered and transcribed																
Confirm that bibliographical data references are properly cited in the internal documentation																
Cross-check a sample of data from each source category (either measurements or parameters used in calculations) for transcription errors																
Accurate data aggregation and correctness of calculations																
Parameters and units are correctly recorded																
Data fields are properly labelled																
Data transmission of intermediate result correct																
Units are properly labelled and correctly carried through from beginning to end of calculations																
Conversion factors respectively temporal and spatial adjustment factors are correct																
Data path and data coherence are understandable																
Consistency given for the multiple use of data																
Archiving of data and records ensured																
Emissions complete																
Uncertainty estimation of emissions existent																
emission measurements in compliance with international accredited standards																

	Uncertainties			**check done**		
Greenhouse gas	CO2	CH4	N2O	Remarks	Date	Person
Content check						
Check that uncertainties in emissions and removals are estimated and calculated correctly						
Check that qualifications of individuals providing expert judgement for uncertainty estimates are appropriate						

Checks for validation of data include:

- checks of activity data (trend checks, time series consistency, completeness, check of assumptions and criteria for activity data, check for transcription errors in data input and reference)
- checks of emission factors (trend checks, time series consistency, completeness, check of correct recording of units and the use of appropriate conversion factors, check of documentation of assumptions and criteria for the selection of emission factors, check for transcription errors in data input and reference)
- checks of emissions (trend checks, time series consistency, completeness, check of documentation of assumptions and criteria for emissions, check for transcription errors in data

input and reference, check of correct recording of units and the use of appropriate conversion factors)

- check of uncertainties (check of correct calculation and estimation of uncertainties in emissions and removals).

1.5.6.2 Quality Assurance procedures

The following Quality Assurance procedures are conducted:

Internal audit during NIR preparation time performed by the quality manager, the National Inventory Compiler and a consultant from the "Umweltbundesamt Wien". The internal review analyses every sector as well as the QMS system and checks:

- whether inventory work and the inventory comply with Revised 1996 IPCC Guidelines, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories and Good Practice Guidance for Land Use, Land Use Change and Forestry
- whether data acquisition, calculation, referencing and archiving is handled according to the defined methods
- whether there are enough resources for inventory work
- whether relevant data are available and if the reliability of external data is guaranteed
- whether the QMS system needs improvement
- whether recommendations of EU reviews, UNFCCC reviews and previous internal audits have been considered and implemented.

QA/QC training for the sector experts and the National Inventory Compiler during execution of the internal audit.

Support by inventory experts from the "Umweltbundesamt Wien".

External audits conducted by experts who provide support for inventory work, EU or UNFCCC.

1.5.6.3 QA/QC plan

The results from internal and external audits are merged in the QA/QC plan. This plan lists the relevant sector, recommendations for improvement, responsibilities, deadlines and gives opportunity for attest.

Since the current QA/QC plan contains recommendations for the improvement of the QMS as well as for inventory improvement, it will be segmented in a QA/QC plan and an inventory improvement plan in 2009.

In addition, there will be a decision making body that will be able to prioritise the recommended improvements and at the same time be able to care for associated resources.

1.5.6.4 Planned improvements

The following QMS improvements should be implemented in 2009:

- Definition and implementation of quality objectives (revision of the quality policy draft).
- Establishment of a decision making body for relevant decisions such as adopting the QA/QC and the inventory improvement plan, prioritisation of possible inventory improvements and the set of deadlines.
- Segmentation of the current QA/QC plan in a QA/QC and an inventory improvement plan.
- Definition of roles of experts in the QMS.
- Preparation of checklist procedures according to the role and process step in inventory work.
- Establishment of an official approval procedure for the GHG Inventory before submission.

1.5.7 Archiving and documentation

Within the inventory system, a system for transparent documentation of inventory data and related information (special circumstances, assumptions etc.) is implemented. Archiving takes place on the server "Circa" within the folder "Inventaires gaz à effet de serre"[26]. The data is secure for at least fifteen years.

As a principle every file shall be named clearly, shall be write/delete protected and supply relevant information concerning validity in the footer.

1.6 Uncertainty Assessment

Uncertainty estimates are an essential element of a complete inventory of greenhouse gas emissions and removals and requires a detailed understanding of the uncertainties of the respective input parameters. They should be derived for both the national level and the trend estimate, as well as for the component parts such as emission factors, activity data and other estimation parameters for each category.[27] Principally, two different TIER for the estimation of combined uncertainties are presented in the IPCC GPG: TIER 1 uses simple error propagation equations, while TIER 2 uses Monte Carlo.

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26 https://circalux.etat.lu/Members/irc/public/invges/home (only for members)

27 2000 IPCC GPG – Chapter UNCERTAINTIES

TIER 1 is based upon error propagation and is used to estimate uncertainty in individual categories, in the inventory as a whole, and in trends between a year of interest and a base year. The key assumptions, requirements, and procedures are described here. TIER 1 should be implemented using Table 3.2 of the IPCC Guidelines for National Greenhouse Gas Inventories (2006).

The TIER 2 is based on a Monte Carlo analysis, which is suitable for detailed category-by-category assessment of uncertainty, particularly where uncertainties are large, distribution is non-normal, the algorithms are complex functions and/or there are correlations between some of the activity sets, emissions factors, or both.

In December 2007, the Environment Agency contracted Austrian Research Centers GmbH - ARC [28] for performing a detailed uncertainty analysis of Luxembourg's GHG inventory[29]. National information or at least national expert knowledge directly from the stage of inventory development was used for the assessment of uncertainties.

Since the last submission and as a follow up of the 2007 in-country-review, the CRF Sectors 1 & 5 have been revised. Furthermore new key categories are identified. For those new categories uncertainties are defined for activity data and emission factors in the same manner as has been done in the study[29].

Due to limited resources and assigned priority within the inventory preparation for the submission 2009 only a TIER 1 uncertainty analysis was performed. It is planed to update the TIER 2 analysis periodically.

The respective sectoral uncertainties are documented in detail in the sectoral chapters of this report.

1.6.1 Data origin

In the following the used activities as evaluated within the framework of the study [29] are described.

1.6.1.1 Data origin - Energy & Transport

Activities

A comprehensive top-down – bottom-up approach was conducted by the Environment Agency for the entire energy sector. In these consultations were involved

- «Ministère de l'Economie et du Commerce Extérieur», «Ministère de l'Environnement» and «Ministère des Transports » ;

28 www.arcs.ac.at/

29 Winiwarter and Köther, 2008, Uncertainty related to Luxembourg's national Greenhouse Gas inventory, ARC, Vienna (Austria)

- Administration de l'Environnement: Division Air/Bruit, Division des Déchets, Division des Établissements Classés, Registre des quotas d'émission de gaz à effet de serre du Luxembourg ;
- Administration des Douanes et Accises (Ministère des Finances);
- Statec: Service Central de la Statistique et des Etudes Economiques;
- all relevant fuel importer and fuel distributor's;
- plant operator's;
- CFL Société Nationale des Chemins de fer Luxembourgeois.

Primary energy carrier in Luxembourg is natural gas. Gas is used in the major power plant (TwinErg), in industry including electro-steel works (Arbed, now known as Arcelor-Mittal) and in domestic heating (private households as well as commerce). The ministry of economy collects consumption / import data from the only provider SOTEG. Since 2006, other providers also enter the market, but the still use the transport facilities (pipelines) of SOTEG – thus the data situation remains stable.

Comparison of data is possible between figures reported by industry participating to the ETS, and the distributor's figures as well as emission reports of plant operators. This is the only country-specific information on uncertainty that is available.

There are some preparatory activities for biogas cleaning in order to be fed it into the gas network.

The amount of gasoline and diesel fuel being sold in Luxembourg gas stations is monitored by monthly reports from the petrol distributors. Eight major companies exist ; products are being refined mostly in Belgium and Netherlands and imported. Even strategic reserves (90 days consumption) are being stored outside Luxembourg. It is believed that the information provided is of high quality.

Liquid fuels play also a role in the commerce and private combustion sector, even if this contributes much less to overall emissions. However, distribution of heating fuels outside Luxembourg may be prone to foreign legislation and taxation thus limiting importance of exports.

Solid fuels played a considerable role in the past, both in the power plant and in the steel industry sectors. This changed during the mid 1990's, when the blast furnaces were closed down and the modern gas fired power plant was started up. An analysis of solid fuel combustion and its quality is somewhat difficult to perform as an ex post analysis.

Emission factors

Emission factors for CO_2 are generally straightforward; they derive from the carbon content of the fuel. As the carbon content of fuels is closely coupled to the energy content, and the assessment of energy quantities is normally given as energy units (or in other units together with a defined conversion factor), thus much of the uncertainty included in the numbers presented is present likewise in the conversion factor and cancels out.

The situation for CH_4 and N_2O emission factors is quite different. Factors have been taken from IPCC 2006 guidelines (default factors) or COPERT III methodology, respectively. Especially the application of COPERT default factors for N_2O emissions is associated with high uncertainties as COPERT III is based on the situation (available N_2O measurements) in 2000 and much more information is now available on transport N_2O emissions. Comparing COPERT III emission factors [30] to alternate emission factors [31, 32] indicates differences up to a factor 3 with COPERT III emission factors (but also within each other).

1.6.1.2 Data origin - Industrial Processes

Within processes, two key sources are to be noted (cement production, iron and steel production). In addition, a quite limited number of industrial installations has to be considered. Product use is covered in a specific study on F-gases.

Cement production:
One plant exists in Luxembourg, which exclusively produces clinker. Any confusion with total cement production is impossible, as cement is mixed (from the clinker produced) at a different facility of the same company. Ca content of product is used to estimate CO_2 emissions (according to IPCC methodology) which is a stoechiometric factor. Errors could only occur at high Mg content which however is not the case. Ca content as well as amount of production are submitted directly by the producer. Ca content is fairly stable near 67%, there is little reason for uncertainty. Using IPCC default uncertainty estimates (IPCC, 2006) thus provides most probably an overestimation. Using an activity uncertainty of 1.5%, emission factor uncertainty of 2% not including 1.5% analytical uncertainty for Ca content (including this factor makes 2.5% for emission factor uncertainty) yields an overall uncertainty of 3%.

Iron and Steel production:
Very different conditions exist for the situation of 1990 and since about 2000. Originally, Luxembourg steel industry used basic oxygen furnaces that were fed with one third scrap metal, and two thirds raw iron from blast furnaces. Blast furnaces operated on imported coke, anthracite and calcium oxide. Thus emissions due to coking or calcination never occurred in Luxembourg. In the

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30 Ntziachristos and Samaras, 2000, EEA Technical Report No 45, EEA, Copenhagen (Denmark)
31 INFRAS, 2004, Handbuch Emissionsfaktoren des Strassenverkehrs (HBEFA 2.1), Bern (Switzerland)
32 Winiwarter, 2005, IR-05-055, IIASA, Laxenburg (Austria)

1990's, basic oxygen furnaces were replaced by electric arc furnaces to be operated on scrap only. Blast furnaces became redundant by the end of 1997.

Both parts of steel production combine process and energy related emissions in a way that make them difficult to be disentangled. For pragmatic reasons (and to be as close as reasonable to the real situation) gaseous fuels have been considered causing energy related emissions (this includes blast furnace gas derived from solid fuels), and solid fuels (coke, anthracite, residue oil and – for electric arc furnaces – carbon electrodes) process related. The most problematic point here is probably the differentiation between blast furnace gas and the underlying solid fuels. This definitely is correlated via the energy balance.

Three Steel plants exist in Luxembourg, all of the same company (Arcelor-Mittal). In addition, a plant recuperating iron from slag and collected dust (direct reduction furnace) is also considered (Primorec). Information on production, carbon content and amount of fuels is available in all cases. In the electric arc furnaces, a considerable fraction of carbon (10-15%) contributing to CO_2 derives from electrodes.

A preliminary uncertainty analysis has been performed for the iron and steel industry, using IPCC uncertainty defaults but due to detailed information IPCC default uncertainties probably overestimate the Luxembourg situation.

Glass production:
One facility produces glass and provides production figures. The emission factor derives from the loss on ignition of raw materials, also provided by the manufacturer. This factor is confirmed by an alternative method assessed according to the ETS system. Still the uncertainty estimates have been adapted from the IPCC default (IPCC, 2006) in a national approach and in consequence the 2% used for activity and 5% for emission factor more probably are a high estimate of this sector's uncertainty.

F-gases:
A study assessing F-gas emissions has been completed, a new study commissioned. According to preliminary results, the new study confirms the finding of the study already completed. F-gas emissions derive primarily from refrigeration and air conditioning systems, switches, insulation windows and similar devices. All estimates are highly uncertain – especially as it is almost impossible to assess cross-border effects. E.g. repair (refilling) of refrigeration systems can be done by national or foreign technicians – interviewing support suppliers in Luxembourg alone will not work.

1.6.1.3 Data origin - Solvent and Other product use

Solvents:

A study assessing emissions from solvent use has been completed in 2008. The main activity data are the foreign trade statistics and production statistics as well as inquiries from relevant plant operators.

N_2O use:

Based on figures in the German inventory, a per-capita rate of 40g/person and year have been applied. No information on uncertainty is presented.

1.6.1.4 Data origin - Agriculture

Assessment of CH_4 emissions from Luxembourg's agriculture follows strictly IPCC guidelines. Since 2007, a common base of statistics exists between the statistical office STATEC and the Service d'Economie Rurale (Ministry of agriculture) (unpublished data) for data on the structure of agricultural holdings. Previously, differences less than 1% e.g. on extension of agricultural land (130,000 ha) were observed. Production data produced by the Service d'Economie Rurale are estimated to be similarly precise.

Since the BSE crises, a register is used to cover each individual bovine animal. Ear marks had been used before already. The register categories (using the Belgian system SANITEL, where Luxembourg is treated like a Belgian province) do not always provide the full information required for emission calculation – specifically, no differentiation between milk cow and suckler cow is directly available through the register. However it is possible to approach these categories through the characteristics contained in the register and other information available. Luxembourg national figures on milk yield have been applied.

The agricultural sector, especially bovine production, is extremely carefully being supervised – for sanitary reasons, but also because of subsidies. The uncertainty is somewhat higher in pigs than bovines (numbers in reports by farms are rounded) or in sheep, which are often reported by part-time farmers; in contrast, goat numbers are more precise as they derive from larger farms. Horses are only covered if "horse clubs" are registered as farms– pleasure horses are not included in the statistics.

Differentiation between systems (solid-liquid) is based on expert judgement (ASTA). Bovines are assumed to spend half a year (6 months) outside, and 6 months inside buildings.

Bookkeeping regarding nitrogen balance is provided by about 800 farms (this covers more than half of the full-time farmers), and total nitrogen balances are derived from this number according to the agricultural area (not according to crop). Fertilizer sales statistics are not being used, as there is considerable "private level" fertilizer sales across the border – not covered by export statistics.

Precise data are available since 1999. Improved application has been shown to positively influence N-balances, but fertilizer prices are also reflected in the statistical data.

N from manure is not considered in N balances, but instead is derived from the animal numbers.

N-fixing crops are taken from crop statistics (alfalfa, clover – problem are mixtures with grassland as extent of mixture is not clear); for sewage sludge see chapter on Wastewater.

1.6.1.5 Data origin - Waste

Waste disposal:
Waste disposal is organized via three regional disposal districts, which originally have been formed due to hygienic considerations. The southern district (SIDOR) operates a waste incinerator (MWI), which is considered in the "energy" section. About two thirds of Luxembourg's waste are being combusted, approx. 130000 t/yr. Recently, the northern district (SIDEC) started a mechanical-biological treatment plant. Routinely separation of combustible material has been performed, which is used at the only waste incinerator. The remaining waste is landfilled, like also in the eastern district (SIGRE) where only simple (cold) pre-treatment is performed. Recovery of landfill waste started in 2002 (flaring) and 2000 (electricity and heat plant), respectively.

Amounts of waste originally have been estimated by volume only, but since the 1990's weight of waste is available. Waste fractions have been analysed in specific campaigns (mid-1990's, mid-2000's, and around 2000 for SIDOR only), specifically clustering information by consumer habits and availability of waste separation facilities.

Waste analysis is being used to determine IPCC waste fractions to which default DOC contents are applied. Evaluation of results of waste analysis (in other context) is being performed on differences between years smaller than 1 abs.-%, indicating that the authors put large confidence in the results. No information is available on the composition of the combustible fraction taken off the SIDEC waste and delivered to the MWI. This fraction will have a higher C content than the average waste, neglecting may lead to a potential underestimation of the fossil CO2 emitted from the MWI and a potential overestimation of total DOC amounts in SIDEC.

In accordance with IPCC guidelines, conversion of DOC into 50% methane is assumed using a first order decay function, not accounting for methane oxidation in the top soil layer. Recovered CH4, as determined from monthly reports of the landfill operators (measured quantities) is subtracted from the estimated emissions.

Composting:
Seven composting installations exist in LU, plus one that co-composts sewage sludge. The latter ("soil concepts" plant) uses active ventilation and operates fully aerobic – without methane formation. The other plants operate in part under anaerobic conditions, with a residence time in the

composter of a few weeks. Emission calculation is performed using default factors from the IPCC guidelines, where also uncertainty estimates can be taken from.

Wastewater:

The division of water protection in the interior and land management ministry performs emission calculation themselves. The sector is not among the key sources. Measured data of organic C and organic N are being used to understand the flows of C and N in the systems. This allows circumventing the less meaningful parameters of population equivalents. In Luxembourg, there are 7 waste water treatment plants designed for a population equivalent of >50000, 5 additional > 10000, plus 19 > 2000. These plants provide analytical data of input and output N and C, thus also allowing to estimate the conversion. 90% of total wastewater from Luxembourg is covered.

1.6.2 Assessing input uncertainties

In the following the assessing input uncertainties as evaluated within the framework of the study[29] are described.

1.6.2.1 Method

Information on uncertainty from a number of national assessments[33] are used and adapt the factors presented with the information of experts on the Luxembourg situation. The basic idea was to evaluate uncertainties at the same level as input data are available.

In many cases this was not feasible. Input data for emission inventories are often available only or at least at better quality at an aggregated level than at the most detailed level. Here we employed uncertainties at the level where the best quality was expected (coupling of inputs). This approach helped avoiding the introduction of unnecessary (calculation-related) additional uncertainties. As will be explained in the respective calculation algorithms, only the Monte-Carlo approach is able to appropriately handle this situation.

1.6.2.2 Energy sector

Following the information of the national experts, energy activity data were understood to be best available at the level of national total for gas, liquid fuels and solid fuels, respectively. The national trade balances allowed to account for the total, the differentiation into individual sectors was considered less reliable. This situation is rather typical for national energy balances (see e.g. Austria[34]).

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33 Charles et al., 1998, AEAT-2688-1, AEA Technology, Culham (UK) ; Monni and Syri, 2003, VTT Research Notes 2209, Espoo (Finland) ; Ramirez-Ramirez et al., 2006, NWS-E-2006-58, Copernicus Institute for Sustainable Development and Innovation, Utrecht (Netherlands) ; Winiwarter, 2008, ARC-sys-0154, Vienna (Austria).

34 Winiwarter, 2008, ARC-sys-0154, Vienna (Austria).

Consequently, uncertainty estimates for activities in the energy sector were given separately for gaseous, liquid and solid fuels, normally without further subdivision. Activities within each of the groupings were considered fully “correlated”, i.e. statistically dependent. Due to the detailed assessment and the fact that just a single provider is responsible for all imports, we assume an uncertainty range of +/- 0.5%. Liquid fuels are regarded as uncertain by +/- 2% in 1990, in recent times (due to improved data quality schemes established with the requirement of maintaining a strategic reserve) +/- 1%. More complex is the situation for solid fuels, where we separately treat coal (2% uncertainty, just as liquids), coke (3% uncertainty, following Monni and Syri33, for steel industry: the difference being that data derive from private industry which is less easily controllable, especially with regard to the old data of the 1990’s) and electric furnace electrodes (5% uncertainty, as not included in the energy balance). The relevant uncertainty of steel industry activity, other than electrodes, is considered to be covered in the uncertainty of coke – which also includes gaseous fuels (coke oven gas) derived from solids. Uncertainty of fuels from biomass is estimated at 10%.

Also emission factors of fuel combustion are considered strongly related. For fossil fuels, CO_2 emission factors directly derive from the carbon content, which is very well understood for gaseous and liquid fuels (0.5% uncertainty, respectively; as CO_2 emissions from transport are being calculated according to fuel sold, this factor is directly applicable also on “road fuel export”). Carbon content of solid fuels is a function of fuel quality, which not always is perfectly understood – especially concerning the old data of the 1990’s. We apply an uncertainty of 3% (following Monni and Syri[33], for generic solid fuel emission factors) for all solid fuels, and 1% for the situation now which is more strongly controlled by coal use in boilers than previously. High quality electrodes are regarded to be covered by the 1% uncertainty of emission factor over the whole period.

For biomass and waste, the uncertainty is relatively high as depending on the fossil carbon component in waste (biomass carbon is considered neutral), we use 20% following Charles et al. [33].

Even if a number of different emission factors on CH_4 and N_2O are available, these factors often refer to very few measurements and a subsequent source specific interpretation. Thus it seems useful to also consider these uncertainty estimates to be correlated. While we use uncertainty estimates for solid, liquid and gaseous fuels as well as biomass&waste all at +/- 50% (Charles et al. [33]), we consider at least those four groups statistically independent, both in the case of N_2O and CH_4. In contrast to CO_2, here we regard the emission factor of coke oven gas to be related to that of gaseous fuels, instead of to solid fuels.

Separate treatment was only required for transport emissions. Ntziachristos (personal information, 2008) regards the uncertainty of COPERT “at least 50%” for CH_4 and N_2O. As COPERT was applied to the vehicle fleet of Luxembourg, but applied to all vehicles that buy fuel in Luxembourg, we extend this factor to 60%, and use for catalyst-created N_2O also a slightly extended range (40-250% of best estimate) compared to that suggested by Hausberger[35] for Austria.

1.6.2.3 Industry and product use

Iron and steel industry (as described above) is being dealt with according to the energy sector (solid fuels), with the sole exception of electrodes (5% uncertainty of activity). As the routes of steel production are entirely different in 1990 and 2006, also the associated uncertainties are different and are considered statistically independent.

Energy related emissions from cement and glass production are also covered in energy, including waste combustion. For the decarbonizing part of the processes we refer to the uncertainty reported for Luxembourg directly, which is 1.5% for activity and 2.5% for the CO_2 emission factor. Likewise we apply national factors also to the glass industry (2% for activity, 5% for emission factor).

Assessing emissions from solvent follows the Austrian approach (Windsperger, pers. information). Thus, we also apply the Austrian uncertainty estimates (5% activity uncertainty, 10% CO_2 emission factor uncertainty). For N_2O use we consider activity (population numbers) as exact, while the emission factor is regarded at 20% uncertainty following Monni and Syri[33]. This is much higher than the 1% used but not explained by Ramirez-Ramirez et al.[33] but in line with Boogerts and Starcks[36] who apply 25%.

F-gas emission uncertainty (not split into activity and emission factor) has been taken over from Austria, with 54% uncertainty for HFC's and 56% uncertainty for SF_6. Again this is the order of magnitude also used by Monni and Syri[33] but somewhat higher than the 20% suggested by Ramirez-Ramirez et al.[33], which however are not explained.

1.6.2.4 Agriculture and waste

The uncertainty associated with activity statistics is generally believed to be quite small. Arable land crops, used to estimate soil emissions, are on the high end at 10%, just the "fallows" (which is the basis for calculating indirect soil emissions) is considered statistically dependent, but twice as high. Reason for choosing these relatively high numbers is the inadequacy of activity parameter – with respect to the emission factors' uncertainty (see below) this contribution is negligible anyway. Animal numbers' uncertainty is estimated between 2% (for cattle, which are extremely well cov-

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35 Hausberger, 2005, Report No. FVT-68/05/ Haus EM 24/04-6790, Forschungsinstitut für Verbrennungskraftmaschinen und Thermodynamik mbH, Graz (Austria)

36 Boogaerts and Starcks, 2004, Report 40003117, De Norske Veritas, Consulting Benelux, Antwerp (Belgium)

ered due to their inclusion in a register) and 10% for animals distributed over many small farms (sheep, horses, chicken).

For emission factors, we follow uncertainties developed for Austria. The CH_4 emission factor for soil emissions is considered uncertain by +/-100%, the N_2O emission factor is within a factor of 10 (lognormal distribution, from 30% to 300% of the best estimate) following IPCC (2006). Enteric fermentation CH_4 emissions are uncertain by 20% for cattle, 30% for all other animals. Manure application emission factor follow a 70% uncertainty for CH_4 and a range from 50% to 200 % (lognormal distribution) for N_2O.

The high quality of information available on landfills resembles the situation of Austria. Thus based on Austrian data, uncertainty of waste deposited is considered uncertain by 12%, and the CH_4 emission factor by 25%. Also other uncertainty factors are copied from the Austrian inventory, but with hardly any effect on the result. Also for the sector of Land use, land use change and forestry, Austrian data have been applied. Again, this sector is extremely small in Luxembourg, such that the overall result will not be affected by any choice of parameters taken.

1.6.3 Results using the Tier 1 (error propagation) approach

The results of the error propagation approach are strictly limited to the key sources and the potential of the IPCC spreadsheet used. Table 1 presents this resulting spreadsheet. An extension to other sources than key sources is in theory possible, but sources can only be dealt with individually. Thus their inclusion would contradict the concept expressed by IPCC (2006) to focus limited resources where they can be applied in the most useful manner. Key sources are selected understanding that a focus to other sources is not so important.

As a part of the spreadsheet development, algorithms have been established to assess the respective contributions of sources to the uncertainty of the emission level as well as to the trend uncertainty. The respective contributions of individual source sectors become explicit in columns "H" and "M" of the table (numbers printed in boldface). The overall level uncertainty as well as trend uncertainty is being derived as the square root of the squares of the respective contributions.

The TIER 1 approach excluding LULUCF suggests an overall level uncertainty of 2.82% and a trend uncertainty of 1.83% and the TIER 1 approach including LULUCF suggests an overall level uncertainty of 2.91% and a trend uncertainty of 1.79% (all numbers as two standard deviations).

Thus it becomes clear that small contributions are basically negligible for the overall total listed in the bottom line of the table, and most of the influence to the total derives from the very few elevated numbers. Nitrous oxide emissions from soil (direct and indirect) and transport, especially based on Diesel fuel, are the most pronounced contributors to the uncertainty of the 2007 inventory. Uncertainty of the trend, according to Table 1-9, is characterized by transport, both diesel and gasoline fuels, and only next by soil N_2O release.

With respect to the specific situation in Luxembourg it is interesting to note that uncertainty associated with a previous economic situation, with steel industry a major aspect of the economy (1990), is considerably higher than today. While not as important as the (relatively constant) agricultural contribution of N_2O, uncertainty associated with solid fossil fuels may be identified as the reason for this discrepancy.

Uncertainties in the levels of one of the years important for the trend, but not for the other year, definitely also contribute to the emission trend uncertainty. In the case of Luxembourg this is the steel industry, but also consumption of liquid fuels for transport (including the associated CH_4 and N_2O emissions) which became more important recently, even if the actual point of release is outside Luxembourg's territory. Overall uncertainty is 2.34%-points (uncertainty of emission difference with respect to the base year emission), and due to the uncertainty in the base year it is clearly not possible to be decreased by further efforts in inventory compilation. While additional activities may improve knowledge on a current situation, it is almost impossible to provide a similar task for the past[37].

Compared to the results of other countries, level and trend uncertainties in Luxembourg are on the lower end of the range. This is plausible, as the situation in Luxembourg is characterized by high energy consumption and emission density, compared to other countries. With respect to GHG emissions, energy data are among the best known, and also CO_2 emission factors are much better understood (can be derived from material balances) than emission factors of CH_4 or N_2O. The fact that, in the total inventory, N_2O and CH_4 are less pronounces at the same time leads to a structurally lower uncertainty.

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37 Rypdal and Winiwarter, 2001, Environmental Science and Policy, 4, 107-116.

Table 1-9 – Uncertainty analysis of Luxembourg's GHG inventory - Table 6.1 - Tier 1 excluding LULUCF

Key IPCC Source Categories	Gas	1990 (BY) emissions	2007 emissions	AD uncertainty	EF uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in 2007	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by emission factor uncertainty	Uncertainty in trend in national emissions intro-duced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Uncertainty in trend in national emissions intro-duced by emission factor uncertainty	Uncertainty in trend in national emissions intro-duced by activity data uncertainty
		Gg CO_2 equivalent		*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*		
1A1a - Solid Fuels	CO_2	1230,42	0,00	2,00%	1,00%	2,24%	0,00%	-9,23%	0,00%	-0,09%	0,00%	0,09%	1	0
1A1a - Gaseous Fuels	CO_2	26,61	1291,59	0,50%	0,50%	0,71%	0,07%	9,65%	9,85%	0,07%	0,07%	0,10%	0	0
1A1a - Other Fuels	CO_2	33,29	65,68	10,00%	0,50%	10,01%	0,05%	0,25%	0,50%	0,00%	0,07%	0,07%	0	0
1A2a - Liquid Fuels	CO_2	50,85	6,38	2,00%	0,50%	2,06%	0,00%	-0,33%	0,05%	0,00%	0,00%	0,00%	1	0
1A2a - Solid Fuels	CO_2	3734,63	0,00	3,00%	1,00%	3,16%	0,00%	-27,95%	0,00%	-0,28%	0,00%	0,28%	1	0
1A2a - Gaseous Fuels	CO_2	431,26	562,10	0,50%	0,50%	0,71%	0,03%	1,05%	4,29%	0,03%	0,03%	0,04%	0	0
1A2b - Gaseous Fuels	CO_2	13,19	55,15	0,50%	0,50%	0,71%	0,00%	0,32%	0,42%	0,00%	0,00%	0,00%	0	0
1A2c - Liquid Fuels	CO_2	116,52	3,19	2,00%	0,50%	2,06%	0,00%	-0,85%	0,02%	0,00%	0,00%	0,00%	1	0
1A2c - Gaseous Fuels	CO_2	56,53	167,77	0,50%	0,50%	0,71%	0,01%	0,85%	1,28%	0,01%	0,01%	0,01%	0	0
1A2f - Liquid Fuels	CO_2	89,95	247,85	2,00%	0,50%	2,06%	0,04%	1,21%	1,89%	0,01%	0,05%	0,05%	1	0
1A2f - Solid Fuels	CO_2	338,17	214,13	3,00%	1,00%	3,16%	0,05%	-0,91%	1,63%	-0,01%	0,07%	0,07%	1	0
1A2f - Gaseous Fuels	CO_2	245,47	467,05	0,50%	0,50%	0,71%	0,03%	1,72%	3,56%	0,03%	0,03%	0,04%	0	0
1A2f - Other fuels	CO_2	0,00	49,69	2,00%	1,00%	2,24%	0,01%	0,38%	0,38%	0,00%	0,01%	0,01%	1	0
1A3b - Gasoline	CO_2	1300,92	1362,02	2,00%	0,50%	2,06%	0,22%	0,62%	10,38%	0,00%	0,29%	0,29%	1	0
1A3b - Diesel Oil	CO_2	1363,56	5201,88	2,00%	0,50%	2,06%	0,83%	29,39%	39,66%	0,15%	1,12%	1,13%	1	0
1A3b - Gasoline	N_2O	26,05	27,95	2,00%	100,00%	100,02%	0,22%	0,02%	0,21%	0,02%	0,01%	0,02%	1	0
1A3b - Diesel Oil	N_2O	7,93	70,94	2,00%	60,00%	60,03%	0,33%	0,48%	0,54%	0,29%	0,02%	0,29%	1	0
1A4a - Liquid Fuels	CO_2	474,26	368,31	2,00%	0,50%	2,06%	0,06%	-0,75%	2,81%	0,00%	0,08%	0,08%	1	0
1A4a - Gaseous Fuels	CO_2	188,97	312,73	0,50%	0,50%	0,71%	0,02%	0,97%	2,38%	0,02%	0,02%	0,02%	0	0
1A4b - Liquid Fuels	CO_2	474,26	352,37	2,00%	0,50%	2,06%	0,06%	-0,87%	2,69%	0,00%	0,08%	0,08%	1	0
1A4b - Gaseous Fuels	CO_2	188,97	312,73	0,50%	0,50%	0,71%	0,02%	0,97%	2,38%	0,02%	0,02%	0,02%	0	0
1A5b - Liquid Fuels	CO_2	47,79	6,38	3,00%	0,50%	3,04%	0,00%	-0,31%	0,05%	0,00%	0,00%	0,00%	1	0
2A1 Minerals	CO_2	557,09	426,27	1,50%	2,00%	2,50%	0,08%	-0,93%	3,25%	0,09%	0,07%	0,11%	0	0
2A7 - Glass Production	CO_2	53,57	62,92	2,00%	5,00%	5,39%	0,03%	0,08%	0,48%	0,00%	0,01%	0,01%	1	0

Key IPCC Source Categories	Gas	1990 (BY) emissions	2007 emissions	AD uncertainty	EF uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in 2007	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by emission factor uncertainty	Uncertainty in trend in national emissions intro-duced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Uncertainty in trend in national emissions intro-duced by emission factor uncertainty	Uncertainty in trend in national emissions intro-duced by activity data uncertainty
		Gg CO_2 equivalent		*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*		
2C1	CO_2	984,91	203,49	5,00%	1,00%	5,10%	0,08%	-5,84%	1,55%	0,02%	0,11%	0,11%	0	0
2F	*F-gases*	17,12	90,98	NE	NE	NE	NE	0,57%	0,69%	NE	NE	NE	0	0
4A1	CH_4	266,66	240,69	2,00%	30,00%	30,07%	0,56%	-0,17%	1,83%	0,78%	0,05%	0,78%	0	0
4B1	CH_4	53,42	62,55	2,00%	144,57%	144,58%	0,70%	0,08%	0,48%	0,97%	0,01%	0,98%	0	0
4D1	N_2O	178,08	166,38	10,00%	150,00%	150,33%	1,94%	-0,07%	1,27%	-0,10%	0,18%	0,21%	1	0
4D2	N_2O	58,57	55,12	25,08%	173,21%	175,01%	0,75%	-0,02%	0,42%	-0,03%	0,15%	0,15%	1	0
4D3	N_2O	141,49	118,36	20,00%	150,00%	151,33%	1,39%	-0,16%	0,90%	-0,24%	0,26%	0,35%	1	0
5A1	CO_2	205,39	-396,18	3,00%	55,00%	55,08%	-1,69%	-4,56%	-3,02%	-2,35%	-0,13%	2,35%	0	0
Total excl. LULUCF	***CO_2e***	**12750,50**	**12572,63**				**2,82%**					**1,83%**		
% National Total excl. LULUCF	***%***	**97,20%**	**97,36%**											
National Total excl. LULUCF	***CO_2e***	**13117,79**	**12913,52**											

0.0000 = NO

Table 1-10 – Uncertainty analysis of Luxembourg's GHG inventory - Table 6.1 - Tier 1 including LULUCF

Key IPCC Source Categories	Gas	1990 (BY) emissions	2007 emissions	AD uncertainty	EF uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in 2007	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by emission factor uncertainty	Uncertainty in trend in national emissions intro-duced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Uncertainty in trend in national emissions intro-duced by emission factor uncertainty	Uncertainty in trend in national emissions intro-duced by activity data uncertainty
		Gg CO2 equivalent		*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*		
1A1a - Solid Fuels	*CO2*	1230,42	0,00	2,00%	1,00%	2,24%	0,00%	-8,67%	0,00%	-0,09%	0,00%	0,09%	1	0
1A1a - Gaseous Fuels	*CO2*	26,61	1291,59	0,50%	0,50%	0,71%	0,07%	9,50%	9,69%	0,07%	0,07%	0,10%	0	0
1A1a - Other Fuels	*CO2*	33,29	65,68	10,00%	0,50%	10,01%	0,05%	0,26%	0,49%	0,00%	0,07%	0,07%	0	0
1A2a - Liquid Fuels	*CO2*	50,85	6,38	2,00%	0,50%	2,06%	0,00%	-0,31%	0,05%	0,00%	0,00%	0,00%	1	0
1A2a - Solid Fuels	*CO2*	3734,63	0,00	3,00%	1,00%	3,16%	0,00%	-26,26%	0,00%	-0,26%	0,00%	0,26%	1	0
1A2a - Gaseous Fuels	*CO2*	431,26	562,10	0,50%	0,50%	0,71%	0,03%	1,18%	4,22%	0,03%	0,03%	0,04%	0	0
1A2b - Gaseous Fuels	*CO2*	13,19	55,15	0,50%	0,50%	0,71%	0,00%	0,32%	0,41%	0,00%	0,00%	0,00%	0	0
1A2c - Liquid Fuels	*CO2*	116,52	3,19	2,00%	0,50%	2,06%	0,00%	-0,80%	0,02%	0,00%	0,00%	0,00%	1	0
1A2c - Gaseous Fuels	*CO2*	56,53	167,77	0,50%	0,50%	0,71%	0,01%	0,86%	1,26%	0,01%	0,01%	0,01%	0	0
1A2f - Liquid Fuels	*CO2*	89,95	247,85	2,00%	0,50%	2,06%	0,04%	1,23%	1,86%	0,01%	0,05%	0,05%	1	0
1A2f - Solid Fuels	*CO2*	338,17	214,13	3,00%	1,00%	3,16%	0,05%	-0,78%	1,61%	-0,01%	0,07%	0,07%	1	0
1A2f - Gaseous Fuels	*CO2*	245,47	467,05	0,50%	0,50%	0,71%	0,03%	1,77%	3,50%	0,02%	0,02%	0,04%	0	0
1A2f - Other fuels	*CO2*	0,00	49,69	2,00%	1,00%	2,24%	0,01%	0,37%	0,37%	0,00%	0,01%	0,01%	1	0
1A3b - Gasoline	*CO2*	1300,92	1362,02	2,00%	0,50%	2,06%	0,22%	1,05%	10,22%	0,01%	0,29%	0,29%	1	0
1A3b - Diesel Oil	*CO2*	1363,56	5201,88	2,00%	0,50%	2,06%	0,86%	29,39%	39,03%	0,15%	1,10%	1,11%	1	0
1A3b - Gasoline	*N2O*	26,05	27,95	2,00%	100,00%	100,02%	0,22%	0,03%	0,21%	0,03%	0,01%	0,03%	1	0
1A3b - Diesel Oil	*N2O*	7,93	70,94	2,00%	60,00%	60,03%	0,34%	0,48%	0,53%	0,29%	0,02%	0,29%	1	0
1A4a - Liquid Fuels	*CO2*	474,26	368,31	2,00%	0,50%	2,06%	0,06%	-0,58%	2,76%	0,00%	0,08%	0,08%	1	0
1A4a - Gaseous Fuels	*CO2*	188,97	312,73	0,50%	0,50%	0,71%	0,02%	1,01%	2,35%	0,02%	0,02%	0,02%	0	0
1A4b - Liquid Fuels	*CO2*	474,26	352,37	2,00%	0,50%	2,06%	0,06%	-0,70%	2,64%	0,00%	0,07%	0,07%	1	0
1A4b - Gaseous Fuels	*CO2*	188,97	312,73	0,50%	0,50%	0,71%	0,02%	1,01%	2,35%	0,02%	0,02%	0,02%	0	0
1A5b - Liquid Fuels	*CO2*	47,79	6,38	3,00%	0,50%	3,04%	0,00%	-0,29%	0,05%	0,00%	0,00%	0,00%	1	0
2A1 Minerals	*CO2*	557,09	426,27	1,50%	2,00%	2,50%	0,09%	-0,73%	3,20%	0,09%	0,07%	0,11%	0	0
2A7 - Glass Production	*CO2*	53,57	62,92	2,00%	5,00%	5,39%	0,03%	0,09%	0,47%	0,00%	0,01%	0,01%	1	0

Key IPCC Source Categories	Gas	1990 (BY) emissions	2007 emissions	AD uncertainty	EF uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in 2007	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions intro-duced by emission factor uncertainty	Uncertainty in trend in national emissions intro-duced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Uncertainty in trend in national emissions intro-duced by emission factor uncertainty	Uncertainty in trend in national emissions intro-duced by activity data uncertainty
		Gg CO2 equivalent		*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*		
2C1	*CO2*	984,91	203,49	5,00%	1,00%	5,10%	0,08%	-5,41%	1,53%	0,02%	0,11%	0,11%	0	0
2F	*F-gases*	17,12	90,98	NE	NE	NE	NE	0,56%	0,68%	NE	NE	NE	0	0
4A1	*CH4*	266,66	240,69	2,00%	30,00%	30,07%	0,58%	-0,07%	1,81%	0,77%	0,05%	0,77%	0	0
4B1	*CH4*	53,42	62,55	2,00%	144,57%	144,58%	0,72%	0,09%	0,47%	0,96%	0,01%	0,96%	0	0
4D1	*N2O*	178,08	166,38	10,00%	150,00%	150,33%	2,00%	-0,01%	1,25%	-0,01%	0,18%	0,18%	1	0
4D2	*N2O*	58,57	55,12	25,08%	173,21%	175,01%	0,77%	0,00%	0,41%	0,00%	0,15%	0,15%	1	0
4D3	*N2O*	141,49	118,36	20,00%	150,00%	151,33%	1,43%	-0,11%	0,89%	-0,16%	0,25%	0,30%	1	0
5A1	*CO2*	205,39	-396,18	3,00%	55,00%	55,08%	-1,74%	-4,42%	-2,97%	-2,31%	-0,13%	2,32%	0	0
Total excl. LULUCF	*CO2e*	12955,89	12176,45				2,91%					1,79%		
% National Total excl. LULUCF	*%*	97,22%	97,23%											
National Total excl. LULUCF	*CO2e*	13326,23	12522,88											

0.0000 = NO

1.7 Completeness

CRF table 9(a) on completeness have been filled for every reported year 1990 to 2007. As indicated above (see Section 1.2.2), it is expected that this table recapitulates all the explanations given for the notation keys reported in Luxembourg's GHG inventory for a given year since all the checks included in CRF Reporter were passed successfully by submission 2009v1.4. Hence, if missing information is encountered in CRF table 9(a) for some years, this not due to a lack of explanations from the side of Luxembourg, but well due to conversion problems in CRF Reporter when the CRF tables were created.

In this section, some additional information is presented. An assessment of completeness for each CRF sector is given in the sector overview part of each of the sector chapters.

1.7.1 Sources and sinks

All sources and sinks included in the IPCC Guidelines are covered. With regards to LULUCF, this submission contains new estimations for LULUCF, the three main sub-categories now being covered, there are still some improvements needed.

1.7.2 Gases

Both direct GHGs as well as precursor gases are covered by Luxembourg's inventory. However, indirect GHG – NO_x, CO, NMVOCs – and SO_2 need to be re-evaluated in the light of the revision of the inventories Luxembourg is compiling for the UNECE CLRTAP. Generating better emission estimates for these gases are part of our planned improvements (see Chapter 9).

1.7.3 Geographic coverage

The geographic coverage is complete. There is no part of the national territory not covered by the inventory.

1.7.4 Notation keys

The sources and sinks not considered in the inventory, but included in the IPCC Guidelines, are clearly indicated. The reasons for such exclusions are explained. In addition, the notation keys presented below are used to fill in the blanks in all the CRF tables.

Notation keys used in the NIR are consistent with those reported in the CRF tables. Notation keys used are those described on page 9 of document FCCC/SBSTA/2006/9 of 18 August 2006.

Allocations to categories may differ from Party to Party. The main reasons for different category allocations are different allocations in national statistics, insufficient information in national statistics and/or national methods, and the impossibility to disaggregate emission declarations.

IE (included elsewhere)

The notation key IE is used for emissions by sources and removals by sinks of GHG that have been estimated but included elsewhere in the inventory instead of the expected source/sink category. Where IE is used in the inventory, CRF table 9 indicates where (in the inventory) these emissions or removals have been included. Such deviation from the expected category is also explained.

NE (not estimated)

The notation key NE is used for existing emissions by sources and removals by sinks of GHG which have not been estimated. Where NE is used in an inventory for emissions or removals, CRF table 9 indicates why emissions or removals have not been estimated. For emissions by sources and removals by sinks of GHG marked by NE, check-ups are in progress to establish if they actually are NO (not occurring). As part of the improvement programme of the inventory, it is planned that these source or sink categories are either estimated or allocated to NO.

NA (not applicable)

The notation key NA is used for activities or processes in a given source/sink category that do not produce emissions or lead to removals of a specific gas. As part of the improvement programme of the inventory, it is planned to revise all the NA notation keys to confirm whether they are indeed NA or rather NE or NO.

NO (not occurring)

The notation key NO is used for activities or processes in a given source/sink category that do not occur within Luxembourg.

C (confidential)

The notation key C is used for emissions which could lead to the disclosure of confidential information if reported at the most disaggregated level. In this case, a minimum of aggregation is required to protect business information. So far, no confidential information has been identified in Luxembourg's GHG inventory.

1.7.5 Transparency and completeness indexes

Transparency and completeness indexes are calculated as follows:

- Transparency (*TR*) [%] = [1 – (number of IE/number of estimates)]*100
- Completeness (*CP*) [%] = [1 – (number of NE/number of estimates)]*100

In Table 1-11, transparency and completeness of submission 2008v1.2 – and of Luxembourg's latest submission – submission 2009v1.4 – are compared. The exercise focuses on the inventory year 2006 and the sectoral report tables only. The level of detail for CRF sources and categories is up to 4 digits for the energy sector (e.g. IPCC Sub-category 1A1a) and 3 digits for the other sectors (e.g. IPCC Sub-category 4D3). Finally, only the 6 GHG are covered by this counting exercise. Under these conditions, 307 cells have been scrutinized: 87 for CRF sector 1, 104 for CRF sector 2, 10 for CRF sector 3, 55 for CRF sector 4, 33 for CRF sector 5 and 18 for CRF sector 6.

As it can be seen in Table 1-9, the transparency has remained the same between the two submissions except for CRF Sectors 1 and 3. For the former, this is due to the fact that IPCC Sub-categories 1A5 and 1B2b for CO_2, which were previously reported elsewhere, are now individually estimated. For the latter, CO_2 emissions from IPCC Sub-category 3A-3C are now separately estimated and no longer included in IPCC Category 3D - Other.

With regard to completeness, the improvement of the inventory is quite remarkable with an overall rise from 80.3 to 89.3%. This increase in completeness is the result of a totally revised set of estimates for CRF Sectors 1, 3 and 5 – see relevant chapters further in this NIR – as well as of the inclusion of industrial waste water treatment N2O related emissions for the first time in the inventory.

Table 1-11 – Transparency and completeness in UNFCCC submissions 2008v1.2 and 2009v1.4: 2006

CRF Sector	Submission 2008v1.2				Submission 2009v1.4			
	IE	*NE*	*TR*	*CP*	*IE*	*NE*	*TR*	*CP*
Energy (sectoral approach) – CRF 1	10	5	*88%*	*86%*	3	2	97%	98%
Industrial Processes – CRF 2	2	13	*98%*	*88%*	2	13	98%	87%
Solvent and Other Product Use – CRF 3	1	4	*90%*	*60%*	0	3	100%	70%
Agriculture – CRF 4	0	1	*100%*	*98%*	0	1	100%	98%
LULUCF – CRF 5	0	36	*100%*	*8%*	0	13	100%	61%
Waste – CRF 6	3*	2	*83%**	*89%*	3*	1	83%*	94%
Total	16	61	*95%*	*81%*	6	33	98%	89%

* includes waste incineration that is reported under IPCC Sub-category 1A1a since the energy produced while burning waste is recovered.

1.8 National Registry

Submission 2009v1.4 is also a voluntary submission under the Kyoto Protocol for Luxembourg. In this context, a Party included in Annex I to the Convention that is also Party to the Kyoto Protocol – such as Luxembourg – could start reporting supplementary information from the year 2008 onwards, though these elements, according to Articles 5, 7 and 8 of the Kyoto Protocol, will only be compulsory for the first year of the commitment period after the Protocol has entered into force for that Party.[38] Luxembourg will not provide the whole spectrum of supplementary information it

38 See letter to the Parties from the UNFCCC Secretariat of 13 March 2008 on the submission of information under Articles 5, 7 and 8 of the Kyoto Protocol.

could report in the Kyoto Protocol reporting scheme at the moment, but rather focus on one element: its National Registry.

1.8.1 A consolidated system for the National Registry

Luxembourg and Belgium maintain a consolidated registry system with both registries operating independently but sharing the same hardware environment. The software application is based on the "Community registry software" provided under a free license by the European Commission.

- The following project partners are involved in the registry activities:
- software development: Dr. Lippke & Dr. Wagner Gmbh, Berlin
- software maintenance: Dr. Lippke & Dr. Wagner Gmbh, Berlin
- hardware and network hosting: Colt Telecom Gmbh
- technical support and adaptive maintenance: Colt Telecom Gmbh

The different tasks of the partners are summarised in Table 1-12 below.

Table 1-12 – National Registry – partners' tasks

Partners	Tasks
Registry administrators Belgium-Luxembourg	- project coordination, planning, development - coordination with software provider, support/hosting company, other Registries, ITL/CITL - incident solving
Support/hosting company	- adapting interface - keep the Registry running - Internet/server security - incident solving - back-up/disaster recovery - 2nd level helpdesk
Database manager	- 1st level user helpdesk - daily administration - test of new software versions
Software provider	- version development - incident solving - 3rd level helpdesk

1.8.2 National Registry accesses

A public access to the Registry is possible from the environment web portal of Luxembourg: http://www.environnement.public.lu/air_bruit/dossiers/registre_national_quotas_GES/index.html.

The following information is available to the public on this web page:

- international policy context;
- National Allocation Plan (NAP);
- FAQ;

- helpdesk;
- access to the secured site for the National Registry: https://www.climateregistry.lu.

1.8.3 Database structure and capacity of the National Registry

The database structure and capacity correspond to the requirements of the Data Exchange Standards (*DES*).[39]

More details concerning the database structure and the technical standards for data exchange are to be found in the readiness questionnaire together with additional clarifications handed to the UNFCCC secretariat.

1.8.4 National Registry security

Prior to opening an account in the Registry, an ID-Check (= passport copy, paper signature) is performed before granting access trough a Username/Password combination. An automatic logoff ensures that no unauthorised person may have access to an account in absence of the holder.

The Registry System is secured by a SSL/VPN secure login whereas data integrity is checked during reconciliation every night. In order to re-establish coherent databases, manual interventions are performed by the Registry administrator in case of a negative result from reconciliation.

Updating of software is only performed after thorough tests in a test environment in order to minimise the risk that updates and patches might destabilising the system.

Internet/server hardware is monitored 24/7 year round. At the hosting company level, the registry software is running on dedicated servers which are backed-up according to procedures detailed in the above-mentioned readiness questionnaire.

1.8.5 National Registry Data Centre

The Data Centre in Berlin is equipped with a redundant power supply, with UPS systems as well as with emergency power supplies for longer outages. Air-conditioning is maintained by separate systems at 20-25 °C and 40-60% RH.

Access to the Data Centre is very limited and strictly controlled.

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39 See the IAR report: http://unfccc.int/kyoto_protocol/registry_systems/independent_assessment_reports/items/4061.php as well as paragraph 127 of the Report of the review of the initial report of Luxembourg (doc. FCCC/IRR/2007/LUX of 14 December 2007): http://unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php.

A redundant fire detection system is in place and communication is ensured by 2 Internet Service Providers trough multiple access points.

1.8.6 Persons and moral persons holding Registry accounts

The Government of Luxembourg did not allocate specific authorizations as regards the various Kyoto units. In fact, if one person or a moral person opens an account in the Registry, it is automatically authorized to hold any type of Kyoto units. Table 1-11 below lists the moral persons and the persons holding an account in the National Registry. This list is compliant with Article 6 of Decision 2005/166/EC.[40]

Table 1-13 – National Registry – authorized persons and moral persons

Moral persons authorised to hold any unit type in the Registry		
Installation	**Operator**	**Categories of activities**
Cegyco S.A.	Cegyco S.A.	Combustion
Centrale énergétique "Power"	Dupont de Nemours Luxembourg	Combustion
Installation de cogénération	Ceduco S.A.	Combustion
Guardian Luxguard I S.A.	Guardian Luxguard I	Glass
Guardian Luxguard II S.A.	Guardian Luxguard II	Glass
Usine Intermoselle	Ciments Luxembourgeois S.A.	Cement clinker
Kronospan Luxembourg S.A.	Kronospan Luxembourg S.A.	Combustion
Centrale d'énergie du Kirchberg	Luxénergie S.A.	Combustion
Centrale d'énergie Stade Josy Barthel	Luxénergie S.A.	Combustion
Luxlait Association Agricole	Luxlait Association Agricole	Combustion
Arcelor Rodange - Site d'Esch-Schifflange	Arcelor Rodange S.A.	Pig iron or steel
Arcelor Profil Luxembourg - Site de Differdange	Arcelor Profil Luxembourg S.A.	Pig iron or steel
Arcelor Profil Luxembourg - Site d'Esch-Belval	Arcelor Profil Luxembourg S.A.	Pig iron or steel
Primorec S.A.	Primorec S.A.	Pig iron or steel
Centrale TGV d'Esch/Alzette	Twinerg S.A.	Combustion
Persons holding accounts		
Carbon Management Consulting LTD		
Cegedel SA		

40 Commission Decision 2005/166/EC of 10 February 2005 laying down rules implementing Decision 280/2004/EC of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.

2 Trends in GHG Emissions

According to the Kyoto Protocol, Luxembourg's GHG emissions will have to be 8% below base year emissions during the five-year commitment period from 2008 to 2012. The European Community and its Member States also have a common reduction target of 8%, which they decided to achieve jointly. In April 2002, the Council of the European Union has adopted a decision, the so-called "burden sharing agreement"[41] which includes reduction targets for each Member State. Luxembourg agreed to reduce its GHG emissions for 2008–2012 by 28% compared to the base year emissions level.

When appreciating GHG emission composition and trends in Luxembourg, one should keep in mind that the IPCC methodology used for compiling GHG inventories is raising some peculiar issues for small countries, in particular because of the "territory" or "origin" principle underpinning it. This is the reason why this chapter starts with a section examining specific national circumstances. These specific conditions are relating to socio-economic characteristics that have significant effects on Luxembourg's GHG total emissions when applying IPCC accounting rules.

The second section of this chapter will provide an overview of the GHG emission trends for Luxembourg as they can be figured out from the GHG inventory.

2.1 National Circumstances

2.1.1 Demography, geography and climate

2.1.1.1 Demographic structure and workforce

End 2007, the population of Luxembourg amounted to 483 800 inhabitants. Within 47 years, the residential population has grown by some 169 000 inhabitants or about 54% – almost 26% since 1990.

Table 2-1 – Population growth: 1960-2007

calculated on 31st December	1960	1990	2000	2001	2002	2003	2004	2005	2006	2007
(x 1000)	314.9	384.4	439.0	444.0	448.3	455.0	461.2	469.1	476.2	483.8

Source: STATEC, *Statistical Yearbook*, Table B.1100
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=467&IF_Language=fra&MainTheme=2&FldrName=1

Demographic growth in Luxembourg is dominated by immigration. Nationals themselves saw their number stagnating, and without immigrants taking the citizenship of Luxembourg they

41 Council Decision of 25 April 2002 (2002/358/EC) concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the UNFCCC and the joint fulfilment of commitments thereunder (OJ L130, 15.5.2002). See also document FCCC/CP/2002/2.

would even have fallen. Population growth is one of the key drivers for domestic energy use, mainly in the housing and transportation sector. Thus, the past and future developments had and will have a significant impact on energy use and, consequently, on Luxembourg's GHG emissions.

In addition to the population growth, end 2007, 139 200 cross-border commuters from neighbouring regions were working in Luxembourg: among the paid workers, 50.7% of the commuters came from France, 25.9% from Belgium and 23.4% from Germany. In total, the commuters accounted for 43.3% of all paid workers in Luxembourg and for about 29% (i.e. more than a quarter) of the residential population.[42] A vast majority of workers from abroad commute by car.[43] However, in order to alter the current modal-split of home-work journeys, Luxembourg invests predominantly and jointly with the neighbouring regions into the public transport offer.

Table 2-2 – Cross-border commuters: 1980-2007

calculated on 31st December	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007
(x 1000)	11.9	35.3	90.3	100.1	104.9	108.8	114.4	121.2	129.0	139.2

Source: STATEC, *Statistical Yearbook*, Table B.5107:
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=360&IF_Language=fra&MainTheme=2&FldrName=5&RFPath=37

Note: from 2001 onwards, calculated on 30th September.

2.1.1.2 Geography

The total land surface of Luxembourg covers 2 586 km². The maximum distance from north to south is some 82 km, from west to east about 57 km. Of the total area of Luxembourg, in 2007, about 86% was agricultural land and land under forest. The built-up areas occupied about 9% of the total surface and land covered by water and transport infrastructure about 5%.

Table 2-3 – Land use in Luxembourg: 1972-2007

(percentages)	1972	1990	2000	2005	2007
Total land	100.0	100.0	100.0	100.0	100.0
Agricultural & wooden area	93.2	91.8	87.4	86.5	86.2
Built-up area	3.1	4.3	8.1	8.7	8.9
of which industrial area & other	*...*	*...*	*2.7*	*2.8*	*2.8*
Transport network & sheets of water	3.2	3.4	3.9	4.2	4.3
Watercourses	0.5	0.5	0.6	0.6	0.6

Source: STATEC, *Luxembourg in Figures 2008*, page 6:

http://www.statistiques.public.lu/fr/publications/horizontales/luxChiffresEN/index.html

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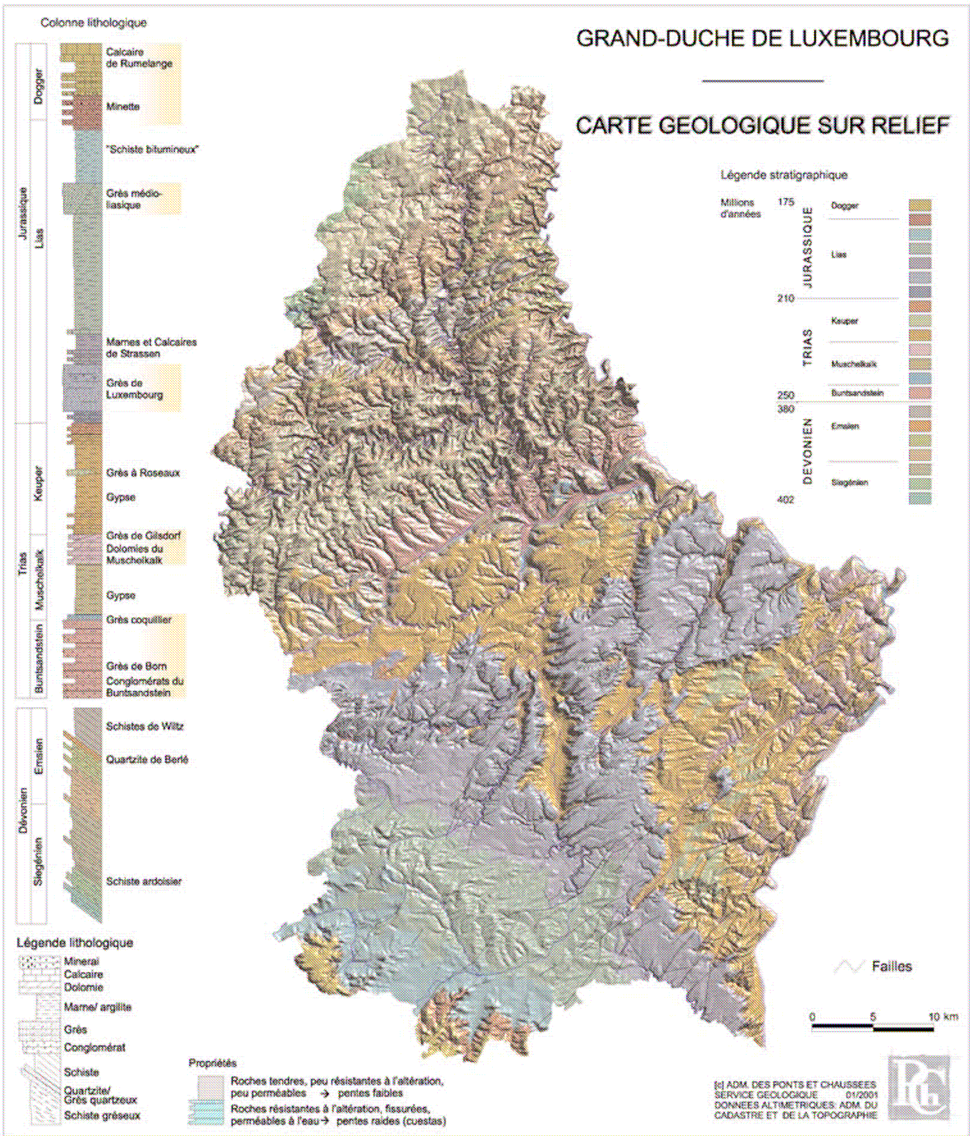
42 Figures presented in this paragraph come from STATEC, *Statistical Yearbook*, tables B.5100 and B.5107 (situation end September 2007 for B.5107):
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=353&IF_Language=fra&MainTheme=2&FldrName=5&RFPath=37 for B.5100
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=360&IF_Language=fra&MainTheme=2&FldrName=5&RFPath=37 for B.5107.

43 In 2007 , 89% of the cross-border commuters were only using their car for their home-work journeys according to a recent study: see http://www.ceps.lu/pdf/6/art1415.pdf?CFID=1253513&CFTOKEN=38691590&jsessionid=20303f926e506f584f4d.

The north of Luxembourg is a part of the Ardennes and is called “Ösling”. Its altitude is at an average of 400 to 500 meters above sea level. The “Ösling” landscape is affected by hills and deep river valleys, as for instance the Sure River (Sauer). With 560 m, the highest elevation is called the “Kneiff” in Wilwerdange. In the South of Luxembourg lies the rank “Gutland”, which belongs to the “Lothringer Stufenland”. This area has higher population and industrial densities than “Ösling”. The lowest point in the country, called “Spatz” (129 m above sea-level), is located at the confluence of the Moselle and the Sure rivers in Wasserbillig. Most important rivers are the Moselle, the Sure, the Our – all three delimiting the border with Germany – and the Alzette.

A geological map of Luxembourg is presented below (in French).

Figure 2-1 – Geological map of Luxembourg’s territory



Source: STATEC, *Annuaire statistique du Luxembourg 2008*, page 39:

http://www.statistiques.public.lu/fr/publications/horizontales/annuaireStatLux/A.pdf

2.1.1.3 Climate

The climate in Luxembourg is a moderate Western European climate with mild winters and comfortable summers. For the city of Luxembourg, average temperatures in January, the coldest month, are about 0.8°C. Highest temperatures are reached typically during the summer months July and August. At this time the average temperature is about 17.5°C. Minimum and maximum temperatures reach from minus 10°C in January to more than 30°C in July. For the inventory reporting, according to definitions in place, with an annual average temperature below 15°C, Luxembourg lies in a cool climate region.

Table 2-4 – Climate in the city of Luxembourg: averages for the period 1971-2000

	January	April	July	October	12 months
Average temperature – °C	1.0	7.8	17.7	8.9	8.9
Maximum temperature – °C	10.4	21.8	31.0	20.3	20.8
Minimum temperature – °C	-9.9	-3.3	6.2	-1.5	-2.2
Rainfall – mm	71.8	51.6	61.8	71.6	782.3

Source: STATEC, *Annuaire statistique du Luxembourg 2008*, tables A.2100, A. 2101 and A.2102, pages 43-44: http://www.statistiques.public.lu/fr/publications/horizontales/annuaireStatLux/A.pdf

Climate conditions have a significant impact on energy use for heating purposes. An increase in average temperature in the upcoming years should have a positive impact on energy use, especially in the residential, commercial and institutional sectors. Such an increase in average temperature is observed over the last year, as it can be seen from Table 2-5.[44] Nevertheless, other meteorological parameters do not show clear trends.

Table 2-5 – Evolution of some meteorological parameters for the city of Luxembourg: yearly averages: 1961-2007

(12 months averages)	1961-1990	1971-2000	1990	2000	2005	2006	2007
Average temperature – °C	9.0	8.9	9.3	9.9	10.5	11.1	11.3
Rainfall – mm	782.2	782.3	781.9	1022.0	610.8	848.7	837.9
Sunshine hours	1631	1529	1949	NE	NE	1601	1581
Relative humidity – %	80	77	78	81	80	NE	80

Source: STATEC, *Statistical Yearbook*, Tables A.2100, A.2102, A.2103 and A.2104: http://www.statistiques.public.lu/stat/ReportFolders/ReportFolder.aspx?IF_Language=fra&MainTheme=1&FldrName=2

2.1.2 Economic structure

Gross value added in Luxembourg is mainly generated in the financial and corporate service sector. The share of total gross value added in this branch has increased from about 39% in 1995 to 47% in 2007. While the commercial sector has maintained a constant share at about 20 to 22.5%, the share of the industry sector has decreased significantly from 15% in 1995 to a bit less than 10% in

44 For monthly details, see table A.2100 in STATEC's *Statistical Yearbook:* http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=1018

2007. Other service activities ranged between a share of 15 to 17.5% and construction kept a constant share in total gross value added at a low level of about 6%. The contribution of the agricultural sector is negligible with less than 1%.

The increasing shares in gross value added from less energy and carbon intensive sectors (as financial and services) has a positive effect on the carbon intensity of the Luxembourg economy.

Table 2-6 – Sectoral gross value added at current prices: 1995-2007[45]

(mio. €)	1995	2000	2001	2002	2003	2004	2005	2006	2007
Agriculture, hunting, forestry and fishing (A & B)	140.6	134.3	136.5	143.6	141.5	139.2	116	116.3	137.5
%	1.0%	0.7%	0.7%	0.7%	0.6%	0.6%	0.4%	0.4%	0.4%
Total industry, including energy (C to E)	2088.6	2475.1	2519.8	2523.9	2682.8	2766.4	2835.9	2881.2	3196.2
%	15.3%	12.6%	12.4%	11.7%	11.5%	11.3%	10.5%	9.4%	9.8%
Construction (F)	884.1	1126.4	1247.2	1446.5	1497.1	1539.8	1662.8	1795.5	1915
%	6.5%	5.7%	6.2%	6.7%	6.4%	6.3%	6.1%	5.9%	5.8%
Wholesale and retail trade, repair of motor vehicles, motorcycles and personal and household goods; hotels and restaurants; transport, storage and communication (G to I)	2915.7	4274.1	4567.5	4848.8	5015.0	5303.4	5557.2	6035.9	6805
%	21.3%	21.8%	22.5%	22.5%	21.6%	21.6%	20.5%	19.7%	20.8%
Financial intermediation; real estate, renting and business activities (J& K)	5366.0	8587.2	8362.2	8975.5	9968.7	10485.5	12267	14841.4	15449.4
%	39.2%	43.8%	41.2%	41.7%	42.9%	42.7%	45.3%	48.5%	47.1%
Other services (public aministration and defence, compulsory social security; education; health and social work; other community social and personal service activities; private households with employed persons (L to P)	2279.9	3026.3	3439.8	3603.9	3930.3	4328.3	4614.1	4912.4	5277.7
%	16.7%	15.4%	17.0%	16.7%	16.9%	17.6%	17.1%	16.1%	16.1%
Total: all NACE branches	13675.1	19623.4	20273.1	21542.2	23235.3	24562.6	27052.9	30582.7	32780.9

Source: STATEC, *Statistical Yearbook*, Table D.1304:
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=216&IF_Language=fra&MainTheme=4&FldrName=2&RFPath=15

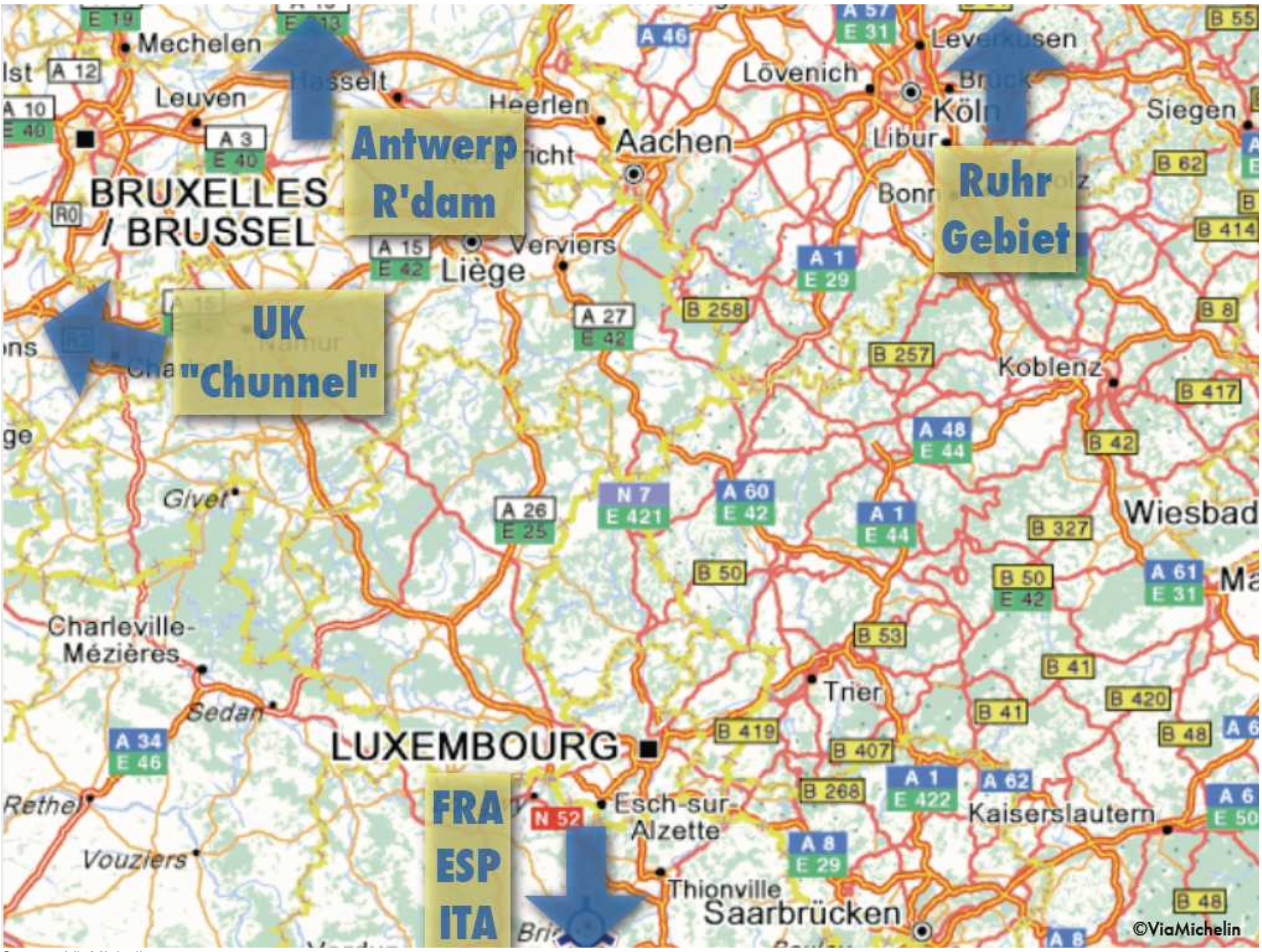
2.1.3 UNFCCC and Kyoto Protocol: a demanding challenge for Luxembourg

2.1.3.1 Location and corresponding road transport flows

Luxembourg's location and its economic development have made it a focal point for international road traffic. Luxembourg is located at the heart of the main traffic axes for Western Europe (see Figure 2-2) and, therefore, has traditionally had a high volume of road transit traffic for both goods (freight transport) and passengers (tourists on their way to or back from southern Europe). The latter has increased even further by the high number of commuter journeys observed every working day. In comparison with international traffic, domestic traffic plays only a relatively small role since it responsible for only one quarter of the total road fuels sold in Luxembourg.

45 Data prior to 1995 have not yet been translated into the new System of Economic Accounts (SEC).

Figure 2-2 – Geographic location of Luxembourg



Source: ViaMichelin

Road traffic is also the largest source of emissions in Luxembourg's GHG balance. Fuel quantities sold at Luxembourg's petrol stations, after having been converted into GHG volumes, are, according to IPCC reporting rules, totally included in the GHG balance, although around 75% of the emissions cannot be assigned to vehicles registered in Luxembourg and are actually emitted mostly abroad. This phenomenon is referred to as "road fuel exports", i.e. fuel sold to non-residents – whether they are in transit or commuting for work or leisure. Luxembourg, thus, exhibits a completely untypical and unique structural feature in its GHG emissions balance: in 2007, some 6.68 Mio. tonnes of CO_2-equivalents (*t CO_2e*) were produced by the road transportation sector and out of these, almost 4.9 Mio. t CO_2e, or 73%, was the result of road fuels bought by non-residents and were, consequently, merely emitted abroad. That amount represented around 37.9% of the total 2007 GHG emissions for Luxembourg (excluding LULUCF). According to the baseline scenario used by Luxembourg for its second National Allocation Plan (*NAP*), this proportion may increase up to 46% by 2012.[46]

Since Luxembourg's public finances have to rely on overall lower specific rates of taxation and excises, only marginal variations in the price differentials for petrol and diesel can be initiated by the authorities. Indeed, if Luxembourg's rates of taxation and prices are higher than those in the surrounding countries, it is rather easy for any citizen of Luxembourg to avoid domestic taxation and to practise arbitrage: no location in Luxembourg is further than a maximum of 25-30 km away from a border with a neighbouring country. Lower taxation rates for certain goods – such as fuels, e.g. – have therefore always been part of Luxembourg fiscal policy and will remain crucial in the future, because of the country's geographical location and its small area. Whereas in larger neighbouring states, increasing certain tax rates would result in a slight shift in demand and in arbitrage deals at the outer fringes of their national territory – with a corresponding relatively slight reduction in tax revenues – this would not be the case for Luxembourg where such a policy may result in big losses in tax incomes.

2.1.3.2 Country and economy sizes

Special attention must also be made for the small size of the country's economy in a different context: it is a contributory factor to the fact that, in spite of the healthy economic situation, the courses of the overall development of the country, of the demand for energy and of the emissions balance are often affected by a single plant which is starting its activities, closing them down or changing its production processes. This became particularly clear when the steel industry switch from blast furnaces to electric arc furnaces was completed during the 1990s: from 1990 to 1998, GHG emissions in Luxembourg were reduced by one third.

These last years, the construction of a single power station, the ultra-modern TWINerg gas and steam plant, represents a further illustrative example: the plant, located in Esch-sur-Alzette, is a gas and steam turbine power station running on natural gas, with an electrical output of 350 MWel (efficiency 57% new).[47] There are plans for decoupling heat at a later stage (28 MWth) for remote heating of the new Belval-Ouest district project.[48] When TWINerg started its operation in mid-2002, Luxembourg, which to all intents and purposes did not have so far any substantial electricity generating capacity to call its own, saw, at once, its GHG emissions increasing by 0.9 to 1 Mio. t CO_2e

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46 See also tables and figures in Section 2.2 below. Nevertheless, "road fuel exports" have reached a maximum in 2005 with 5.7 Mio. t CO_2e, which represented 78% of road transportation GHG emissions and 41.5% of the total GHG emissions (excluding LULUCF). Consequently, the upward trend that was characterizing "road fuel exports" since 1995 is slightly reversing these last years.

47 See http://www.twinerg.lu/data/fr/home.htm

48 See http://www.agora.lu.

per year. To give another illustration on how this project affected the GHG emissions pattern in Luxembourg, one can underline that it represents 35% of the allocated emissions volume of the whole GHG Emissions Trading Scheme sector (*ETS*) for the commitment period under the Kyoto Protocol.

The impact that single industrial projects might have, plays also the other way round when a production unit or a plant is closed down. If this problematic might not be an issue for large economies, it is for Luxembourg, as shown by the examples discussed above.

2.1.3.3 Limited GHG emissions reduction potentials

As of today, Luxembourg does not have those significant technical potentials which exist in other countries where residual "old-technology" industrial and power plants still operate. In Luxembourg, there were almost none, and there still are none of those GHG reduction potentials stemming from the modernisation or the replacement of existing national industrial or power plants. In fact, with the move from blast to electric arc furnaces in the steel sector during the 1990s, Luxembourg very soon exhausted its only major technical potential for GHG emissions reduction. With the process change in the steel industry – an activity which accounted for almost 40% of Luxembourg's total GHG emissions in 1990 (excluding LULUCF) – total emissions from industry and electricity generation – i.e. largely the sectors covered by the ETS – decreased to just 2.4 Mio. t CO_2e in 1998 – or about 26% of total GHG emissions (excluding LULUCF) – coming from slightly more than 8 Mio. t CO_2e in 1990 - or about 61% of total GHG emissions (excluding LULUCF).[49]

Also, any ultramodern fossil fuel-based electricity generating plant that Luxembourg might decide to construct will automatically lead to an increase of its national GHG emissions, since there are no existing power plants which can be stopped in return. Thus, those highly efficient combined heat-power (*CHP*) installations and the ultramodern gas and steam power station (TWINerg) that have been promoted and are operating in Luxembourg since 1998 have led to an additional amount of approx. 1.2 Mio. t CO_2e in the GHG balance.[50] It is therefore clear that any new fossil-fuel power generating installation that might be constructed will inevitably lead to a deterioration of Luxembourg's GHG balance. This also implies that the implementation of the EU CHP installation guidelines, which in other countries may lead to CO_2 reductions thanks to increased efficiency, is counterproductive for Luxembourg.

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49 In 2007, the values are about 3.9 Mio. t CO_2e and 30% respectively. The lowest share was obtained in 2001, the year prior the TWINerg started its production.

50 1Mio. t CO_2e for the TWINerg and 0.2 Mio. t CO_2e for CHP installations.

2.1.3.4 The "origin" principle of the IPCC reporting Guidelines vs. the "polluter pays" principle

The "origin" or "territorial" principle applied for reporting GHG emissions under the IPCC Guidelines generates a GHG balance for Luxembourg that looks significantly less favourable than would a "consumer" approach produce. The "origin" principle is in favour of Luxembourg in that its imports of electricity are excluded from its GHG emission balance: those emissions are attributed to the electricity producing countries. But, as indicated above, "road fuel exports" emissions are recorded in Luxembourg's GHG balance.

Now, if the "polluter pays" principle is used as a yardstick, Luxembourg's assessment is that, at present,[51] its GHG emissions according to the IPCC Guidelines are some 2.5 Mio. t CO_2e "too high". The same correction for the year 2012 has been evaluated in the framework of the second NAP for Luxembourg. For the baseline scenario, it gave a difference of approximately 4.8 Mio. t CO_2e between the "origin" and the "polluter pays" principles with the former higher than the latter.

Thus, Luxembourg's efforts to develop efficient, low-carbon electricity production are not rewarded in the actual reporting system for GHG emissions. Luxembourg has, for many years, promoted the construction and the development of highly efficient CHP installations and of a modern gas and steam power plant. Luxembourg has also actively supported power generation and uses based upon renewable energies and, for all these policies, further developments are still in the offing. The impact of these policies has been evaluated using GEMIS 4.2:[52] it has been estimated that electricity imports – with an average emission factors of 0.78 (kt CO_2 per GWh) – have fallen by more than 2,000 GWh since 1998 and have been replaced by national electricity generation with an average emission factor of 0.41 (kt CO_2 per GWh).

So, in terms of the GHG balance, the promotion of renewable energies in the electricity sector, which is associated with major investments, is of little interest. Moreover, additional capacities based upon renewable energies cannot actually be used to replace any electricity from inefficient existing fossil-fuel plants in Luxembourg. Nor will they substitute the highly efficient national production plants which have just been constructed. In reality, they will replace the imported electricity which does not appear in Luxembourg's GHG balance. In this sense, the existing system provides Luxembourg with the incentive not to earmark the generally scant subsidies for Europe's priority investments in renewable energies but, instead, to invest these in measures which might improve its GHG balance.

51 Estimates for the year 2004 realized while producing the second NAP.

52 GEMIS stands for *Global Emission Model for Integrated Systems*: see http://www.oeko.de/service/gemis.

2.2 Description of Emission Trends for GHG Emissions

This section presents Luxembourg's GHG emission trends between the base year (1990) and the latest year covered by submission 2009v1.4, i.e. 2007. For the purpose of an accurate analysis of Luxembourg's emissions, the classical examination of GHG source and sink categories as defined in the CRF (Section 2.2.1 to 2.2.4) will be completed, in Section 2.2.5, by:

- an alternative combination of the CRF source and sink categories so to clearly isolate the major drivers behind GHG emission trends and structure in Luxembourg;
- tables and figures on energy consumption and production.

2.2.1 GHG trend overview

In 2007, as underlined by Table 2-7, carbon dioxide was the main source of GHG in Luxembourg. This source counted for a bit less than 91.5% of the total GHG emissions calculated in CO_2e – total excluding LULUCF.[53] The second source of GHG was nitrous oxide with slightly mote than 4% of the total emissions. Methane was the third source with 3.6%. Fluorinated gases only accounted for 0.7% of the total emissions, with hydrofluorocarbons representing 0.67% of the total and sulphur hexafluoride representing 0.03% of the total. There were no known sources of perfluorocarbons in Luxembourg.

In 2007, total GHG emissions amounted to 12.914 Mio. t CO_2e, 1.56% below their level for the base year.[54] As Figure 2-3 shows, several phases can clearly be distinguished over the period 1990 to 2007:

- firstly, from base year up to 1993, Luxembourg's emissions remained rather stable;
- then, between 1994 and 1998, they started to decrease significantly to reach their lowest value in 1998;
- from 1999 up to 2004, emissions augmented recurrently;
- from 2004 to 2006, a stabilisation around 13.3 Mio. t CO_2e is observed;
- from 2006 to 2007, emissions experienced a relatively important decrease (-2.94%).

The evolution during those 18 years can essentially be explained by changes in production techniques, as well as by changes in the final "energy-mix" consumption. Of course, increasing or decreasing activities for certain source categories also played a crucial role in Luxembourg's GHG emissions trend.

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53 In Section 2.2, when it is referred to "total (GHG) emissions" it is meant "total GHG emissions excluding LULUCF". Reference is made to total emissions excluding LULUCF since this is the one that counts for the reduction target under the Kyoto Protocol.

54 The base year for CO_2, CH_4 and N_2O is 1990. For the F-gases, the base year is 1995. However, due to lack of data on F-gases for the first half of the 1990s, 1995 emission estimates are equalled to 1990 emission estimates (see Table 2-7).

Table 2-7 – Luxembourg's GHG emissions and removals – overview by main gases and CRF Sectors: 1990-2007

Gg (1000 t.) CO_2 equivalent	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2 emissions, incl. net CO_2	12344.32	12642.34	12020.72	12035.13	11350.77	8999.53	8869.46	8202.85	7625.60	7894.13	8425.80	8697.64	9754.49	10211.74	11686.26	11837.33	11856.93	11453.26
from LULUCF (1)	*92.63%*	*92.69%*	*92.22%*	*92.26%*	*91.97%*	*89.95%*	*89.60%*	*88.76%*	*87.94%*	*88.20%*	*88.69%*	*89.32%*	*90.39%*	*91.05%*	*91.53%*	*91.78%*	*91.81%*	*91.46%*
CO_2 emissions, excl. net CO_2	12136.02	12611.07	12360.09	12486.04	11632.18	9384.52	9428.70	8803.73	7970.95	8364.31	8897.31	9239.90	10300.82	10770.93	12204.39	12330.88	12245.75	11844.04
from LULUCF	*92.52%*	*92.67%*	*92.42%*	*92.52%*	*92.15%*	*90.32%*	*90.16%*	*89.45%*	*88.40%*	*88.79%*	*89.23%*	*89.88%*	*90.85%*	*91.48%*	*91.86%*	*92.09%*	*92.05%*	*91.72%*
CH_4 (2) emissions, incl. net CH_4	466.01	475.88	463.74	465.70	460.77	470.12	476.75	471.99	472.24	481.39	476.10	470.18	468.92	459.22	458.41	458.63	456.11	453.54
from LULUCF (1)	*3.50%*	*3.49%*	*3.56%*	*3.57%*	*3.73%*	*4.70%*	*4.82%*	*5.11%*	*5.45%*	*5.38%*	*5.01%*	*4.83%*	*4.35%*	*4.09%*	*3.59%*	*3.56%*	*3.53%*	*3.62%*
CH_4 (2) emissions, excl. net CH_4	466.01	475.88	463.74	465.70	460.77	470.12	476.75	471.99	472.24	481.39	476.10	470.18	468.92	459.22	458.41	458.63	456.11	453.54
from LULUCF	*3.55%*	*3.50%*	*3.47%*	*3.45%*	*3.65%*	*4.52%*	*4.56%*	*4.80%*	*5.24%*	*5.11%*	*4.77%*	*4.57%*	*4.14%*	*3.90%*	*3.45%*	*3.42%*	*3.43%*	*3.51%*
N_2O (3) emissions, incl. net N_2O	498.78	504.46	532.63	527.39	512.58	518.34	529.26	537.37	539.11	534.45	551.33	515.68	505.96	473.95	544.92	515.02	511.39	525.10
from LULUCF (1)	*3.74%*	*3.70%*	*4.09%*	*4.04%*	*4.15%*	*5.18%*	*5.35%*	*5.81%*	*6.22%*	*5.97%*	*5.80%*	*5.30%*	*4.69%*	*4.23%*	*4.27%*	*3.99%*	*3.96%*	*4.19%*
N_2O (3) emissions, excl. net N_2O	498.65	504.33	532.50	527.26	512.45	518.20	529.12	537.23	538.97	534.31	551.20	515.54	505.83	473.82	544.79	514.88	511.26	524.96
from LULUCF	*3.80%*	*3.71%*	*3.98%*	*3.91%*	*4.06%*	*4.99%*	*5.06%*	*5.46%*	*5.98%*	*5.67%*	*5.53%*	*5.01%*	*4.46%*	*4.02%*	*4.10%*	*3.85%*	*3.84%*	*4.07%*
HFCs (4)	14.21	14.21	14.21	14.21	14.21	14.21	19.97	25.73	31.49	37.25	43.01	50.92	58.82	66.73	74.63	82.54	87.04	87.04
	0.11%	*0.10%*	*0.11%*	*0.11%*	*0.11%*	*0.14%*	*0.19%*	*0.26%*	*0.35%*	*0.40%*	*0.43%*	*0.50%*	*0.52%*	*0.57%*	*0.56%*	*0.62%*	*0.65%*	*0.67%*
PFCs (4)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
SF_6 (4)	2.91	2.91	2.91	2.91	2.91	2.91	3.03	3.15	3.28	3.40	3.52	3.57	3.62	3.68	3.73	3.78	3.86	3.94
	0.02%	*0.02%*	*0.02%*	*0.02%*	*0.02%*	*0.03%*	*0.03%*	*0.03%*	*0.04%*	*0.04%*	*0.04%*	*0.03%*	*0.03%*	*0.03%*	*0.03%*	*0.03%*	*0.03%*	*0.03%*
1. Energy	10642.61	11206.87	11040.68	11193.10	10437.03	8542.38	8650.90	8140.36	7471.07	7831.63	8349.84	8744.46	9795.25	10330.46	11745.22	11882.12	11740.68	11345.27
	81.13%	*82.35%*	*82.56%*	*82.94%*	*82.69%*	*82.22%*	*82.72%*	*82.71%*	*82.86%*	*83.13%*	*83.74%*	*85.06%*	*86.39%*	*87.74%*	*88.40%*	*88.73%*	*88.25%*	*87.86%*
2. Industrial Processes	1612.68	1535.59	1465.61	1445.58	1352.51	992.16	942.47	839.46	686.29	729.84	761.99	713.53	737.19	686.27	735.85	736.22	793.78	783.66
	12.29%	*11.28%*	*10.96%*	*10.71%*	*10.72%*	*9.55%*	*9.01%*	*8.53%*	*7.61%*	*7.75%*	*7.64%*	*6.94%*	*6.50%*	*5.83%*	*5.54%*	*5.50%*	*5.97%*	*6.07%*
3. Solvent and Other Product Use	23.90	22.98	21.88	20.85	19.57	19.74	19.42	19.00	17.88	17.30	15.81	16.54	16.76	16.80	18.80	18.47	17.88	18.81
	0.18%	*0.17%*	*0.16%*	*0.15%*	*0.16%*	*0.19%*	*0.19%*	*0.19%*	*0.20%*	*0.18%*	*0.16%*	*0.16%*	*0.15%*	*0.14%*	*0.14%*	*0.14%*	*0.13%*	*0.15%*
4. Agriculture	775.27	781.29	785.20	776.84	754.92	778.38	788.82	786.47	784.10	785.24	782.18	749.90	737.40	686.65	732.56	699.54	695.54	710.64
	5.91%	*5.74%*	*5.87%*	*5.76%*	*5.98%*	*7.49%*	*7.54%*	*7.99%*	*8.70%*	*8.34%*	*7.84%*	*7.29%*	*6.50%*	*5.83%*	*5.51%*	*5.22%*	*5.23%*	*5.50%*
5. LULUCF (5)	208.44	31.41	-339.23	-450.77	-281.28	-384.86	-559.10	-600.74	-345.22	-470.04	-471.37	-542.13	-546.19	-559.06	-518.00	-493.42	-388.69	-390.64
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
6. Waste	63.34	61.67	60.07	59.74	58.49	57.30	55.97	56.53	57.60	56.66	61.32	55.69	51.42	54.19	53.52	54.36	56.14	55.14
	0.48%	*0.45%*	*0.45%*	*0.44%*	*0.46%*	*0.55%*	*0.54%*	*0.57%*	*0.64%*	*0.60%*	*0.62%*	*0.54%*	*0.45%*	*0.46%*	*0.40%*	*0.41%*	*0.42%*	*0.43%*
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Total GHG including LULUCF	13326.23	13639.81	13034.21	13045.34	12341.23	10005.10	9898.47	9241.09	8671.71	8950.63	9499.77	9737.98	10791.82	11215.31	12767.95	12897.29	12915.33	12522.88
	100.00%	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*
Total GHG excluding LULUCF	13117.79	13608.40	13373.44	13496.11	12622.52	10389.96	10457.57	9841.83	9016.93	9420.67	9971.14	10280.11	11338.01	11774.37	13285.95	13390.71	13304.02	12913.52
	100.00%	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*

Source: Environment Agency and Ministry of the Environment.

Notes:

(1) these percentages are relative to the total GHG emissions, including LULUCF.

(2) the methane emissions are converted in CO_2 equivalents by multiplying the emissions by 21, i.e. the global warming potential (GWP) value for methane based on the effects of GHG over a 100-year time horizon.

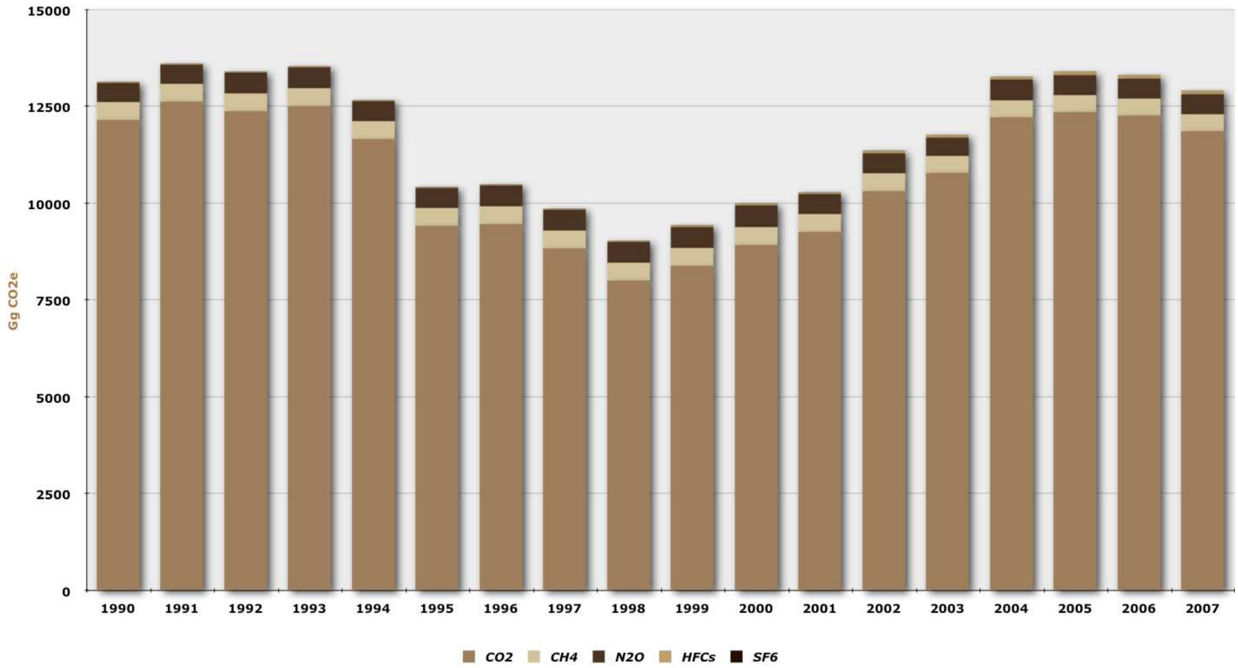
(3) the nitrous oxide emissions are converted in CO_2 equivalents by multiplying the emissions by 310, i.e. the global warming potential (GWP) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

(4) the F-gases are those not covered by the Montreal Protocol, i.e. the HFCs, PFCs and SF6 expressed in CO_2 equivalents using the the global warming potential (GWP) values based on the effects of GHG over a 100-year time horizon.

(5) the land-use change and forestry emissions are covering CRF categories 5A, 5B & 5C only.

Figure 2-3 – Luxembourg's GHG emissions and removals (excl. LULUCF) – absolute values: 1990-2007

GHG



CRF Sectors

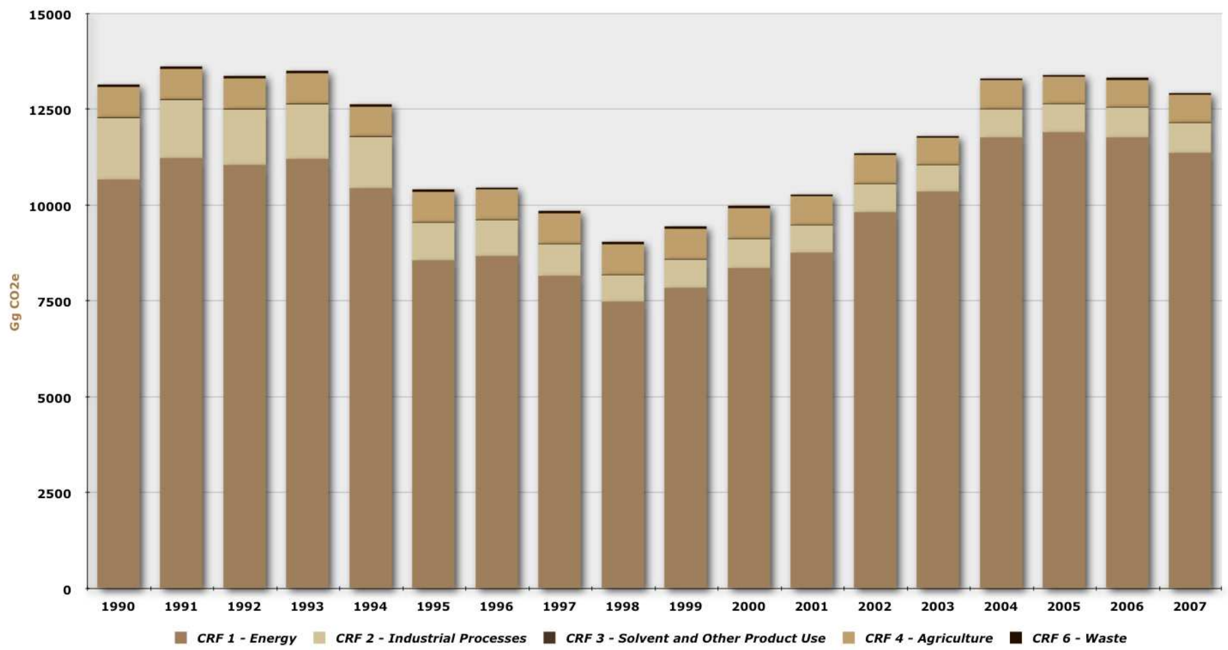
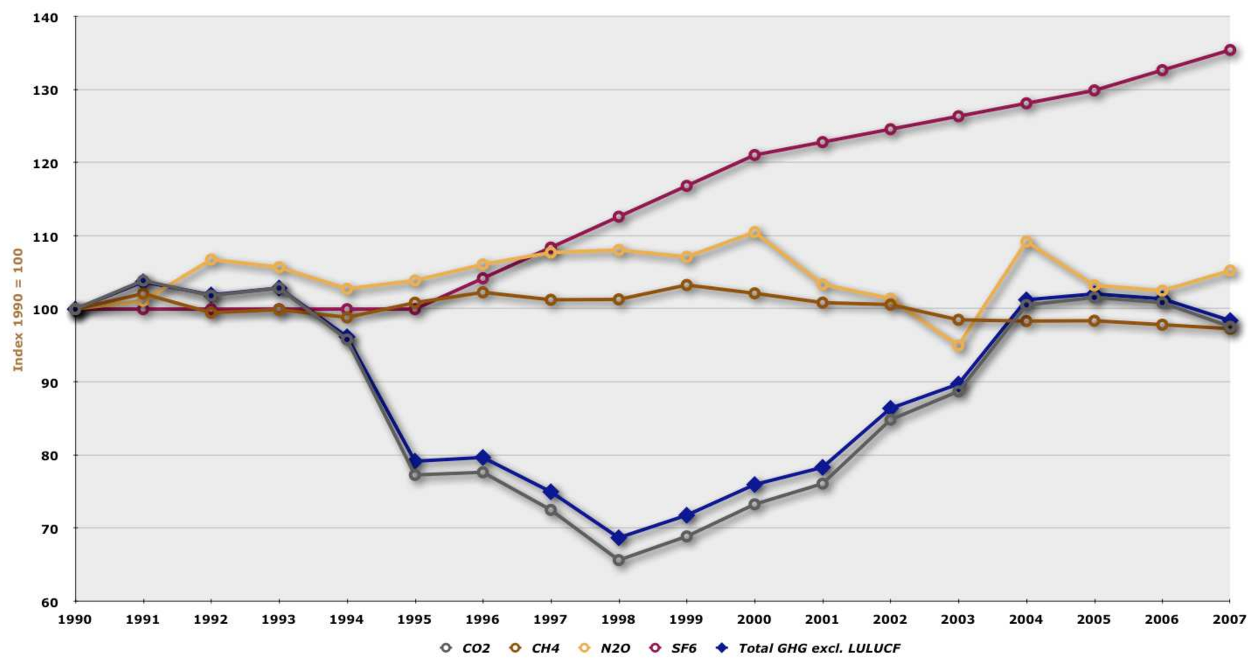


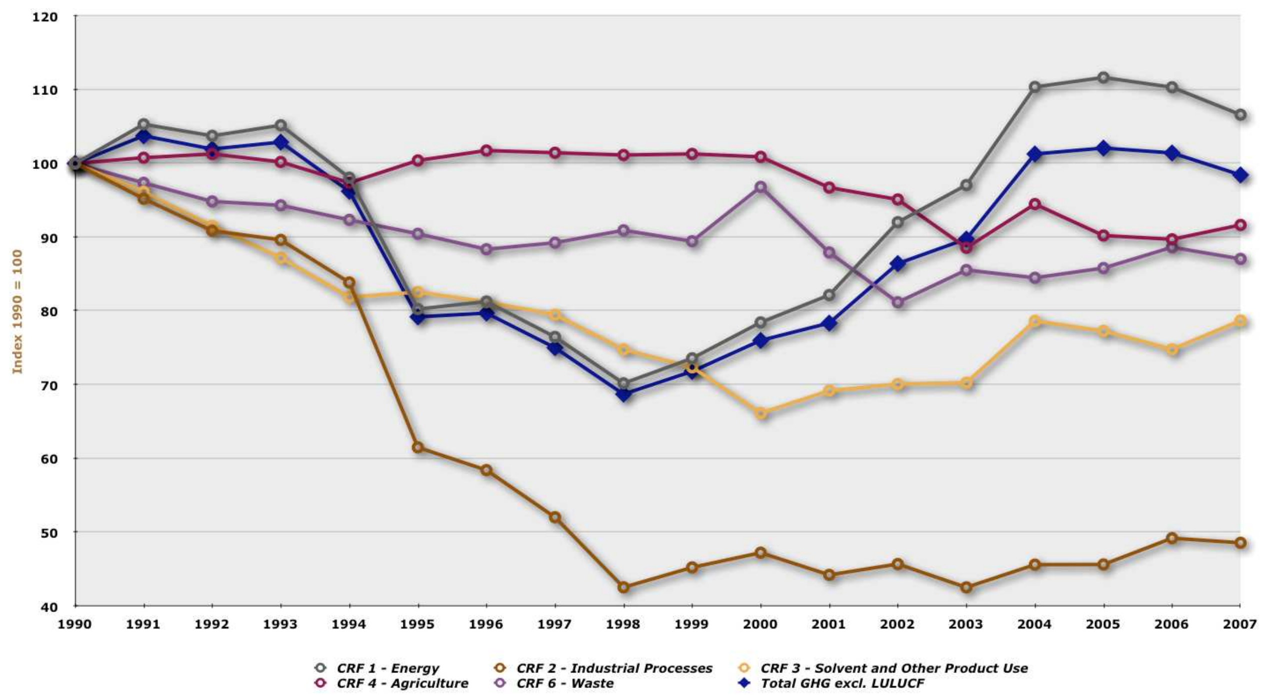
Figure 2-4 – Luxembourg's GHG emissions and removals (excl. LULUCF) – indexes: 1990-2007

GHG



Note: HFcs are not included in this figure for readability reasons (+612.7% between 1990 and 2007).

CRF Sectors



A major example for a technological change in production took place in the iron and steel industry, where the steel production process was moved from blast furnaces to electric arc furnaces between 1994 and 1998 and, therefore, solid fuels (coke) were replaced, to a very large extent, by electricity and natural gas. Due to that technological change, the total energy consumption in steel industry was significantly reduced and the "energy-mix" greatly modified (see Section 3.4.3). This process change was the main driver for the reduction in GHG emissions observed between 1994 and 1998. Changes also occurred in the industrial and residential/commercial/institutional sectors, where the consumption of liquid fuels (residual oil, gasoline) was reduced in favour of natural gas in conjunction with the extension of the natural gas network in Luxembourg.

The road transport sector, on the other hand, is a clear example on how activity levels of a source category can influence the overall GHG emission trend. Indeed, the upward trend for GHG emissions recorded from 1999 to 2004 was merely justified by increasing energy consumption and fuel sales in the transport sector. The stabilization spotted for the inventory years 2004 to 2006 was largely the result of steady sales of gasoline for road transportation together with a lower use of energy in the residential, commercial and institutional sectors. Finally, the decrease in total emissions from 2006 to 2007 was driven by a "road fuel exports" related emissions reduction combined with a diminution of GHG emissions from the power generation sector.

More detailed explanations are provided in Sections 2.2.2 (dealing with gases) and 2.2.3 (on CRF Sectors), as well as in the analysis of emission trends for each sector (see the first section of CRF Sectors Chapters 3 to 8).

A fundamental point worth mentioning when analysing Luxembourg's GHG emission trends and their composition over time, is the small size of Luxembourg, and therefore, the special nature of its economy. Indeed, the structure of the economy, the related energy demand and the energy and emission balances may vary significantly, whether a new economic activity starts its operations or an existing one ceases them. This characteristic explains, for instance, the reduction of emissions pertaining to the industrial sector: with 6.7 Mio. t in 1990, CO_2e emissions from industrial processes and fuel combustion in industry accounted for 51% of total GHG emissions. They could eventually be reduced to 2.2 Mio. t in 1998 – i.e. 24.5% of total GHG emissions – mainly after the reorganization of the steel industry took place in the mid-nineties (move from blast furnaces to electric arc furnaces indicated above). At that time, GHG emissions of Luxembourg were almost one third below the base year level. Another illustrative example is the building of the TWINerg power plant (see also Section 2.1.3.2 above). This plant started its operation in mid-2002 and, by 2007, was responsible of about 0.9 Mio. t CO_2, i.e. around 7% of the total GHG emissions.[55] These considerations can easily be identified in Table 2-8, which distributes, for each GHG, emissions amongst the main source categories.

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55 The highest emissions recorded for the TWINerg plant were 1.02 Mio t CO_2 in 2006, i.e. 7.6% of the total GHG emissions reported for that year.

Table 2-8 – Luxembourg's GHG emissions and removals – details by main gases: 1990-2007

Gg (1000 t.) CO_2 equivalent	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2	**12136.02**	**12611.07**	**12360.09**	**12486.04**	**11632.18**	**9384.52**	**9428.70**	**8803.73**	**7970.95**	**8364.31**	**8897.31**	**9239.90**	**10300.82**	**10770.93**	**12204.39**	**12330.88**	**12245.75**	**11844.04**
	92.52%	*92.67%*	*92.42%*	*92.52%*	*92.15%*	*90.32%*	*90.16%*	*89.45%*	*88.40%*	*88.79%*	*89.23%*	*89.88%*	*90.85%*	*91.48%*	*91.86%*	*92.09%*	*92.05%*	*91.72%*
of which																		
CRF 1 - Energy	10525.81	11078.54	10898.28	11044.95	10285.13	8397.32	8497.05	7981.04	7308.09	7664.02	8171.86	8569.75	9614.79	10143.78	11533.66	11668.12	11530.73	11138.38
	80.24%	*81.41%*	*81.49%*	*81.84%*	*81.48%*	*80.82%*	*81.25%*	*81.09%*	*81.05%*	*81.35%*	*81.96%*	*83.36%*	*84.80%*	*86.15%*	*86.81%*	*87.14%*	*86.67%*	*86.25%*
CRF 1A1 - Fuel Combustion from	1299.25	1242.90	1140.24	1227.91	977.54	833.07	720.17	446.75	164.20	182.38	186.10	211.59	1164.36	1195.78	1438.08	1452.84	1522.69	1358.55
Energy Industries	*9.90%*	*9.13%*	*8.53%*	*9.10%*	*7.74%*	*8.02%*	*6.89%*	*4.54%*	*1.82%*	*1.94%*	*1.87%*	*2.06%*	*10.27%*	*10.16%*	*10.82%*	*10.85%*	*11.45%*	*10.52%*
CRF 1A2 - Fuel Combustion from	5107.88	4937.32	4691.07	4725.24	4214.86	2662.70	2597.58	2192.20	1539.43	1657.23	1682.39	1573.82	1524.34	1471.03	1603.89	1687.48	1691.46	1797.60
Manuf. Industries & Construction	*38.94%*	*36.28%*	*35.08%*	*35.01%*	*33.39%*	*25.63%*	*24.84%*	*22.27%*	*17.07%*	*17.59%*	*16.87%*	*15.31%*	*13.44%*	*12.49%*	*12.07%*	*12.60%*	*12.71%*	*13.92%*
CRF 1A3 - Fuel Combustion from	2701.49	3207.13	3501.26	3546.66	3607.58	3423.22	3523.36	3729.88	3895.85	4196.24	4730.44	5026.57	5375.56	5937.34	6794.48	7016.55	6842.18	6571.27
Transport	*20.59%*	*23.57%*	*26.18%*	*26.28%*	*28.58%*	*32.95%*	*33.69%*	*37.90%*	*43.21%*	*44.54%*	*47.44%*	*48.90%*	*47.41%*	*50.43%*	*51.14%*	*52.40%*	*51.43%*	*50.89%*
of which, road fuel export **(1)**:																		
share in transport sector	67.18%	72.23%	68.89%	65.94%	66.41%	63.53%	66.47%	66.29%	66.09%	66.99%	68.08%	68.94%	70.68%	72.26%	77.15%	78.08%	75.93%	73.30%
estimated CO_2 emissions	1814.74	2316.49	2412.11	2338.74	2395.82	2174.76	2341.84	2472.58	2574.78	2810.90	3220.66	3465.18	3799.37	4290.08	5241.81	5478.42	5195.06	4816.95
	13.83%	*17.02%*	*18.04%*	*17.33%*	*18.98%*	*20.93%*	*22.39%*	*25.12%*	*28.55%*	*29.84%*	*32.30%*	*33.71%*	*33.51%*	*36.44%*	*39.45%*	*40.91%*	*39.05%*	*37.30%*
CRF 1A4 - Fuel Combustion from	1366.41	1640.41	1514.92	1500.71	1443.91	1459.62	1621.46	1573.21	1648.91	1583.93	1519.60	1692.66	1531.06	1530.20	1684.13	1495.25	1464.73	1398.13
Other Sectors	*10.42%*	*12.05%*	*11.33%*	*11.12%*	*11.44%*	*14.05%*	*15.51%*	*15.98%*	*18.29%*	*16.81%*	*15.24%*	*16.47%*	*13.50%*	*13.00%*	*12.68%*	*11.17%*	*11.01%*	*10.83%*
CRF 1A5 & 1B2 - Other Energy	50.78	50.78	50.78	44.43	41.24	18.71	34.47	39.00	59.72	44.23	53.33	65.11	19.47	9.44	13.08	16.00	9.67	12.83
Sources	*0.39%*	*0.37%*	*0.38%*	*0.33%*	*0.33%*	*0.18%*	*0.33%*	*0.40%*	*0.66%*	*0.47%*	*0.53%*	*0.63%*	*0.17%*	*0.08%*	*0.10%*	*0.12%*	*0.07%*	*0.10%*
CRF 2 - Industrial Processes	1595.57	1518.48	1448.49	1428.47	1335.39	975.05	919.47	810.58	651.52	689.19	715.45	659.03	674.75	615.86	657.49	649.90	702.87	692.67
	12.16%	*11.16%*	*10.83%*	*10.58%*	*10.58%*	*9.38%*	*8.79%*	*8.24%*	*7.23%*	*7.32%*	*7.18%*	*6.41%*	*5.95%*	*5.23%*	*4.95%*	*4.85%*	*5.28%*	*5.36%*
Other Sources **(2)**	14.64	14.06	13.32	12.62	11.66	12.16	12.18	12.11	11.33	11.11	9.99	11.12	11.28	11.29	13.24	12.86	12.14	12.98
	0.11%	*0.10%*	*0.10%*	*0.09%*	*0.09%*	*0.12%*	*0.12%*	*0.12%*	*0.13%*	*0.12%*	*0.10%*	*0.11%*	*0.10%*	*0.10%*	*0.10%*	*0.10%*	*0.09%*	*0.10%*
CH_4 (3)	**466.01**	**475.88**	**463.74**	**465.70**	**460.77**	**470.12**	**476.75**	**471.99**	**472.24**	**481.39**	**476.10**	**470.18**	**468.92**	**459.22**	**458.41**	**458.63**	**456.11**	**453.54**
	3.55%	*3.50%*	*3.47%*	*3.45%*	*3.65%*	*4.52%*	*4.56%*	*4.80%*	*5.24%*	*5.11%*	*4.77%*	*4.57%*	*4.14%*	*3.90%*	*3.45%*	*3.42%*	*3.43%*	*3.51%*
of which																		
CRF 1 - Energy	55.49	61.25	61.33	59.31	58.50	57.44	61.06	59.34	59.03	59.70	60.60	61.07	73.81	73.43	78.99	75.45	76.18	72.51
	0.42%	*0.45%*	*0.46%*	*0.44%*	*0.46%*	*0.55%*	*0.58%*	*0.60%*	*0.65%*	*0.63%*	*0.61%*	*0.59%*	*0.65%*	*0.62%*	*0.59%*	*0.56%*	*0.57%*	*0.56%*
CRF 4A+4B - Enteric Fermentation and	356.52	362.47	352.02	357.15	354.65	366.37	369.98	367.37	368.21	378.04	369.67	368.91	359.02	348.56	343.51	347.03	343.10	345.13
Manure Management	*2.72%*	*2.66%*	*2.63%*	*2.65%*	*2.81%*	*3.53%*	*3.54%*	*3.73%*	*4.08%*	*4.01%*	*3.71%*	*3.59%*	*3.17%*	*2.96%*	*2.59%*	*2.59%*	*2.58%*	*2.67%*
Other Sources **(4)**	54.00	52.16	50.38	49.24	47.62	46.31	45.71	45.28	45.00	43.66	45.84	40.19	36.09	37.23	35.91	36.15	36.84	35.89
	0.41%	*0.38%*	*0.38%*	*0.36%*	*0.38%*	*0.45%*	*0.44%*	*0.46%*	*0.50%*	*0.46%*	*0.46%*	*0.39%*	*0.32%*	*0.32%*	*0.27%*	*0.27%*	*0.28%*	*0.28%*
N_2O (5)	**498.65**	**504.33**	**532.50**	**527.26**	**512.45**	**518.20**	**529.12**	**537.23**	**538.97**	**534.31**	**551.20**	**515.54**	**505.83**	**473.82**	**544.79**	**514.88**	**511.26**	**524.96**
	3.80%	*3.71%*	*3.98%*	*3.91%*	*4.06%*	*4.99%*	*5.06%*	*5.46%*	*5.98%*	*5.67%*	*5.53%*	*5.01%*	*4.46%*	*4.02%*	*4.10%*	*3.85%*	*3.84%*	*4.07%*
of which																		
CRF 1 - Energy	61.30	67.07	81.07	88.84	93.40	87.62	92.80	99.99	103.94	107.92	117.38	113.63	106.65	113.25	132.57	138.55	133.77	134.38
	0.47%	*0.49%*	*0.61%*	*0.66%*	*0.74%*	*0.84%*	*0.89%*	*1.02%*	*1.15%*	*1.15%*	*1.18%*	*1.11%*	*0.94%*	*0.96%*	*1.00%*	*1.03%*	*1.01%*	*1.04%*
CRF 4D - Agricultural Soils	378.14	383.95	401.44	388.40	370.30	381.07	387.48	388.98	387.36	383.18	389.07	357.56	356.09	315.45	366.52	330.62	331.61	339.85
	2.88%	*2.82%*	*3.00%*	*2.88%*	*2.93%*	*3.67%*	*3.71%*	*3.95%*	*4.30%*	*4.07%*	*3.90%*	*3.48%*	*3.14%*	*2.68%*	*2.76%*	*2.47%*	*2.49%*	*2.63%*
Other Sources **(6)**	59.21	53.31	49.99	50.02	48.75	49.51	48.85	48.27	47.68	43.21	44.75	44.35	43.09	45.12	45.69	45.72	45.88	50.73
	0.45%	*0.39%*	*0.37%*	*0.37%*	*0.39%*	*0.48%*	*0.47%*	*0.49%*	*0.53%*	*0.46%*	*0.45%*	*0.43%*	*0.38%*	*0.38%*	*0.34%*	*0.34%*	*0.34%*	*0.39%*
F-gases (7)	**17.12**	**17.12**	**17.12**	**17.12**	**17.12**	**17.12**	**23.00**	**28.88**	**34.77**	**40.65**	**46.53**	**54.49**	**62.45**	**70.40**	**78.36**	**86.32**	**90.90**	**90.98**
	0.13%	*0.13%*	*0.13%*	*0.13%*	*0.14%*	*0.16%*	*0.22%*	*0.29%*	*0.39%*	*0.43%*	*0.47%*	*0.53%*	*0.55%*	*0.60%*	*0.59%*	*0.64%*	*0.68%*	*0.70%*
Total GHG excluding LULUCF	**13117.79**	**13608.40**	**13373.44**	**13496.11**	**12622.52**	**10389.96**	**10457.57**	**9841.83**	**9016.93**	**9420.67**	**9971.14**	**10280.11**	**11338.01**	**11774.37**	**13285.95**	**13390.71**	**13304.02**	**12913.52**
	100.00%	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*
LULUCF (8)	**208.44**	**31.41**	**-339.23**	**-450.77**	**-281.28**	**-384.86**	**-559.10**	**-600.74**	**-345.22**	**-470.04**	**-471.37**	**-542.13**	**-546.19**	**-559.06**	**-518.00**	**-493.42**	**-388.69**	**-390.64**

Source: Environment Agency and Ministry of the Environment.

Notes:

(1) estimation done using COPERT IV and the quantities of road fuels sold in Luxembourg: see Chapter 3.

(2) the other CO_2 sources are emissions from solvent and other product use (CRF 3).

(3) the methane emissions are converted in CO_2 equivalents by multiplying the emissions by 21, i.e. the global warming potential (GWP) value for methane based on the effects of GHG over a 100-year time horizon.

(4) the other CH_4 sources are emissions from solid waste disposal on land (CRF 6A), waste water handling (CRF 6B) and composting (CRF 6D).

(5) the nitrous oxide emissions are converted in CO_2 equivalents by multiplying the emissions by 310, i.e. the global warming potential (GWP) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

(6) the other N_2O sources are emissions from anasthesiae (CRF 3D), manure management (CRF 4B), waste water handling (CRF 6B) and composting (CRF 6D).

(7) the F-gases are those not covered by the Montreal Protocol, i.e. the HFCs, PFCs and SF6 expressed in CO_2 equivalents using the the global warming potential (GWP) values based on the effects of GHG over a 100-year time horizon.

(8) the land-use change and forestry emissions are covering CRF categories 5A, 5B & 5C only.

2.2.2 GHG trends by gas

For the different GHG, trends over the period 1990-2007 were as follows:

- CO_2: .... -2.41%
- CH_4: .... -2.68%
- N_2O: .... +5.28%
- F-gases: .... +431,59%

For carbon dioxide, the relatively close values estimated in 1990 and 2007 respectively hide a U-shape evolution over the period as well as important changes in the sources of CO_2 emissions: declining emissions in industrial and thermal power plant combustion, increasing emissions from transport and for natural gas fired power plants – as underlined in the previous section.

The methane emissions decline over the period is the conjunction of reduced methane emissions in agriculture (-3.2%) and in waste management (-33.5%) with growing emissions in energy use (+30.7%), the latter being due to an upward trend for fugitive emissions from natural gas distribution and use.

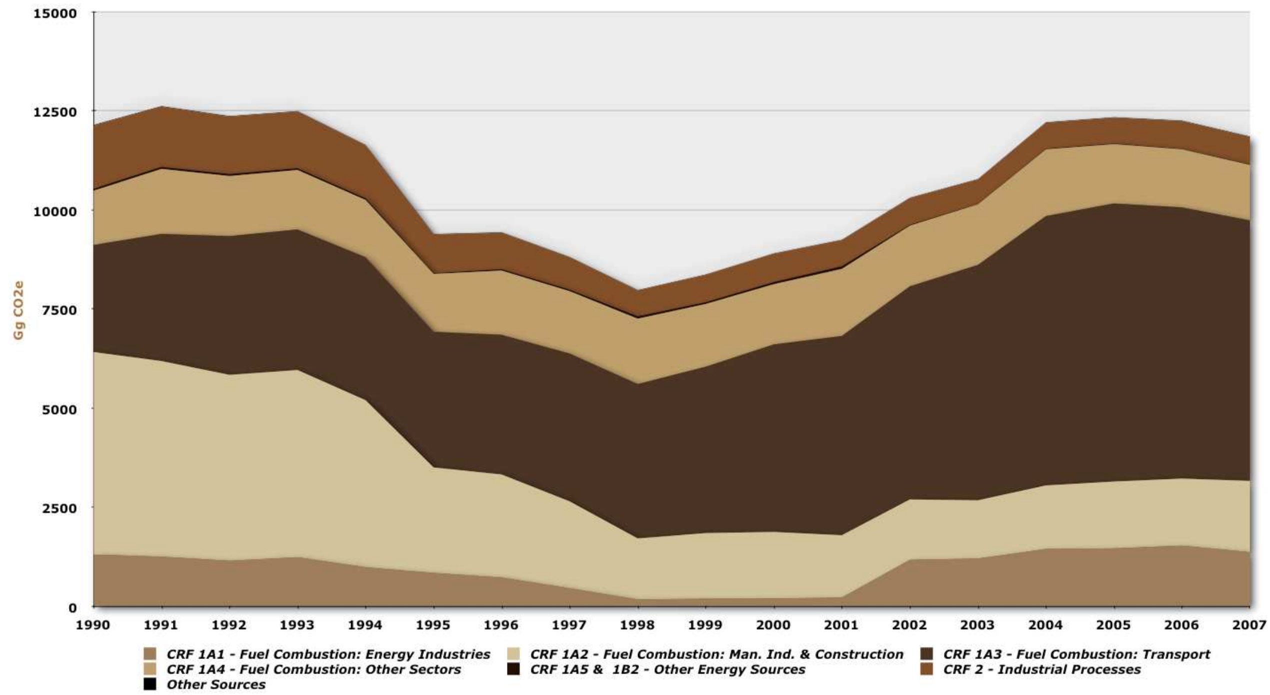
Nitrous oxide emissions development is closely linked to an increase of liquid fuels related emissions in both other manufacturing industries and road transportation (gasoline and diesel oil) that could not be balanced by declining emissions from the agriculture sector.

Finally, with regard to F-gases, HFCs emissions were 6 times higher in 2007 than in the base year, whereas SF_6 emissions showed a 35.4% increase.

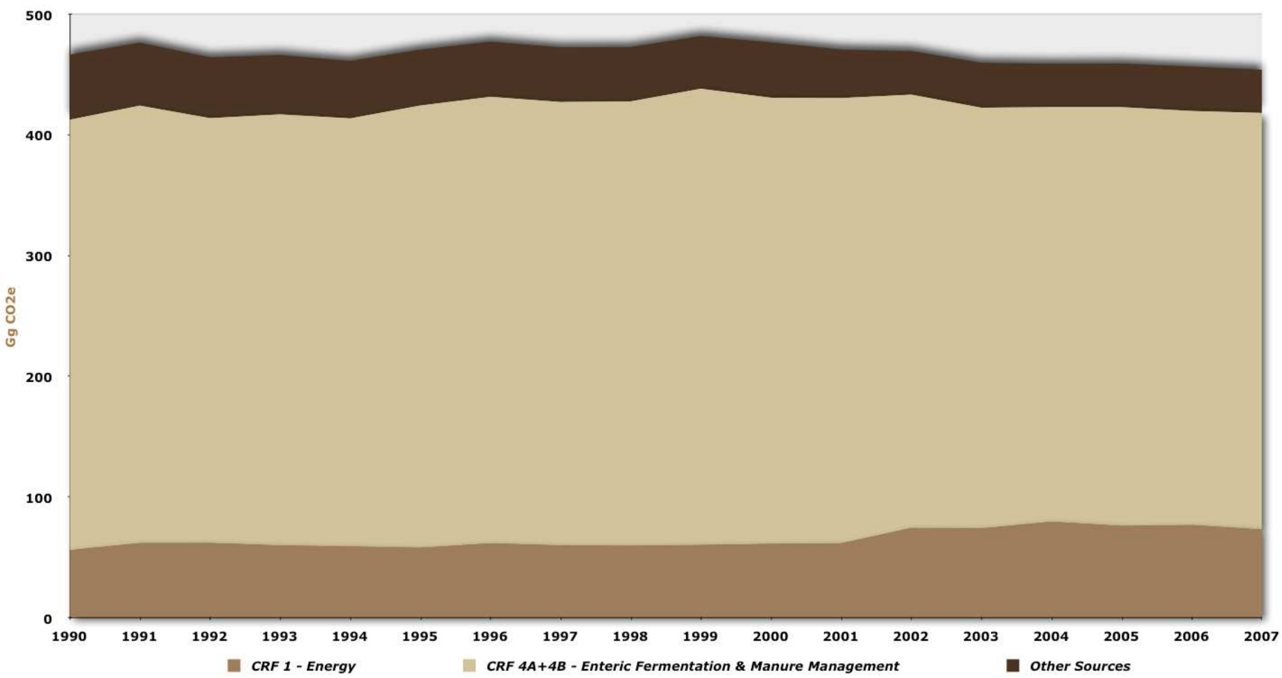
These evolutions can be visualized in Table 2-8, as well as in Figure 2-5 and Figure 2-6.

Figure 2-5 – Luxembourg's GHG emissions and removals (excl. F-gases & LULUCF) – details by main gases: 1990-2007

<u>CO_2</u>



<u>CH_4</u>



N₂O

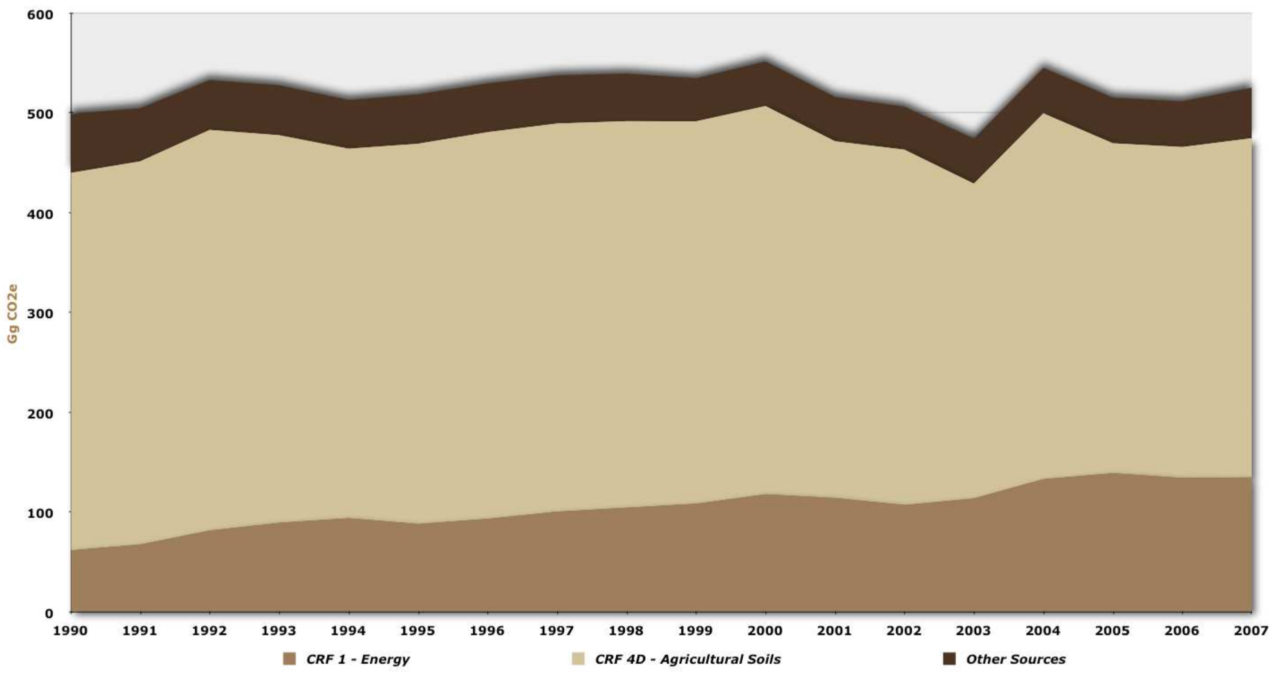
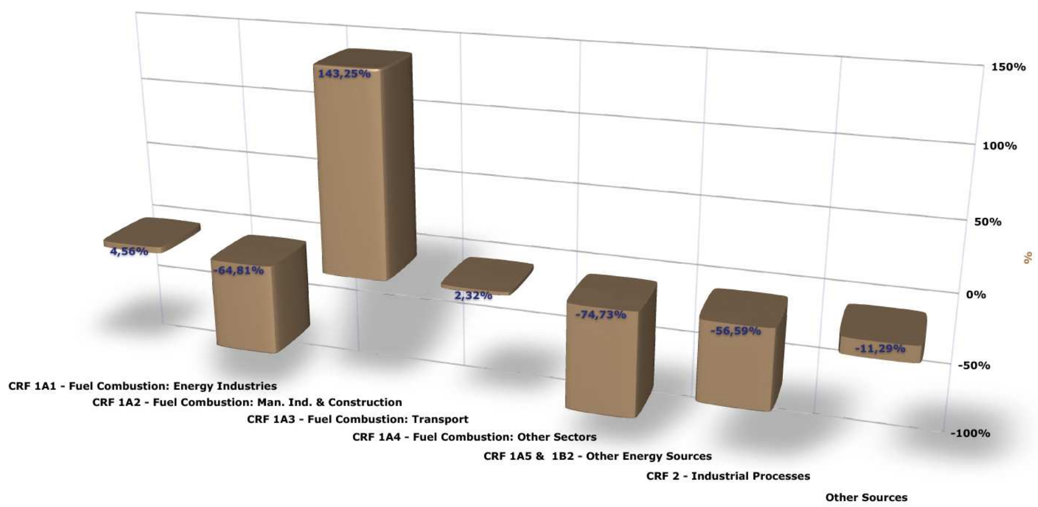
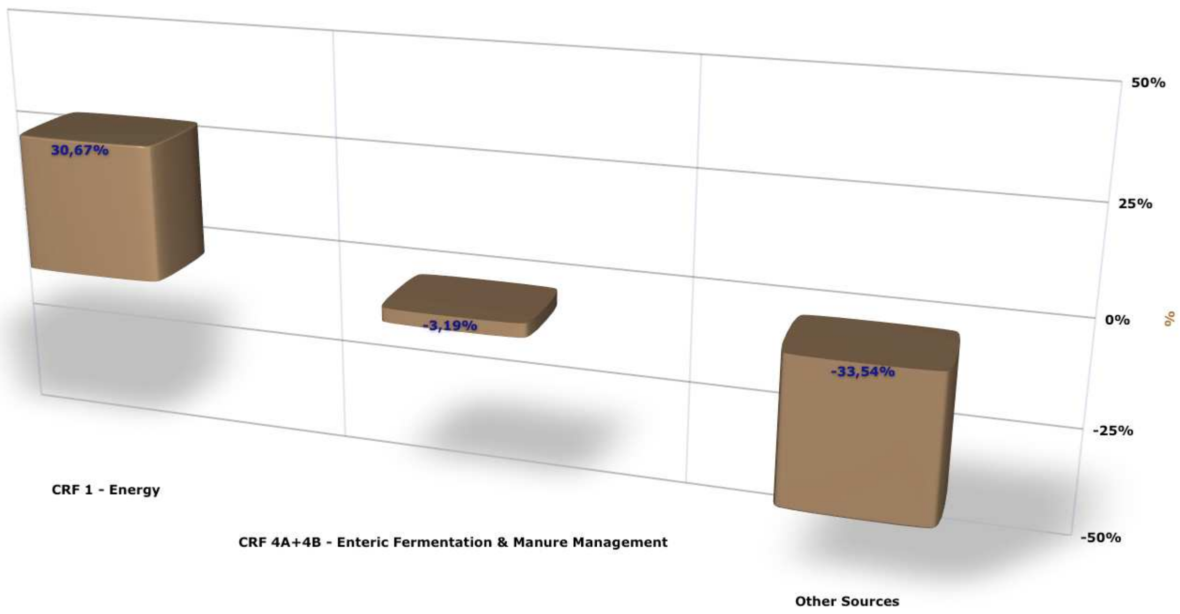


Figure 2-6 – Luxembourg's GHG emission and removal trends in % (excl. LULUCF) – details by main gases 1990-2007

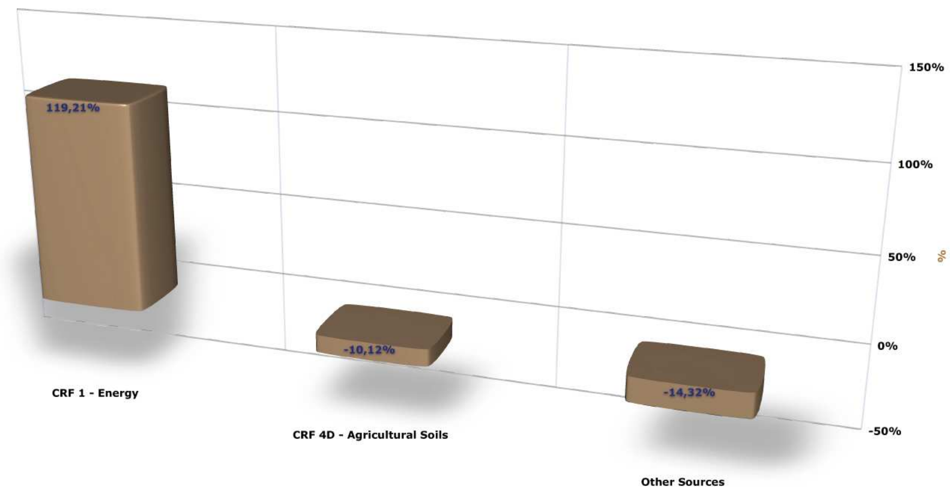
CO_2



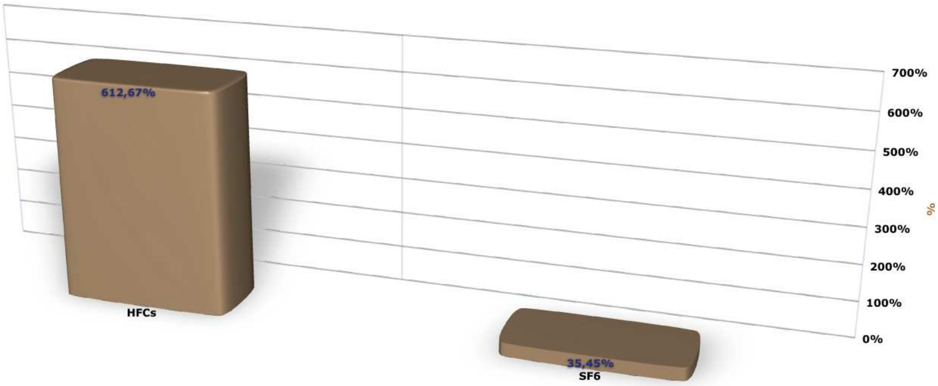
CH_4


30,67%
-3,19%
-33,54%
50%
25%
0%
-25%
-50%
%
CRF 1 - Energy
CRF 4A+4B - Enteric Fermentation & Manure Management
Other Sources

N_2O


119,21%
-10,12%
-14,32%
150%
100%
50%
0%
-50%
%
CRF 1 - Energy
CRF 4D - Agricultural Soils
Other Sources

F-gases



From Table 2-8, and its associated Figure 2-5 and Figure 2-6, emission trends for each of the gases can be analysed further.

2.2.2.1 Carbon dioxide – CO_2

Throughout the period 1990-2007, the main GHG has remained carbon dioxide, which accounted between 88% and 93% of the total GHG emissions. However, the structure of CO_2 emissions has evolved with an increase in fuel combustion, which accounted for 80.2% of total GHG emissions for the base year (1990) and climbed up to 86.3% in 2007.

Road transport, and more precisely "road fuel exports", is, with electricity production, one of the culprits for this development. Indeed, in 1990, fuel combustion from the transport sector accounted for 20.6% of total GHG emissions. Then, with 6.6 Mio. t CO_2, this percentage reached 50.9% in 2007.[56] CO_2 emissions due solely to "road fuel exports" amounted to about 1.8 Mio. t in 1990 and reached 4.8 Mio. t in 2007,[57] i.e. roughly a threefold increase (the same comparison shows only a twofold increase for road fuel consumed by the national vehicle fleet). In 2007, "road fuel exports" represented 73.3% of CO_2 emissions of the transport sector and 37.3% of the total GHG emissions.[58] In 1990, these percentages were, respectively, 67.2% and 13.8%.

Another important source of CO_2 is industrial processes, i.e., in the case of Luxembourg, mainly carbon oxidizing of pig iron from steel industry (basic oxygen furnace steel production) and de-

56 The highest percentage was recorded for the year 2005: 7 Mio. t CO_2 and 52.4% of total GHG emissions.

57 5.5 Mio. t in 2005.

58 For 2005, these percentages were respectively 78% and 40.9%.

carbonisation of mineral input in clinker and glass industry. The steel production process change described above was the main driver behind declining emissions for this sector.

2.2.2.2 Methane – CH_4

Methane emissions originate above all from the agricultural sector, and more precisely from enteric fermentation and from manure production and management. As these emissions have been rather stable over the period 1990-2007, total methane emissions have not varied very much.

For the other methane emitting source categories, the increase observed for fuel combustion is mainly due to fugitive emissions from natural gas distribution and use. The decrease noted for waste is the result of reduced methane emissions from waste landfill sites.

2.2.2.3 Nitrous oxide – N_2O

A large part of nitrous oxide emissions is caused by agricultural soils. Another important source, which has generated increasing N_2O emissions since 1990, is road transport, where incomplete NO_X reduction in catalytic converters of diesel oil motor vehicles leads to N_2O emissions that were multiplied by almost 9 over the period following the increasing share of diesel vehicles on the roads.

2.2.2.4 Hydrofluorocarbons – HFCs and sulphur hexafluoride – SF_6

A first estimation of the emissions of fluorinated GHG types (HFCs, PFCs and SF_6) was done at the end of 1999 by the Environment Agency and Luxembourg's *Centre de Ressources des Technologies pour l'Environnement* (*CRTE*). It indicated that there are some HFCs and SF_6 emissions in Luxembourg, but no emissions of PFCs.

The increase in HFC emissions between 1990 and 2007 is explained by a more wide spread use of mobile and stationary cooling equipments as well as of aerosols.

SF_6 emissions increased from 1990 onwards following a raising use of high voltage electrical devices and a higher amount of gas emitted from noise reduction windows.

2.2.3 GHG trends by sector

In 2007, the energy sector accounted for almost 88% of the total CO_2e GHG emissions. Two sectors represent between 5.5% and 6% of the total emissions: industrial processes (6.1%) and agriculture

(5.5%). The remaining sectors[59] (solvent and other product use, waste[60]) were not even reaching 1% of the total GHG emitted in Luxembourg in 2007: see Table 2-7.

For the different sectors, trends over the period 1990-2007 were as follows:

- Energy: .... +6.60%
- Industrial Processes: .... -51.41%
- Solvent and Other Product Use: .... -21.29%
- Agriculture: .... -8.34%
- Waste:.. -12.94%

Emission reductions observed in all sectors but one could not balance the growth of energy use and production related emissions whose contribution to total GHG emissions ranged from 80% to 90% over the period 1990 to 2007. Within the energy sector, the fastest growing sub-sector was transport (1A3): +142% between 1990 and 2007 with, as a result, a share in the total energy related GHG emissions rising from 26% to 59%. For the other sub-sectors, the observed trends between 1990 and 2007 are +2% for energy industries (1A1), -66% for manufacturing industries (1A2), +3% for the other sectors (1A4) and +176% for fugitive emissions from fuels (1B).[61]

The second largest sector in Luxembourg with regard to GHG emissions, i.e. industrial processes, shows a declining trend between 1990 and 1998, then a relative stabilisation. This evolution was mainly driven by process changes that occurred in the steel industry (recorded under 2C1). As indicated above, this industry moved from blast to electric arc furnaces between 1994 and 1998. As a consequence, steel industry emissions in CO_2e decreased by 79% since 1990.

Trends in agriculture were also favourable between 1990 and 2007: declining GHG emissions were observed for the 3 categories for which emissions are recorded in Luxembourg: enteric fermentation (4A: -9%), manure management (4B: -2%) and agricultural soils (4D: -10%).

In the waste sector, the main source of GHG was solid waste disposal on land (6A), but its weight decreased over the period 1990-2007 due to the combination of reduced amounts of landfilled waste and of increased emissions arising from composting activities (6D). However, GHG emission reduction for solid waste disposal on land (-48% between 1990 and 2007) still drove a reduc-

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59 The sector “other” is not reported for Luxembourg.

60 The waste sector covers only landfilled waste, wastewater handling and composting activities. Waste incineration, which is the main treatment method for municipal waste in Luxembourg, is carried out in the sole incinerator of the country where energy is recovered. Consequently, waste incineration related emissions are accounted for in CRF sector 1 – Energy (details in Chapters 3 and 8 respectively).

61 Fugitive emission growth is closely linked to natural gas use in Luxembourg.

tion for the overall waste sector despite composting rising emissions (wastewater handling emissions (6B) remained stable throughout the period with a 0.1% increase).

Finally, the fact that the iron and steel industry has abandoned blast furnaces between 1994 and 1998, and that fossil fuel consumption as well as road fuel sales have continued to increase after 1998, hide many other emission trends and, due to their importance in the national total GHG emissions, they shape the overall pattern of Luxembourg's GHG emissions trend.

2.2.4 Indirect GHG and SO2

Some indirect GHG – NOx, CO, NMVOCs – and SO_2 emissions are recorded in the inventory. Nevertheless, they need to be re-evaluated in the light of the revision of the inventories Luxembourg is compiling for the UNECE CLRTAP. Consequently, these emissions will not be discussed in this NIR and generating better emission estimates for these gases are part of our planned improvements.

2.2.5 Additional information

This section provides some additional information allowing to better assess GHG emissions, trends and configuration in Luxembourg.

Firstly, Table 2-9 assembles CRF source categories in such a way that GHG emission sources are distributed between main emitters – such as energy production, industry, road transportation – and other categories. Data presented in Table 2-9 are complemented by Figure 2-7.

Secondly, a set of tables and figures focus on primary and final energy consumption in Luxembourg. It is complemented by an energy balance for electric power.

2.2.5.1 GHG trend by source categories – alternative distribution

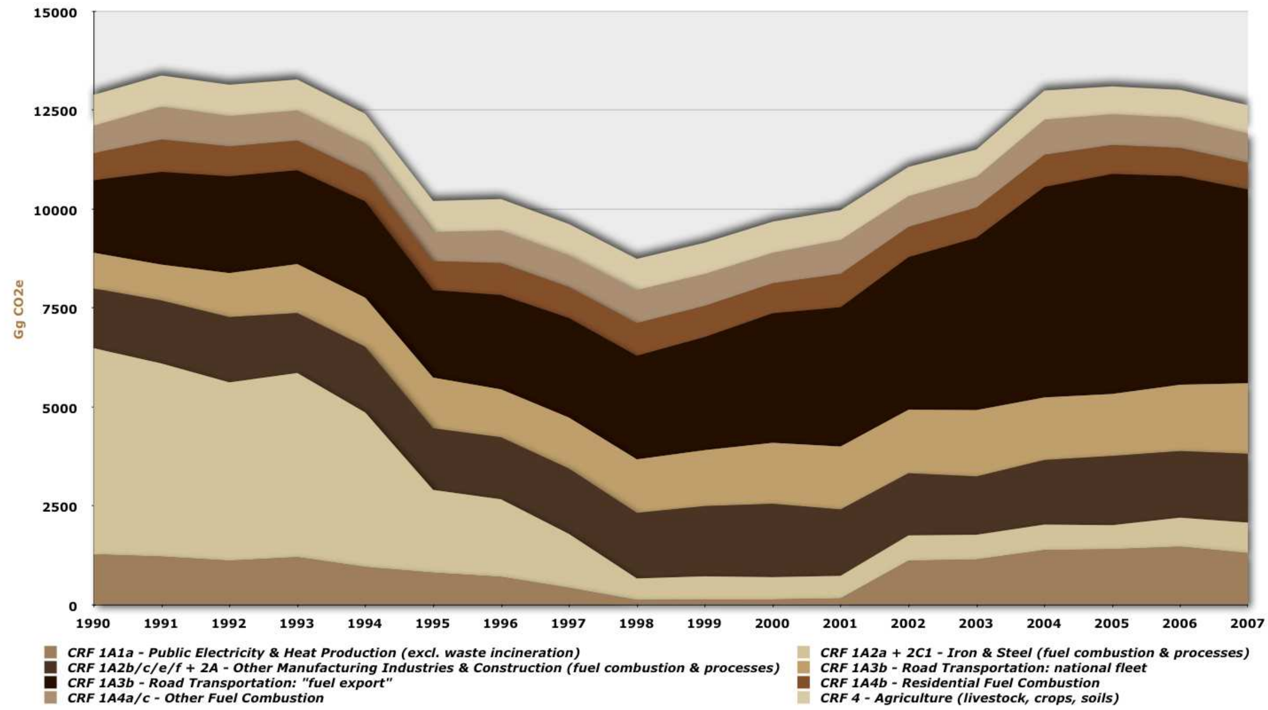
Table 2-9 – Luxembourg's GHG emissions and removals (excl. LULUCF) – alternative presentation: 1990-2007

Gg (1000 t.) CO_2 equivalent	CRF Categories	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Main Emitting Source Categories																			
Public Electricity & Heat Production	*1A1a*	1267.90	1210.89	1107.56	1196.82	947.05	803.98	697.70	420.03	111.65	122.22	127.66	153.92	1106.67	1136.93	1374.61	1394.79	1461.48	1295.72
(excl. waste incineration)		*9.67%*	*8.90%*	*8.28%*	*8.87%*	*7.50%*	*7.74%*	*6.67%*	*4.27%*	*1.24%*	*1.30%*	*1.28%*	*1.50%*	*9.76%*	*9.66%*	*10.35%*	*10.42%*	*10.99%*	*10.03%*
Iron & Steel (fuel combustion	*1A2a + 2C1*	5208.86	4878.94	4504.29	4652.61	3904.20	2091.20	1960.27	1362.64	545.24	589.77	562.79	569.99	639.14	624.14	644.98	609.65	732.83	772.50
& processes)		*39.71%*	*35.85%*	*33.68%*	*34.47%*	*30.93%*	*20.13%*	*18.74%*	*13.85%*	*6.05%*	*6.26%*	*5.64%*	*5.54%*	*5.64%*	*5.30%*	*4.85%*	*4.55%*	*5.51%*	*5.98%*
Other Manufacturing Industries &	*1A2b/c/e/f + 2A*	1510.99	1591.99	1651.46	1516.16	1660.36	1557.73	1568.30	1652.66	1659.12	1774.21	1855.38	1678.21	1572.64	1475.08	1631.74	1749.60	1683.34	1739.51
Construction (fuel combustion & processes)		*11.52%*	*11.70%*	*12.35%*	*11.23%*	*13.15%*	*14.99%*	*15.00%*	*16.79%*	*18.40%*	*18.83%*	*18.61%*	*16.32%*	*13.87%*	*12.53%*	*12.28%*	*13.07%*	*12.65%*	*13.47%*
Road Transportation - national fleet	*1A3b*	900.46	905.76	1110.60	1236.32	1241.35	1280.04	1209.39	1288.15	1351.10	1413.98	1539.65	1589.71	1603.56	1675.43	1580.19	1565.70	1675.11	1783.92
		6.86%	*6.66%*	*8.30%*	*9.16%*	*9.83%*	*12.32%*	*11.56%*	*13.09%*	*14.98%*	*15.01%*	*15.44%*	*15.46%*	*14.14%*	*14.23%*	*11.89%*	*11.69%*	*12.59%*	*13.81%*
Road Transportation - fuel export	*1A3b*	1834.47	2345.23	2447.28	2373.98	2435.63	2214.18	2386.10	2517.75	2620.15	2859.46	3274.28	3518.94	3855.82	4354.52	5319.31	5561.43	5273.54	4896.58
		13.98%	*17.23%*	*18.30%*	*17.59%*	*19.30%*	*21.31%*	*22.82%*	*25.58%*	*29.06%*	*30.35%*	*32.84%*	*34.23%*	*34.01%*	*36.98%*	*40.04%*	*41.53%*	*39.64%*	*37.92%*
Residential Fuel Combustion	*1A4b*	680.66	816.73	753.65	748.07	717.93	727.37	807.02	781.22	822.64	785.08	756.06	841.25	761.56	761.17	810.43	729.11	710.44	670.67
		5.19%	*6.00%*	*5.64%*	*5.54%*	*5.69%*	*7.00%*	*7.72%*	*7.94%*	*9.12%*	*8.33%*	*7.58%*	*8.18%*	*6.72%*	*6.46%*	*6.10%*	*5.44%*	*5.34%*	*5.19%*
Other Fuel Combustion	*1A4a/c*	697.44	836.75	773.63	764.81	737.91	744.11	827.00	804.50	839.38	811.55	776.10	864.21	781.30	780.77	892.10	781.34	770.38	745.14
		5.32%	*6.15%*	*5.78%*	*5.67%*	*5.85%*	*7.16%*	*7.91%*	*8.17%*	*9.31%*	*8.61%*	*7.78%*	*8.41%*	*6.89%*	*6.63%*	*6.71%*	*5.83%*	*5.79%*	*5.77%*
Agriculture (livestock, crops, soils)	*4*	775.27	781.29	785.20	776.84	754.92	778.38	788.82	786.47	784.10	785.24	782.18	749.90	737.40	686.65	732.56	699.54	695.54	710.64
		5.91%	*5.74%*	*5.87%*	*5.76%*	*5.98%*	*7.49%*	*7.54%*	*7.99%*	*8.70%*	*8.34%*	*7.84%*	*7.29%*	*6.50%*	*5.83%*	*5.51%*	*5.22%*	*5.23%*	*5.50%*
Other Source Categories																			
Municipal Waste Incineration	*1A1a (6C)*	33.92	34.65	35.38	33.66	32.93	31.45	24.33	28.83	55.01	62.98	61.19	60.41	61.35	62.62	67.68	62.03	65.39	66.94
(with energy & heat recovery)		*0.26%*	*0.25%*	*0.26%*	*0.25%*	*0.26%*	*0.30%*	*0.23%*	*0.29%*	*0.61%*	*0.67%*	*0.61%*	*0.59%*	*0.54%*	*0.53%*	*0.51%*	*0.46%*	*0.49%*	*0.52%*
Other Transport	*1A3a/c/d*	28.60	28.71	28.84	29.09	28.35	23.21	25.84	25.49	25.37	25.45	25.03	26.88	23.83	21.03	16.88	11.20	8.53	2.83
		0.22%	*0.21%*	*0.22%*	*0.22%*	*0.22%*	*0.22%*	*0.25%*	*0.26%*	*0.28%*	*0.27%*	*0.25%*	*0.26%*	*0.21%*	*0.18%*	*0.13%*	*0.08%*	*0.06%*	*0.02%*
Other Energy Sources	*1A5 + 1B2b*	74.89	75.68	76.49	70.04	66.71	44.16	64.42	69.66	92.93	76.12	87.15	99.96	64.12	54.63	64.79	67.17	62.51	64.14
		0.57%	*0.56%*	*0.57%*	*0.52%*	*0.53%*	*0.43%*	*0.62%*	*0.71%*	*1.03%*	*0.81%*	*0.87%*	*0.97%*	*0.57%*	*0.46%*	*0.49%*	*0.50%*	*0.47%*	*0.50%*
F-gases	*2F*	17.12	17.12	17.12	17.12	17.12	17.12	23.00	28.88	34.77	40.65	46.53	54.49	62.45	70.40	78.36	86.32	90.90	90.98
		0.13%	*0.13%*	*0.13%*	*0.13%*	*0.14%*	*0.16%*	*0.22%*	*0.29%*	*0.39%*	*0.43%*	*0.47%*	*0.53%*	*0.55%*	*0.60%*	*0.59%*	*0.64%*	*0.68%*	*0.70%*
Solvent & Other Product Use	*3*	23.90	22.98	21.88	20.85	19.57	19.74	19.42	19.00	17.88	17.30	15.81	16.54	16.76	16.80	18.80	18.47	17.88	18.81
		0.18%	*0.17%*	*0.16%*	*0.15%*	*0.16%*	*0.19%*	*0.19%*	*0.19%*	*0.20%*	*0.18%*	*0.16%*	*0.16%*	*0.15%*	*0.14%*	*0.14%*	*0.14%*	*0.13%*	*0.15%*
Municipal Waste Disposal on Land	*6A*	47.87	46.18	44.56	43.08	41.53	40.24	39.92	38.94	37.96	36.71	36.95	31.71	26.82	26.71	25.67	25.63	25.50	24.98
		0.36%	*0.34%*	*0.33%*	*0.32%*	*0.33%*	*0.39%*	*0.38%*	*0.40%*	*0.42%*	*0.39%*	*0.37%*	*0.31%*	*0.24%*	*0.23%*	*0.19%*	*0.19%*	*0.19%*	*0.19%*
Waste Water Handling	*6B*	15.47	15.49	15.51	15.64	15.77	15.57	14.75	14.75	14.92	15.04	15.27	15.48	14.28	14.29	14.97	14.97	15.20	15.48
		0.12%	*0.11%*	*0.12%*	*0.12%*	*0.12%*	*0.15%*	*0.14%*	*0.15%*	*0.17%*	*0.16%*	*0.15%*	*0.15%*	*0.13%*	*0.12%*	*0.11%*	*0.11%*	*0.11%*	*0.12%*
Composting	*6D*	NO	NO	NO	1.03	1.19	1.49	1.30	2.85	4.72	4.91	9.11	8.50	10.32	13.19	12.88	13.75	15.44	14.68
		NA	*NA*	*NA*	*0.01%*	*0.01%*	*0.01%*	*0.01%*	*0.03%*	*0.05%*	*0.05%*	*0.09%*	*0.08%*	*0.09%*	*0.11%*	*0.10%*	*0.10%*	*0.12%*	*0.11%*
Total GHG excluding LULUCF		13117.79	13608.40	13373.44	13496.11	12622.52	10389.96	10457.57	9841.83	9016.93	9420.67	9971.14	10280.11	11338.01	11774.37	13285.95	13390.71	13304.02	12913.52
		100.00%	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*	*100.00%*
Memo Items																			
International Bunkers - Aviation		401.98	417.69	405.15	402.02	508.80	577.90	628.15	766.32	863.66	1014.39	979.84	1058.35	1146.27	1193.39	1300.15	1318.99	1237.33	1328.40
		NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
International Bunkers - Marine		0.07	0.07	0.07	0.10	0.08	0.08	0.08	0.08	0.08	0.09	0.10	0.10	0.11	0.11	0.11	0.14	0.15	0.13
		NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
CO_2 Emissions from Biomass		166.27	168.15	170.95	166.54	164.68	161.00	143.40	154.68	143.30	152.27	153.41	155.86	156.38	174.09	188.58	183.84	194.93	357.10
		NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

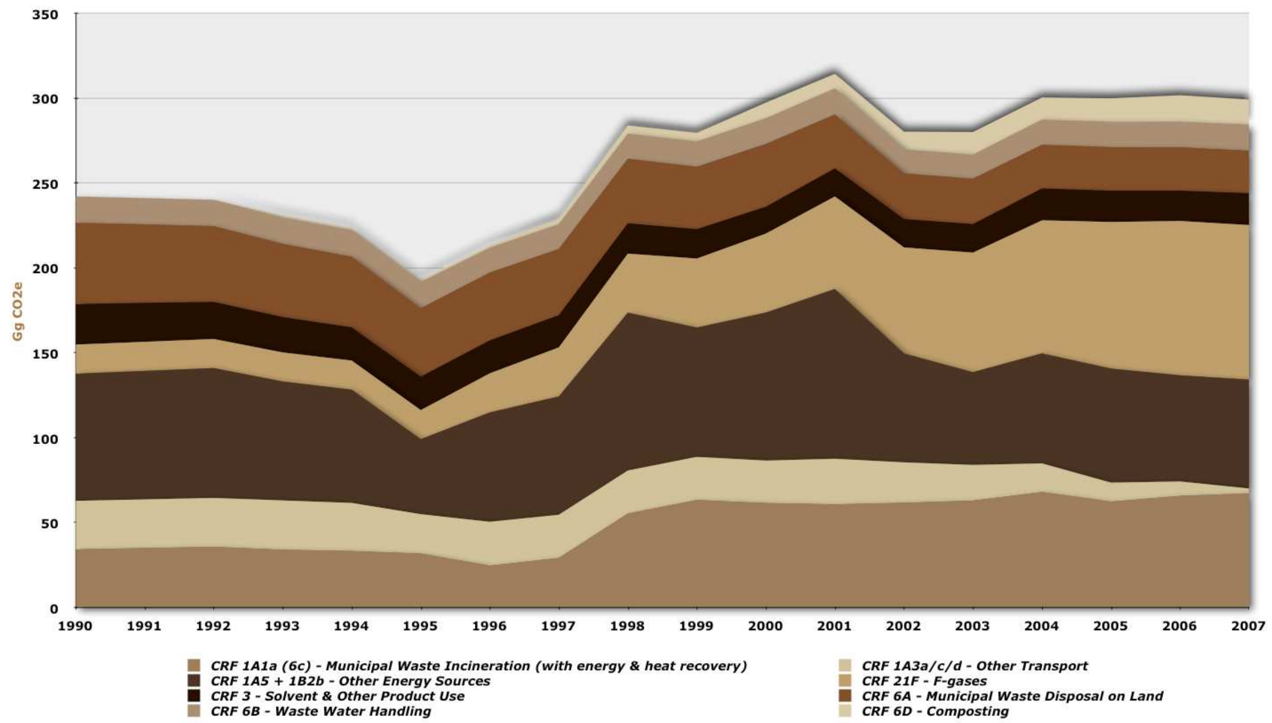
Source: Environment Agency and Ministry of the Environment.

Figure 2-7 – Luxembourg's GHG emissions and removals (excl. LULUCF) – alternative presentation: 1990-2007

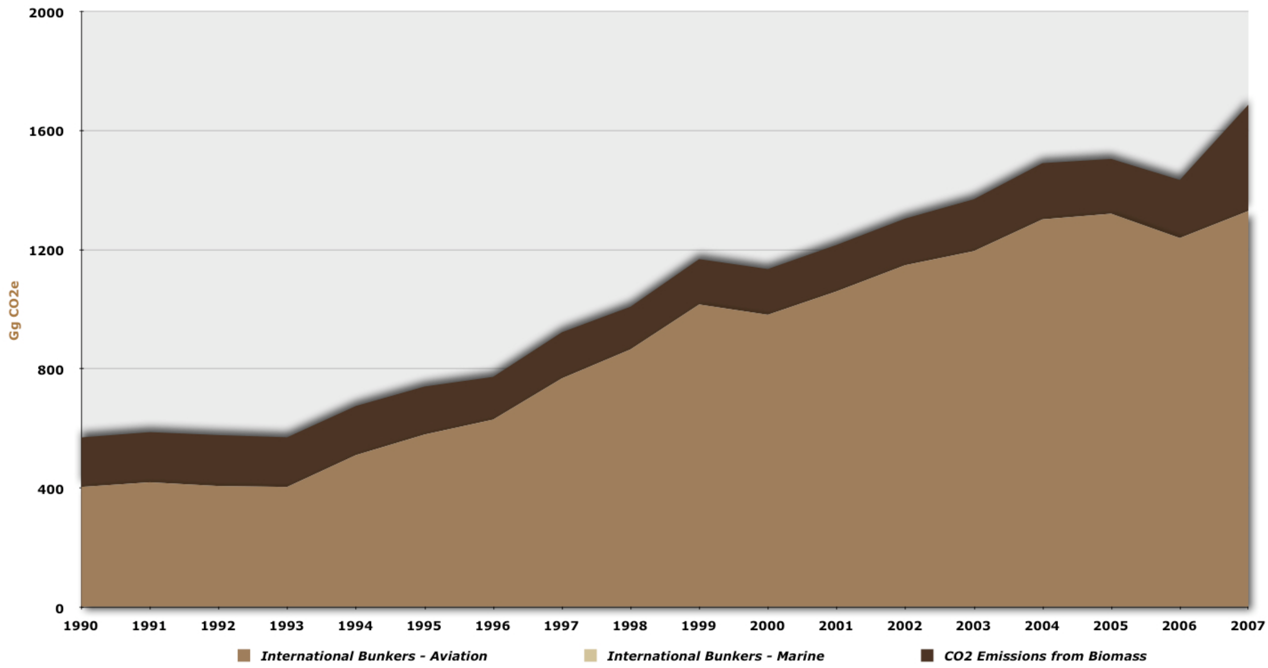
Main emitting source categories



Other source categories



<u>*Memo Items*</u>



2.2.5.2 Energy consumption and balance

Figure 2-8 – Primary energy consumption (excl. air transport): 1990-2007

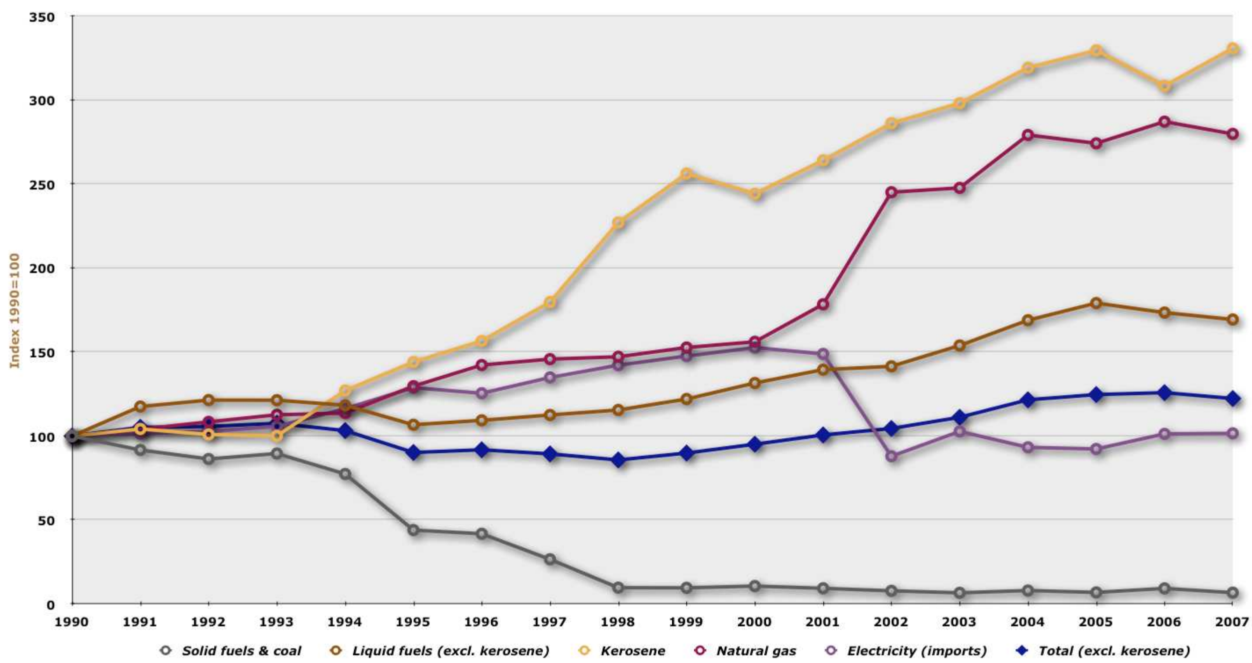


Table 2-10 – Primary energy consumption (excl. air transport): 1990-2007

1000 toe	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Solid fuels & coal	**1198.61**	**1099.27**	**1034.88**	**1073.87**	**928.05**	**527.59**	**501.20**	**319.20**	**116.62**	**115.50**	**128.26**	**112.03**	**94.10**	**79.94**	**96.22**	**82.89**	**111.53**	**81.00**
	34.32%	*29.92%*	*28.04%*	*28.58%*	*25.74%*	*16.74%*	*15.63%*	*10.23%*	*3.89%*	*3.68%*	*3.86%*	*3.19%*	*2.58%*	*2.06%*	*2.27%*	*1.90%*	*2.54%*	*1.90%*
Liquid fuels (excl. kerosene)	**1456.42**	**1711.93**	**1768.12**	**1767.28**	**1723.27**	**1554.27**	**1592.53**	**1638.96**	**1682.32**	**1777.20**	**1916.19**	**2032.22**	**2060.74**	**2241.71**	**2460.46**	**2609.28**	**2526.84**	**2466.90**
	41.70%	*46.60%*	*47.90%*	*47.03%*	*47.80%*	*49.32%*	*49.66%*	*52.50%*	*56.15%*	*56.62%*	*57.68%*	*57.81%*	*56.46%*	*57.74%*	*57.95%*	*59.92%*	*57.49%*	*57.73%*
Kerosene	**127.60**	**132.97**	**128.79**	**127.72**	**162.15**	**183.86**	**199.82**	**229.35**	**289.80**	**326.99**	**311.64**	**337.06**	**365.19**	**380.44**	**407.36**	**420.60**	**393.62**	**422.10**
Natural gas	**477.55**	**496.86**	**517.89**	**537.96**	**542.83**	**619.38**	**679.47**	**696.24**	**703.01**	**729.21**	**745.47**	**852.06**	**1170.77**	**1183.02**	**1333.47**	**1309.80**	**1371.31**	**1336.54**
	13.67%	*13.53%*	*14.03%*	*14.32%*	*15.06%*	*19.66%*	*21.19%*	*22.30%*	*23.47%*	*23.23%*	*22.44%*	*24.24%*	*32.08%*	*30.47%*	*31.41%*	*30.08%*	*31.20%*	*31.28%*
Electricity (imports)	**318.22**	**322.65**	**327.21**	**336.34**	**370.05**	**409.85**	**399.29**	**429.16**	**452.41**	**469.72**	**485.74**	**473.73**	**279.92**	**327.01**	**296.91**	**293.72**	**322.28**	**323.37**
	9.11%	*8.78%*	*8.86%*	*8.95%*	*10.26%*	*13.01%*	*12.45%*	*13.75%*	*15.10%*	*14.96%*	*14.62%*	*13.48%*	*7.67%*	*8.42%*	*6.99%*	*6.74%*	*7.33%*	*7.57%*
Waste incineration (with heat recovery)	**26.84**	**27.92**	**28.16**	**26.94**	**26.34**	**25.15**	**19.40**	**23.14**	**26.41**	**31.62**	**30.77**	**28.15**	**26.72**	**31.42**	**38.19**	**35.79**	**38.17**	**38.91**
	0.77%	*0.76%*	*0.76%*	*0.72%*	*0.73%*	*0.80%*	*0.60%*	*0.74%*	*0.88%*	*1.01%*	*0.93%*	*0.80%*	*0.73%*	*0.81%*	*0.90%*	*0.82%*	*0.87%*	*0.91%*
Biomass (1)	**15.00**	**15.00**	**15.00**	**15.00**	**15.00**	**15.00**	**15.00**	**15.00**	**15.00**	**15.40**	**15.40**	**15.40**	**15.40**	**15.40**	**15.40**	**15.97**	**15.94**	**16.40**
	0.43%	*0.41%*	*0.41%*	*0.40%*	*0.42%*	*0.48%*	*0.47%*	*0.48%*	*0.50%*	*0.49%*	*0.46%*	*0.44%*	*0.42%*	*0.40%*	*0.36%*	*0.37%*	*0.36%*	*0.38%*
Biogas	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0.13**	**0.29**	**0.55**	**2.01**	**2.29**	**4.13**	**4.99**	**7.43**	**8.91**	**9.98**
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.00%*	*0.01%*	*0.02%*	*0.06%*	*0.06%*	*0.11%*	*0.12%*	*0.17%*	*0.20%*	*0.23%*
Total (excl. kerosene)	**3492.64**	**3673.63**	**3691.26**	**3757.39**	**3605.54**	**3151.24**	**3206.89**	**3121.70**	**2995.90**	**3138.94**	**3322.38**	**3515.60**	**3649.94**	**3882.63**	**4245.64**	**4354.88**	**4394.98**	**4273.10**

Source: Ministry of Economic Affairs and External Trade-Energy Department and FiFo Köln
Note:
(1) wood only up to 2004 included, wood and biofuel in 2005, 2006 and 2007.
data prepared in March 2009 (subject to changes since that date)

Table 2-11 – Final energy consumption (excl. air transport): 1990-2007

1000 toe	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Solid fuels & coal, blast furnaces gas	**1021.28**	**909.03**	**852.52**	**888.65**	**782.74**	**448.24**	**434.28**	**281.20**	**116.62**	**115.50**	**128.26**	**112.03**	**94.10**	**79.94**	**96.22**	**82.89**	**111.53**	**81.00**
	30.84%	*26.13%*	*24.43%*	*24.93%*	*22.72%*	*14.79%*	*14.02%*	*9.28%*	*3.96%*	*3.74%*	*3.92%*	*3.31%*	*2.77%*	*2.22%*	*2.45%*	*2.06%*	*2.76%*	*2.03%*
solid fuels & coal	819.56	736.47	704.10	733.06	651.29	382.99	374.29	248.93	116.62	115.50	128.26	112.03	94.10	79.94	96.22	82.89	111.53	81.00
blast furnaces gas	201.72	172.56	148.42	155.59	131.45	65.25	59.99	32.27	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liquid fuels (excl. kerosene)	**1453.61**	**1703.86**	**1750.48**	**1755.69**	**1718.68**	**1552.32**	**1585.14**	**1634.81**	**1681.99**	**1776.83**	**1915.99**	**2031.88**	**2060.51**	**2241.59**	**2460.36**	**2609.28**	**2526.84**	**2466.90**
	43.89%	*48.98%*	*50.16%*	*49.24%*	*49.89%*	*51.21%*	*51.17%*	*53.96%*	*57.05%*	*57.61%*	*58.58%*	*60.02%*	*60.64%*	*62.26%*	*62.55%*	*64.84%*	*62.58%*	*61.87%*
Kerosene	**127.60**	**132.97**	**128.79**	**127.72**	**162.15**	**183.86**	**199.82**	**229.35**	**289.80**	**326.99**	**311.64**	**337.06**	**365.19**	**380.44**	**407.36**	**420.60**	**393.62**	**422.10**
Natural gas	**464.14**	**487.02**	**507.24**	**527.48**	**525.22**	**571.29**	**627.00**	**648.61**	**655.32**	**679.43**	**692.52**	**708.62**	**703.73**	**704.09**	**754.88**	**726.15**	**759.97**	**793.00**
	14.01%	*14.00%*	*14.53%*	*14.80%*	*15.25%*	*18.85%*	*20.24%*	*21.41%*	*22.23%*	*22.03%*	*21.17%*	*20.93%*	*20.71%*	*19.56%*	*19.19%*	*18.04%*	*18.82%*	*19.89%*
Electricity	**357.63**	**363.04**	**364.75**	**378.03**	**400.27**	**430.70**	**422.96**	**435.93**	**456.15**	**473.77**	**491.69**	**484.32**	**487.84**	**517.26**	**552.15**	**529.57**	**559.68**	**575.15**
	10.80%	*10.44%*	*10.45%*	*10.60%*	*11.62%*	*14.21%*	*13.65%*	*14.39%*	*15.47%*	*15.36%*	*15.03%*	*14.31%*	*14.36%*	*14.37%*	*14.04%*	*13.16%*	*13.86%*	*14.43%*
Heat, cogeneration & biomass	**15.40**	**15.40**	**15.00**	**15.40**	**18.00**	**28.84**	**28.47**	**28.86**	**38.09**	**38.96**	**42.31**	**48.45**	**51.90**	**57.27**	**69.69**	**76.36**	**79.74**	**70.86**
	0.46%	*0.44%*	*0.43%*	*0.43%*	*0.52%*	*0.95%*	*0.92%*	*0.95%*	*1.29%*	*1.26%*	*1.29%*	*1.43%*	*1.53%*	*1.59%*	*1.77%*	*1.90%*	*1.97%*	*1.78%*
heat & cogeneration	NO	NO	NO	NO	3.00	13.84	13.07	13.46	22.69	23.56	26.91	33.05	36.50	41.87	54.29	60.39	63.80	54.46
biomass (1)	15.40	15.40	15.00	15.40	15.00	15.00	15.40	15.40	15.40	15.40	15.40	15.40	15.40	15.40	15.40	15.97	15.94	16.40
Total (excl. kerosene)	**3312.06**	**3478.35**	**3489.99**	**3565.25**	**3444.91**	**3031.39**	**3097.85**	**3029.41**	**2948.17**	**3084.49**	**3270.77**	**3385.30**	**3398.08**	**3600.15**	**3933.30**	**4024.25**	**4037.76**	**3986.91**

Source: Ministry of Economic Affairs and External Trade-Energy Department and FiFo Köln
Note:
(1) wood only up to 2004 included, wood and biofuel in 2005, 2006 and 2007.
data prepared in March 2009 (subject to changes since that date)

Table 2-12 – Energy balance for electric power: 1990-2007

GWh		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Imports		**4708.28**	**4713.87**	**4517.87**	**4453.75**	**5026.76**	**5707.38**	**5725.89**	**6040.48**	**6388.99**	**6212.79**	**6465.87**	**6389.20**	**6390.70**	**6562.18**	**6506.31**	**6391.61**	**6823.54**	**6846.58**
National production		**626.24**	**676.37**	**662.49**	**669.79**	**626.80**	**537.67**	**503.77**	**414.77**	**343.23**	**371.12**	**428.47**	**842.18**	**2785.42**	**2784.39**	**3373.52**	**3336.72**	**3538.95**	**3190.23**
	cogeneration	NO	NO	NO	NO	30.00	99.84	122.35	124.83	198.03	205.15	227.96	321.41	341.50	382.28	421.57	417.92	438.09	362.39
	thermic power stations	558.72	622.11	594.14	607.83	505.96	346.53	307.87	205.38	45.38	52.29	51.74	374.43	2312.42	2285.48	2787.37	2736.60	2886.49	2598.86
	of which, TWINerg	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*323.03*	*2275.65*	*2237.29*	*2731.06*	*2646.00*	*2774.01*	*2511.69*
	hydro-electricity	67.52	54.26	68.35	61.96	90.84	91.30	73.55	81.71	94.75	95.53	119.46	114.39	97.38	73.94	95.64	85.03	102.67	107.19
	wind	NO	NO	NO	NO	NO	NO	NO	2.74	4.61	17.14	24.74	23.70	24.73	26.17	39.40	52.25	57.99	64.29
	biomass	NO	NO	NO	NO	NO	NO	NO	0.12	0.46	1.01	4.54	8.20	9.30	15.13	20.34	27.22	32.60	36.59
	photovoltaic	NO	NO	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.04	0.05	0.08	1.40	9.20	17.70	21.11	20.90
Total		**5334.52**	**5390.24**	**5180.36**	**5123.54**	**5653.56**	**6245.06**	**6229.66**	**6455.25**	**6732.22**	**6583.91**	**6894.34**	**7231.39**	**9176.12**	**9346.57**	**9879.83**	**9728.33**	**10362.49**	**10036.81**
exports		**754.92**	**715.17**	**542.95**	**394.41**	**565.57**	**744.15**	**808.06**	**846.96**	**924.12**	**654.97**	**736.85**	**1066.79**	**2939.92**	**2799.41**	**3131.58**	**3131.31**	**3266.55**	**2886.84**
conversion uses and losses		**389.32**	**395.43**	**334.28**	**318.06**	**364.83**	**434.15**	**431.95**	**418.98**	**428.05**	**340.97**	**359.49**	**414.82**	**450.53**	**475.68**	**366.33**	**452.92**	**472.35**	**467.42**
net inland consumption		**4190.27**	**4279.65**	**4303.13**	**4411.08**	**4723.16**	**5066.76**	**4989.66**	**5189.31**	**5380.05**	**5587.98**	**5798.00**	**5749.79**	**5785.67**	**6071.48**	**6381.92**	**6144.11**	**6623.59**	**6682.54**
Total		**5334.52**	**5390.24**	**5180.36**	**5123.54**	**5653.56**	**6245.06**	**6229.66**	**6455.25**	**6732.22**	**6583.91**	**6894.34**	**7231.39**	**9176.12**	**9346.57**	**9879.83**	**9728.33**	**10362.49**	**10036.81**

Summary in GWh	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Net imports	**3953.36**	**3998.70**	**3974.92**	**4059.35**	**4461.19**	**4963.24**	**4917.84**	**5193.52**	**5464.86**	**5557.82**	**5729.01**	**5322.42**	**3450.78**	**3762.77**	**3374.73**	**3260.30**	**3556.99**	**3959.74**
Net national production (1)	**236.91**	**280.95**	**328.21**	**351.73**	**261.97**	**103.52**	**71.82**	**-4.21**	**-84.81**	**30.15**	**68.99**	**427.37**	**2334.89**	**2308.71**	**3007.19**	**2883.81**	**3066.60**	**2722.80**
Net inland consumption	**4190.27**	**4279.65**	**4303.13**	**4411.08**	**4723.16**	**5066.76**	**4989.66**	**5189.31**	**5380.05**	**5587.98**	**5798.00**	**5749.79**	**5785.67**	**6071.48**	**6381.92**	**6144.11**	**6623.59**	**6682.54**
Net inland consumption in Mio. MJ	15072.91	15394.42	15478.88	15867.20	16989.80	18225.75	17948.41	18666.59	19352.70	20100.64	20856.11	20682.68	20811.76	21839.86	22956.55	22101.11	23825.86	24037.92
Net inland consumption in 1000 toe	360.01	367.69	369.71	378.98	405.79	435.31	428.69	445.84	462.23	480.10	498.14	494.00	497.08	521.64	548.31	527.88	569.07	574.14

Source: Ministry of Economic Affairs and External Trade-Energy Department, Institut Luxembourgeois de Régulation and FiFo Köln

Note:

(1) the net national production is the difference between the national production and the conversion process uses and losses.

data prepared in March 2009 (subject to changes since that date)

Figure 2-9 – Final energy consumption (excl. air transport): 1990-2007

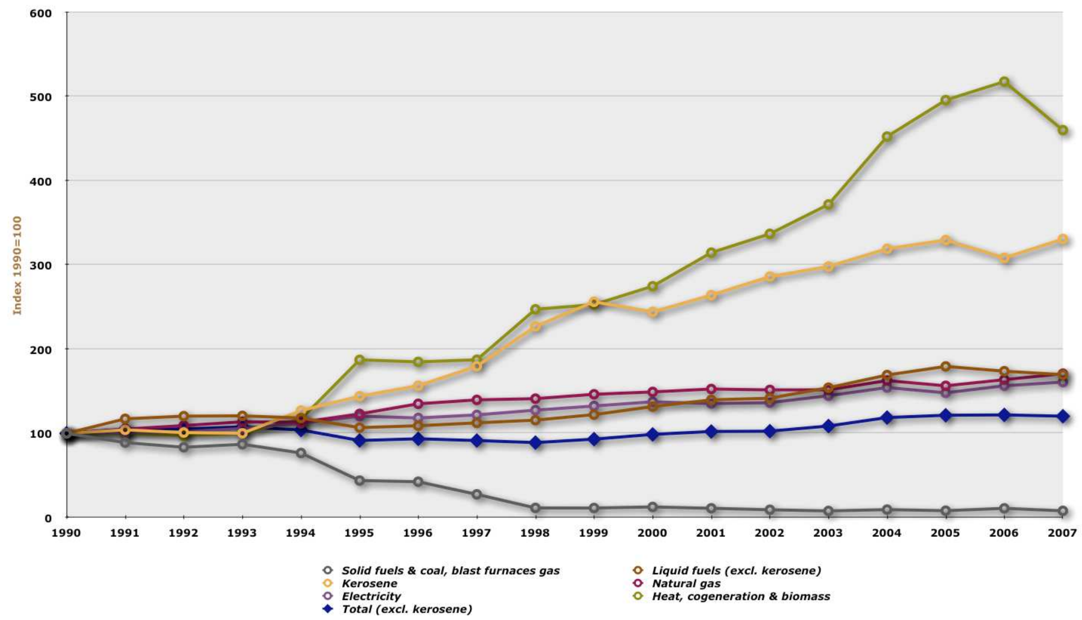
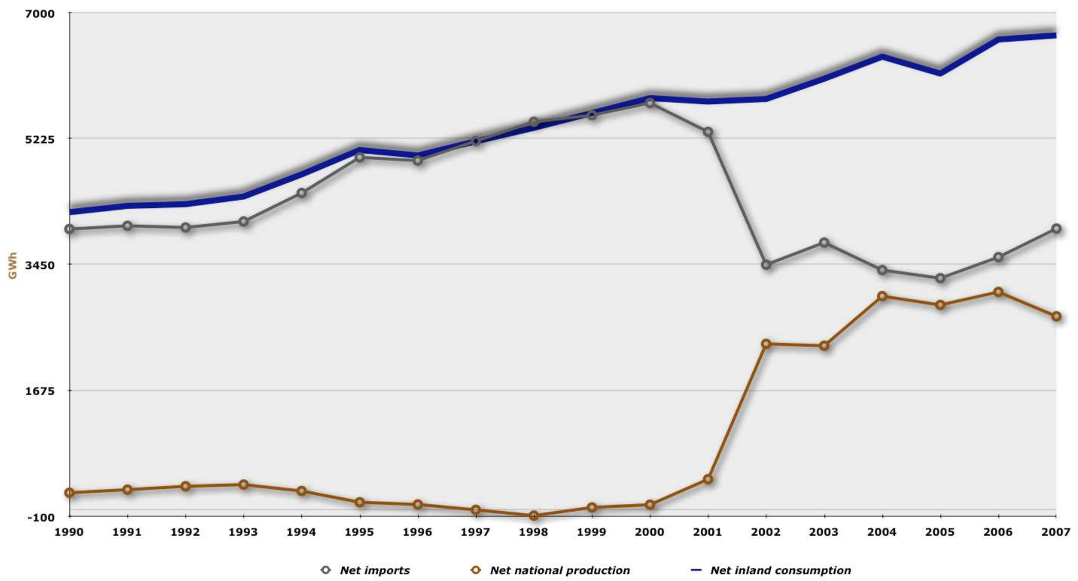


Figure 2-10 – Energy balance for electric power: 1990-2007



3 Energy (CRF Sector 1)

3.1 Sector Overview

Emissions from this sector comprise emissions from fuel combustion activities (source category 1A) and fugitive emissions from fuel (source category 1B). For more details on categories where no emissions are occurring and categories that are not estimated or included elsewhere, see Table 3-4.

Chapter 3 also includes information on and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under CRF categories *1A – Fuel Combustion Activities* and *1B – Fugitive Emissions from Fuels* for the period 1990 to 2007.

CO_2 emissions from fossil fuel combustion are the main source of green house gas emissions in the Grand-Duchy of Luxembourg. In 2007, about 86.2% of national total GHG emissions (excl. LULUCF) were caused by fossil fuel combustion activities in the energy and manufacturing industry, in the transportation sector and in the commercial and residential sector.

Waste incineration related GHG emissions are allocated to IPCC sub-category *1A1a – Fuel Combustion Activities – Energy Industries – Public Electricity and Heat Production* (see Section 0) since energy is recovered and injected in the public electric network from waste burned in the sole incinerator of the country.

Process related emissions are considered in CRF Sector *2 – Industrial Processes* (see Chapter 4).

Other required information, as suggested in Annex I of document FCCC/SBSTA/2006/9, will be presented under each source category review (methodology, AD, EFs, etc.).

3.1.1 Emission Trends

Figure 3-1 and Table 3-1 show the GHG emission trends from 1990 to 2007 for each of the IPCC categories under CRF Sector *1 - Energy*, for which GHG emissions are reported. These are expressed in CO_2 equivalents and include CH_4 and N_2O emissions from biomass, but exclude CO_2 emissions from biomass combustion. CO_2 emissions from biomass combustion are reported under *Memory Items* (see section 3.6). GHG emissions from IPCC category *6C - Waste Incineration* are accounted for in IPCC sub-category *1A1a - Public Electricity and Heat Production*, as energy from waste burning is recovered and injected into the public electricity and district heating network.

Energy production and consumption related GHG emissions have increased by 6.6% between 1990 and 2007 from 10.64 million tonnes CO_2 equivalents in 1990 to 11.34 million tonnes CO_2 equivalents in 2007. For carbon dioxide, methane and nitrous oxide, the growth was 5.8%, 30.7% and 119.2% respectively.

Figure 3-1 – GHG emission trends for CRF Sector 1-Energy: 1990-2007

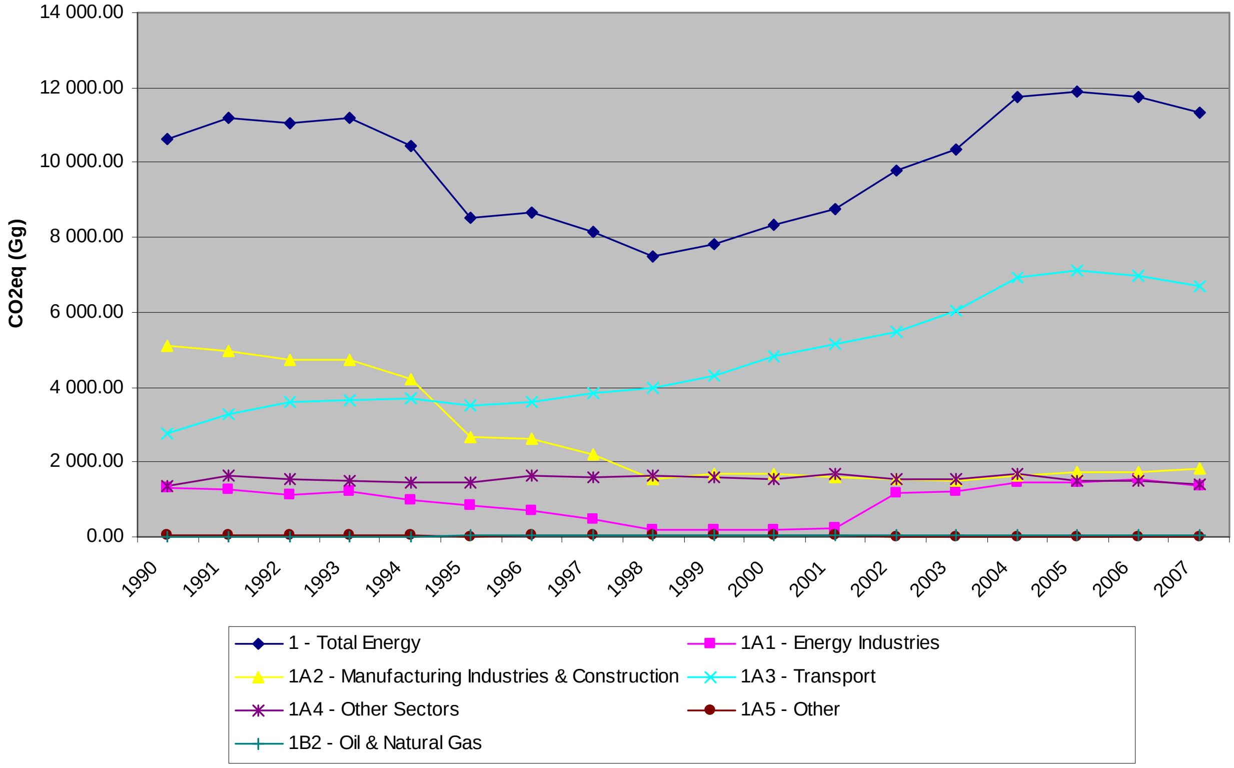


Figure 3-2 and Figure 3-3 clearly illustrate that the overall trends observed at sector level hide very different developments at the IPCC sub-category level. Indeed, between 1990 and 2007, GHG emissions have been strongly influenced by varying fuel consumption levels in industry, in particular in the iron and steel industry, as well as in the road transport sector as percentage growths recorded for IPCC sub-categories *1A2 – Manufacturing Industries and Construction* and *1A3 – Transport* demonstrate. There are several industrial sites which had relatively high levels of GHG emissions, and which, therefore, have had a large impact on the national total of GHG emissions. In the transport sector, road fuel consumption, and even more so road fuel sales,[62] have a very important weight in the national energy balance, and, consequently, have also a very important impact on the total GHG emissions.

In the iron and steel industry, the passage from blast furnaces to electric arc furnaces allowed to significantly reduce GHG emissions between 1994 and 1997. Due to the importance of iron and steel industry in Luxembourg, this evolution hid many other emission trends between 1990 and 1998. After 1998, the increase of road fuel sales and, to a lesser extent, of electric energy production has led to a rather steep increase of GHG emissions in these sectors and, by extension, of the national total for GHG emissions.

62 See Section 2.2.2 in Chapter 2.

Table 3-1 – GHG emission trends in $CO_{2\,eq}$ for CRF Sector 1 – Energy: 1990-2007

1 - Energy

GHG emissions by source & sink category (Gg)

Year	1A1 - Energy Industries				1A2 - Manufacturing Industries & Construction				1A3 - Transport				1A4 - Other Sectors			
	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*
1990	1 301.82	*1 299.25*	*0.04*	*0.01*	5 124.28	*5 107.88*	*0.16*	*0.04*	2 763.52	*2 701.49*	*1.19*	*0.12*	1 377.61	*1 366.41*	*0.36*	*0.01*
1991	1 245.54	*1 242.90*	*0.04*	*0.01*	4 952.46	*4 937.32*	*0.15*	*0.04*	3 279.71	*3 207.13*	*1.40*	*0.14*	1 652.99	*1 640.41*	*0.39*	*0.01*
1992	1 142.94	*1 140.24*	*0.04*	*0.01*	4 707.26	*4 691.07*	*0.14*	*0.04*	3 586.71	*3 501.26*	*1.39*	*0.18*	1 526.80	*1 514.92*	*0.37*	*0.01*
1993	1 230.48	*1 227.91*	*0.04*	*0.01*	4 740.30	*4 725.24*	*0.14*	*0.04*	3 639.39	*3 546.66*	*1.27*	*0.21*	1 512.39	*1 500.71*	*0.37*	*0.01*
1994	979.98	*977.54*	*0.04*	*0.01*	4 229.17	*4 214.86*	*0.13*	*0.04*	3 705.32	*3 607.58*	*1.24*	*0.23*	1 455.36	*1 443.91*	*0.36*	*0.01*
1995	835.43	*833.07*	*0.04*	*0.01*	2 673.88	*2 662.70*	*0.09*	*0.03*	3 517.43	*3 423.22*	*1.10*	*0.23*	1 470.99	*1 459.62*	*0.36*	*0.01*
1996	722.03	*720.17*	*0.03*	*0.00*	2 609.10	*2 597.58*	*0.10*	*0.03*	3 621.33	*3 523.36*	*1.13*	*0.24*	1 633.49	*1 621.46*	*0.38*	*0.01*
1997	448.86	*446.75*	*0.03*	*0.00*	2 204.73	*2 192.20*	*0.08*	*0.03*	3 831.39	*3 729.88*	*1.03*	*0.26*	1 585.19	*1 573.21*	*0.38*	*0.01*
1998	166.66	*164.20*	*0.04*	*0.01*	1 552.83	*1 539.43*	*0.07*	*0.04*	3 996.62	*3 895.85*	*0.99*	*0.26*	1 661.49	*1 648.91*	*0.40*	*0.01*
1999	185.20	*182.38*	*0.05*	*0.01*	1 674.79	*1 657.23*	*0.07*	*0.05*	4 298.89	*4 196.24*	*0.98*	*0.26*	1 596.10	*1 583.93*	*0.39*	*0.01*
2000	188.84	*186.10*	*0.04*	*0.01*	1 702.73	*1 682.39*	*0.08*	*0.06*	4 838.96	*4 730.44*	*0.98*	*0.28*	1 531.63	*1 519.60*	*0.39*	*0.01*
2001	214.34	*211.59*	*0.04*	*0.01*	1 589.17	*1 573.82*	*0.07*	*0.04*	5 135.53	*5 026.57*	*0.95*	*0.29*	1 704.93	*1 692.66*	*0.40*	*0.01*
2002	1 168.02	*1 164.36*	*0.06*	*0.01*	1 537.04	*1 524.34*	*0.07*	*0.04*	5 483.21	*5 375.56*	*0.90*	*0.29*	1 542.34	*1 531.06*	*0.37*	*0.01*
2003	1 199.55	*1 195.78*	*0.06*	*0.01*	1 483.36	*1 471.03*	*0.07*	*0.04*	6 050.98	*5 937.34*	*0.86*	*0.31*	1 541.41	*1 530.20*	*0.37*	*0.01*
2004	1 442.29	*1 438.08*	*0.07*	*0.01*	1 619.23	*1 603.89*	*0.08*	*0.04*	6 916.38	*6 794.48*	*0.82*	*0.34*	1 702.00	*1 684.13*	*0.38*	*0.03*
2005	1 456.83	*1 452.84*	*0.07*	*0.01*	1 709.35	*1 687.48*	*0.08*	*0.07*	7 138.33	*7 016.55*	*0.71*	*0.34*	1 509.92	*1 495.25*	*0.36*	*0.02*
2006	1 526.88	*1 522.69*	*0.07*	*0.01*	1 713.30	*1 691.46*	*0.08*	*0.06*	6 957.17	*6 842.18*	*0.63*	*0.33*	1 480.29	*1 464.73*	*0.36*	*0.03*
2007	1 362.66	*1 358.55*	*0.07*	*0.01*	1 819.34	*1 797.60*	*0.09*	*0.06*	6 683.32	*6 571.27*	*0.52*	*0.33*	1 415.28	*1 398.13*	*0.35*	*0.03*
Trend 1990-2007	*4.67%*	*4.56%*	*66.32%*	*56.85%*	*-64.50%*	*-64.81%*	*-45.02%*	*51.96%*	*141.84%*	*143.25%*	*-56.34%*	*173.39%*	*2.73%*	*2.32%*	*-2.01%*	*164.58%*

1 - Energy

GHG emissions by source & sink category (Gg)

Year	1A5 - Other				1B2 - Oil & Natural Gas				1 - Total Energy			
	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*
1990	56.53	*50.75*	*0.003*	*0.018*	18.36	*0.03*	*0.87*	*NA, NO*	**10 642.12**	*10 525.81*	*2.62*	*0.20*
1991	56.53	*50.75*	*0.003*	*0.018*	19.15	*0.03*	*0.91*	*NA, NO*	**11 206.38**	*11 078.54*	*2.90*	*0.22*
1992	56.53	*50.75*	*0.003*	*0.018*	19.95	*0.03*	*0.95*	*NA, NO*	**11 040.19**	*10 898.28*	*2.90*	*0.26*
1993	49.41	*44.40*	*0.003*	*0.016*	20.64	*0.03*	*0.98*	*NA, NO*	**11 192.61**	*11 044.95*	*2.81*	*0.29*
1994	45.83	*41.21*	*0.002*	*0.015*	20.88	*0.03*	*0.99*	*NA, NO*	**10 436.54**	*10 285.13*	*2.77*	*0.30*
1995	20.61	*18.67*	*0.001*	*0.006*	23.56	*0.04*	*1.12*	*NA, NO*	**8 541.90**	*8 397.32*	*2.72*	*0.28*
1996	38.28	*34.43*	*0.002*	*0.012*	26.14	*0.04*	*1.24*	*NA, NO*	**8 650.37**	*8 497.05*	*2.89*	*0.30*
1997	42.83	*38.96*	*0.002*	*0.012*	26.83	*0.04*	*1.28*	*NA, NO*	**8 139.84**	*7 981.04*	*2.80*	*0.32*
1998	65.86	*59.68*	*0.004*	*0.020*	27.08	*0.04*	*1.29*	*NA, NO*	**7 470.54**	*7 308.09*	*2.79*	*0.34*
1999	48.07	*44.19*	*0.003*	*0.012*	28.05	*0.04*	*1.33*	*NA, NO*	**7 831.11**	*7 664.02*	*2.82*	*0.35*
2000	58.32	*53.29*	*0.003*	*0.016*	28.83	*0.05*	*1.37*	*NA, NO*	**8 349.31**	*8 171.86*	*2.86*	*0.38*
2001	70.12	*65.06*	*0.004*	*0.016*	29.84	*0.05*	*1.42*	*NA, NO*	**8 743.93**	*8 569.75*	*2.89*	*0.37*
2002	20.20	*19.40*	*0.001*	*0.002*	43.92	*0.07*	*2.09*	*NA, NO*	**9 794.72**	*9 614.79*	*3.49*	*0.34*
2003	10.15	*9.37*	*0.001*	*0.002*	44.49	*0.07*	*2.12*	*NA, NO*	**10 329.93**	*10 143.78*	*3.48*	*0.37*
2004	14.57	*13.00*	*0.001*	*0.005*	50.22	*0.08*	*2.39*	*NA, NO*	**11 744.69**	*11 533.66*	*3.74*	*0.43*
2005	17.85	*15.92*	*0.001*	*0.006*	49.32	*0.08*	*2.34*	*NA, NO*	**11 881.59**	*11 668.12*	*3.57*	*0.45*
2006	10.75	*9.59*	*0.001*	*0.004*	51.76	*0.08*	*2.46*	*NA, NO*	**11 740.15**	*11 530.73*	*3.61*	*0.43*
2007	13.56	*12.75*	*0.001*	*0.003*	50.58	*0.08*	*2.40*	*NA, NO*	**11 344.74**	*11 138.38*	*3.43*	*0.43*
Trend 1990-2007	*-76.02%*	*-74.87%*	*-58.17%*	*-86.38%*	*175.55%*	*175.55%*	*175.55%*	*NA*	*6.60%*	*5.82%*	*30.83%*	*119.35%*

Source: Environment Agency.

Notes:

CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

N_2O emissions are converted in CO_2e by multiplying the emissions by 310, i.e. the global warming potential (*GWP*) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

Figure 3-2 – GHG emission trends in % for CRF Sector 1 – Energy: 1990-2007

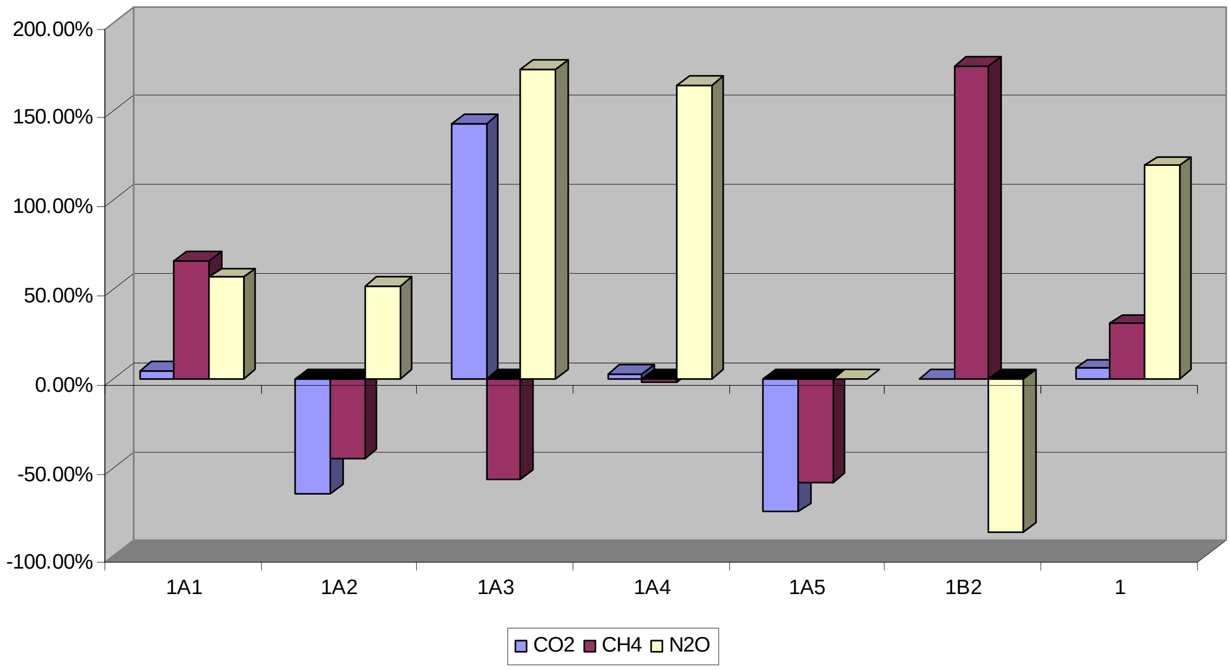
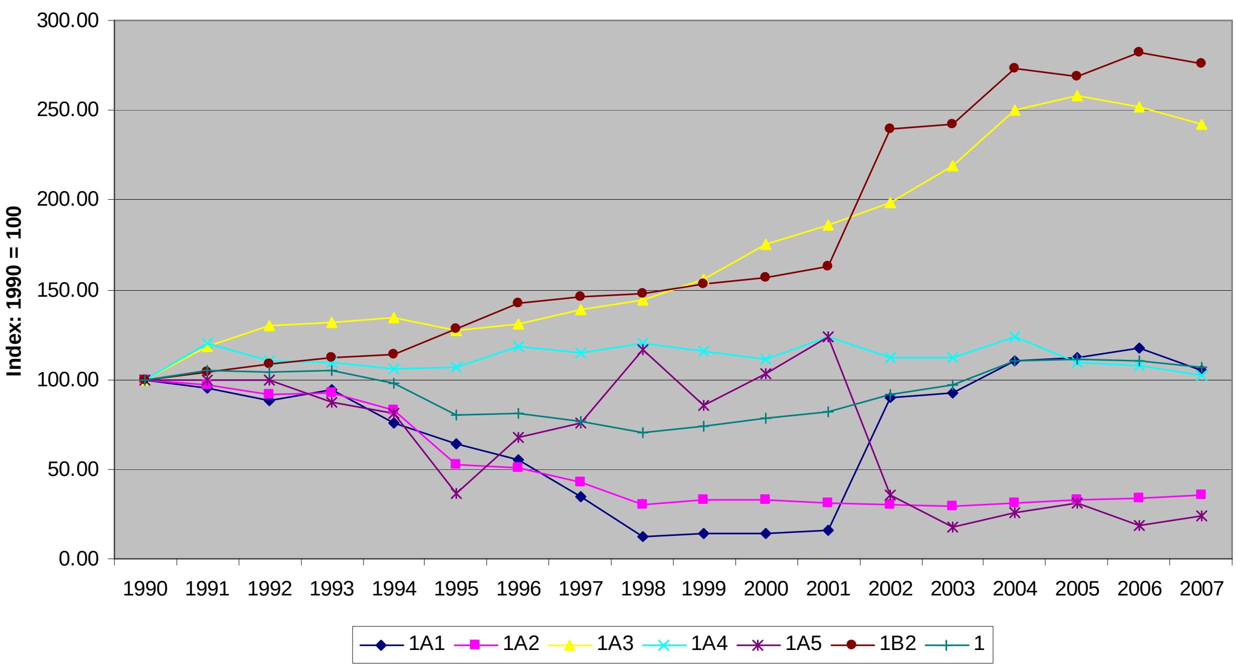


Figure 3-3 – GHG emission trend indexes for CRF Sector 1 – Energy: 1990-2007



All the changes briefly presented in the previous paragraphs – as well as in Section 2.2 - completely modified the pattern of the energy related GHG emissions between 1990 and 2007 with regard to IPCC Sub-categories share – see Figure 3-4 – and to the "energy-mix" or fuel usage for energy production and consumption – see Table 3-2.

Figure 3-4 – IPCC sub-categories share in GHG emissions for CRF Sector 1 – Energy: 1990 and 2007

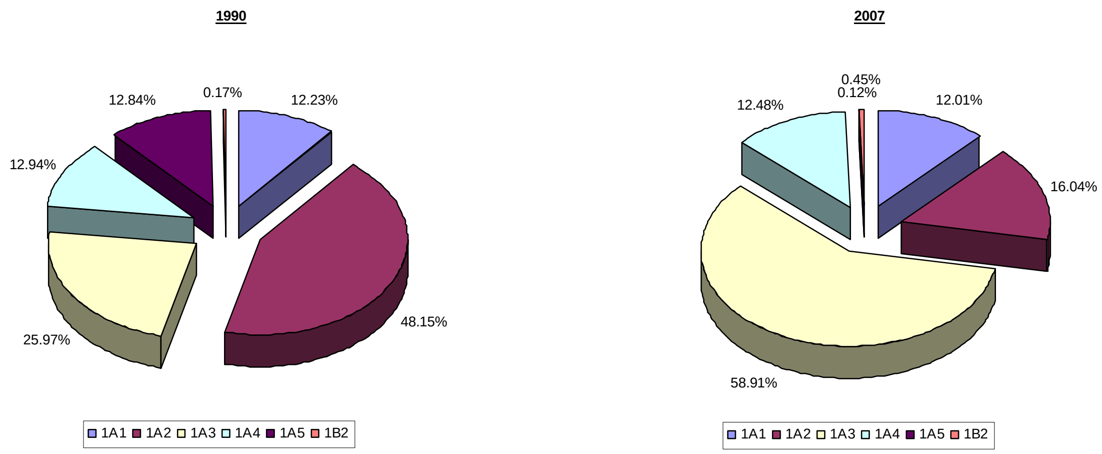


Table 3-2– Final energy consumption trends: 1970-2007

				1000 toe				
Year	Total	*Coal*	*Blast furnace gas*	*Liquid fuels (2)*	*Natural gas*	*Electricity*	*Cogeneration (heat only) (1)*	*Wood & biomass*
1970	**3 720**	*1 270*	*1 000*	*1 230*	*10*	*210*	*NO*	*15*
1980	**3 407**	*1 342*	*346*	*1 049*	*360*	*310*	*NO*	*15*
1990	**3 440**	*820*	*202*	*1 581*	*464*	*358*	*NO*	*15*
1991	**3 611**	*736*	*173*	*1 837*	*487*	*363*	*NO*	*15*
1992	**3 618**	*704*	*148*	*1 879*	*507*	*365*	*NO*	*15*
1993	**3 692**	*733*	*156*	*1 883*	*527*	*378*	*NO*	*15*
1994	**3 607**	*651*	*131*	*1 881*	*525*	*400*	*3*	*15*
1995	**3 216**	*383*	*65*	*1 736*	*571*	*431*	*14*	*15*
1996	**3 298**	*374*	*60*	*1 785*	*627*	*423*	*13*	*15*
1997	**3 259**	*249*	*32*	*1 864*	*649*	*436*	*13*	*15*
1998	**3 238**	*117*	*NO*	*1 972*	*655*	*456*	*23*	*15*
1999	**3 411**	*116*	*NO*	*2 104*	*679*	*474*	*24*	*15*
2000	**3 582**	*128*	*NO*	*2 228*	*693*	*492*	*27*	*15*
2001	**3 722**	*112*	*NO*	*2 369*	*709*	*484*	*33*	*15*
2002	**3 763**	*94*	*NO*	*2 426*	*704*	*488*	*37*	*15*
2003	**3 981**	*80*	*NO*	*2 622*	*704*	*517*	*42*	*15*
2004	**4 340**	*96*	*NO*	*2 868*	*755*	*552*	*54*	*15*
2005	**4 445**	*83*	*NO*	*3 030*	*726*	*530*	*60*	*16*
2006	**4 431**	*111*	*NO*	*2 920*	*760*	*560*	*64*	*16*
2007	**4 408**	*81*	*NO*	*2 889*	*793*	*575*	*54*	*16*
Trend 1990-2007	***28.12%***	*-90.12%*	*NA*	*82.73%*	*70.91%*	*60.61%*	*NA*	*3.90%*
Share 1990	***100.00%***	*23.83%*	*5.87%*	*45.95%*	*13.49%*	*10.41%*	*NA*	*0.45%*
Share 2007	***100.00%***	*1.84%*	*NA*	*65.54%*	*17.99%*	*13.04%*	*1.23%*	*0.36%*

Sources: STATEC: Statistical Yearbook, Table C.3501:
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=530&sCS_ChosenLang=fr.

Notes: (1) including heat recovery from waste incineration.
(2) including blended biodiesel.
data extracted in March 2009 (subject to changes since that date)

Final energy consumption increased by 28.1% between 1990 and 2007. It has passed through a minimum in 1995. All the energy sources have seen their consumption increase over the period, except coal for which the declining use in the first part of the 1990s was closely linked to the discontinuation of the use of blast furnaces in the iron & steel industry. Table 3-2 also shows the dramatic change in the "energy-mix" used in Luxembourg between 1990 and 2007 with a dropping share for solid fuels – for which the main part was used in the iron and steel industry – in favour of liquid fuels and natural gas and, to a lesser extent, to new energy sources such as cogeneration.

In 2007, with 65.5% of the final total energy consumption in Luxembourg, liquid fuels are the most important energy source, with diesel being the first liquid fuel in terms of volumes sold. The liquid fuel consumption in Luxembourg is much lower than the level of fuel sales, because large amounts of road fuels are bought by foreign commuters and transit traffic passing through Luxembourg. Actually, in 2007, almost 73.8% of road fuels are sold to vehicles registered abroad (see Table 3-39 in Section 3.2.7.2).

The importance of natural gas has increased constantly and significantly since 1990. In 2007, natural gas consumption ranked second after the consumption of liquid fuels. This development followed the continuous extension of the natural gas network in Luxembourg.

Natural gas has also become the main energy source of Luxembourg's national electricity production capacity.[63] In 1990, more than 90% of Luxembourg's electric energy consumption was imported and one medium size power plant of about 70 MW was owned by the iron & steel company Arbed.[64] That power plant was mainly run on blast furnace gas and was phased out in 1997 after the last blast furnace went out of service.

In the early 1990s, small cogeneration plants appeared. Their installation was encouraged financially by the Government. This development was followed later by some industrial companies which installed gas turbines to produce electricity and heat simultaneously. In mid-2002, the TWINerg power plant – a gas turbine – started its operation.[65] Almost all of these plants run on natural gas. Gas oil remains, however, the emergency fuel in case of a natural gas supply disruption.

Table 3-3 summarises electricity production trends in Luxembourg since 1990.

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63 This cannot be seen in final energy consumption statistics but in the primary energy consumption figures: see Table 2-10 in Section 2.2.5.2.

64 Later Arcelor, now Arcelor-Mittal.

65 See Section 2.1.3.2 above.

Table 3-3 – Electricity production trends: 1990-2007

Year	Total	Thermic (1)	RES (2)	Cogeneration
	Electricity production (GWh)			
1990	626	559	68	NO
1991	676	622	54	NO
1992	662	594	68	NO
1993	670	608	62	NO
1994	616	506	86	24
1995	528	347	81	100
1996	466	306	53	106
1997	416	214	92	110
1998	396	105	107	184
1999	375	52	133	191
2000	438	51	170	216
2001	864	374	146	344
2002	2 823	2 328	132	363
2003	2 784	2 285	117	382
2004	3 374	2 787	165	422
2005	3 337	2 737	182	418
2006	3 519	2 866	214	438
2007	3 190	2 599	229	362
Trend 1990-2007	*409.43%*	*365.15%*	*239.13%*	*NA*
Share 1990	*100.00%*	*89.22%*	*10.78%*	*NA*
Share 2007	*100.00%*	*81.46%*	*7.18%*	*11.36%*

Sources: STATEC: Statistical yearbook, Table C.3506:
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=535&sCS_ChosenLang=fr;
ILR: http://www.ilr.public.lu/electricite/statistiques/releve_detaille_ilr/index.html .

Notes: (1) includes public thermal power plants (TWINerg), auto producer thermal power plants, and MSW incineration.
(2) RES = Renewable Energy Sources, includes small hydro-electric power, wind power, photovoltaic power plants and biogas combustion plants.
data extracted in March 2009 (subject to changes since that date)

3.1.2 Completeness

Table 3-4 gives an overview of the IPCC categories included under CRF Sector 1 and provides information on the status of emission estimates of all sub-categories.

Table 3-4 – Overview of subcategories of CRF Sector 1 – Energy: status of emission estimates for CO_2, CH_4 and N_2O

GHG source & sink category	Description	Status		
		CO_2	CH_4	N_2O
1A1a	fuel combustion activities – energy industries – public electricity & heat production	X	X	X
1A1b	fuel combustion activities – energy industries – petroleum refining	NO	NO	NO
1A1c	fuel combustion activities – energy industries – manufacture of solid fuels and other energy industries	NO	NO	NO
1A2a	fuel combustion activities – manufacturing industries & construction – iron & steel	X	X	X
1A2b	fuel combustion activities – manufacturing industries & construction – non-ferrous metals	X	X	X
1A2c	fuel combustion activities – manufacturing industries & construction – chemicals	X	X	X
1A2d	fuel combustion activities – manufacturing industries & construction – pulp, paper & print	NO	NO	NO
1A2e	fuel combustion activities – manufacturing industries & construction – food processing, beverages & tobacco	X	X	X
1A2f	fuel combustion activities – manufacturing industries & construction – other	X	X	X
1A3a	fuel combustion activities – transport – civil aviation	X	X	X
1A3b	fuel combustion activities – transport – road transportation	X	X	X
1A3c	fuel combustion activities – transport – railways	X	X	X
1A3d	fuel combustion activities – transport – navigation	X	X	X
1A3e	fuel combustion activities – transport – other transportation	NA	NA	NA
1A4a	fuel combustion activities – other sectors – commercial/institutional	X	X	X
1A4b	fuel combustion activities – other sectors – residential	X	X	X
1A4c	fuel combustion activities – other sectors – agriculture/forestry/fisheries	X	X	X
1A5a	fuel combustion activities – other – stationary	X	X	X
1A5b	fuel combustion activities – other – mobile	X	X	X
1B1a	fugitive emissions from fuels – solid fuels – coal mining & handling	NO	NO	NO
1B1b	fugitive emissions from fuels – solid fuels – solid fuel transformation	NO	NO	NO
1B1c	fugitive emissions from fuels – solid fuels – other	NO	NO	NO
1B2a	fugitive emissions from fuels – oil & natural gas – oil	NA	NA	NO
1B2b	fugitive emissions from fuels – oil & natural gas – natural gas	X	X	
1B2c	fugitive emissions from fuels – oil & natural gas – venting & flaring	NO	NO	NO
1B2d	fugitive emissions from fuels – oil & natural gas – other	NA	NA	NA
Memo Items	international bunkers – aviation	X	X	X
Memo Items	international bunkers – marine	X	X	X
Memo Items	multilateral operations	IE	IE	IE
Memo Items	CO2 emissions from biomass	X		

Note: a **X** indicates that emissions from this sub-category have been estimated, the grey shaded cells are those also shaded in the CRF tables.

3.2 Fuel Combustion Activities (1A)

This chapter gives an overview of emissions and key sources of category *1A - Fuel Combustion* and includes information on completeness, uncertainties, QA/QC, planned improvements as well as on emissions, emission trends, activity data, methodologies applied and emission factors.

3.2.1 Source Category Description

In 2007, GHG emissions of category *1A - Fuel Combustion* amounted to a total of 11,29 million tonnes $CO_{2\ eq}$ (see Table 3-5). The transport sector (*1A3 - Transport*) represented the most important source, with a share of 59.2% of the GHG emissions within category *1A* (51.7% of national total excl. LULUCF). These emissions include emissions from fuel export, i.e. fuel bought by foreign commuters and transit traffic, but mostly emitted outside of Luxembourg's territory.

Combustion in the industrial sector (*1A2 - Manufacturing Industries and Construction*) was the second largest source of emissions with a share of 16.1% of the GHG emissions within category *1A* (14.1% of national total excl. LULUCF), followed by the commercial and residential sector (*1A4 - Other Sectors*) and the energy sector (*1A1 - Energy*) with shares of 12.5% and 12.1%, respectively (11.0% and 10.5% of national total excl. LULUCF , respectively). Emissions from sub-category *1A5 - Other*, which includes emissions from other non-specified sources, are rather low and contributed only 0.1% to the GHG emissions of category *1A - Fuel Combustion* (0.1% of national total).

Table 3-5 - GHG emission trends and shares of 1A-Fuel combustion

1A - Fuel Combustion *GHG emissions by source category excluding CO_2 emissions from biomass ($CO_{2\ eq}$ Gg)*						
Year	1A1 Energy Industries	1A2 Manufacturing Industries & Construction	1A3 Transport-ation	1A4 Other Secors	1A5 Other	1A Fuel Combustion
1990	1 301.8	*5 124.3*	*2 763.5*	*1 377.6*	56.5	*10 623.8*
1991	1 245.5	*4 952.5*	*3 279.7*	*1 653.0*	56.5	*11 187.2*
1992	1 142.9	*4 707.3*	*3 586.7*	*1 526.8*	56.5	*11 020.2*
1993	1 230.5	*4 740.3*	*3 639.4*	*1 512.4*	49.4	*11 172.0*
1994	980.0	*4 229.2*	*3 705.3*	*1 455.4*	45.8	*10 415.7*
1995	835.4	*2 673.9*	*3 517.4*	*1 471.0*	20.6	*8 518.3*
1996	722.0	*2 609.1*	*3 621.3*	*1 633.5*	38.3	*8 624.2*
1997	448.9	*2 204.7*	*3 831.4*	*1 585.2*	42.8	*8 113.0*
1998	166.7	*1 552.8*	*3 996.6*	*1 661.5*	65.9	*7 443.5*
1999	185.2	*1 674.8*	*4 298.9*	*1 596.1*	48.1	*7 803.1*
2000	188.8	*1 702.7*	*4 839.0*	*1 531.6*	58.3	*8 320.5*
2001	214.3	*1 589.2*	*5 135.5*	*1 704.9*	70.1	*8 714.1*
2002	1 168.0	*1 537.0*	*5 483.2*	*1 542.3*	20.2	*9 750.8*
2003	1 199.6	*1 483.4*	*6 051.0*	*1 541.4*	10.1	*10 285.4*
2004	1 442.3	*1 619.2*	*6 916.4*	*1 702.0*	14.6	*11 694.5*
2005	1 456.8	*1 709.4*	*7 138.3*	*1 509.9*	17.8	*11 832.3*
2006	1 526.9	*1 713.3*	*6 957.2*	*1 480.3*	10.7	*11 688.4*
2007	1 362.7	*1 819.3*	*6 683.3*	*1 415.3*	13.6	*11 294.2*
Trend 1990-2007	*4.67%*	*-64.50%*	*141.84%*	*2.73%*	*-76.02%*	*6.31%*
Share 1990	*12.25%*	*48.23%*	*26.01%*	*12.97%*	*0.53%*	*100.00%*
Share 2007	*12.07%*	*16.11%*	*59.18%*	*12.53%*	*0.12%*	*100.00%*

3.2.2 Key Sources

Table 3-6 presents the key source categories of *1A – Fuel Combustion Activities*.

Table 3-6 – Key sources of 1A – Fuel Combustion Activities

1A - Fuel Combustion Activites *Key sources*							
IPCC Category	**Category Name**	**Fuel/Cat.**	**GHG**	**LA excl. LULUCF**	**LA incl. LULUCF**	**TA excl. LULUCF**	**TA incl. LULUCF**
1A1a	Public Heat and Electricity Production	gaseous	CO_2	95-07	02-07	X	X
1A1a	Public Heat and Electricity Production	other	CO_2	98-04, 07			
1A1a	Public Heat and Electricity Production	solid	CO_2	90-97	90-97		
1A2a	MIC - Iron & Steel	gaseous	CO_2	90-07		X	X
1A2a	MIC - Iron & Steel	liquid	CO_2	91-95, 97-99	91	X	
1A2a	MIC - Iron & Steel	solid	CO_2	90-97	90-97		
1A2b	MIC - Non-Ferrous Metals	gaseous	CO_2			X	X
1A2c	MIC - Chemicals	gaseous	CO_2	90, 92, 94-07	90, 92, 94-07	X	X
1A2c	MIC - Chemicals	liquid	CO_2	90-97	90-97	X	X
1A2f	MIC - Other	gaseous	CO_2	90-07	90-07	X	X
1A2f	MIC - Other	liquid	CO_2	90-07	90-91, 97-01, 05-07	X	X
1A2f	MIC - Other	other	CO_2	05-06			
1A2f	MIC - Other	solid	CO_2	90-07	90-05, 07	X	X
1A3b	Road Transportation	diesel oil	CO_2	90-07	90-07	X	X
1A3b	Road Transportation	gasoline	CO_2	90-07	90-07	X	X
1A3b	Road Transportation	diesel oil	N_2O	05-07		X	X
1A3b	Road Transportation	gasoline	N_2O	96-02			
1A4a	Commercial/Institutional	gaseous	CO_2	90-07	90-07	X	X
1A4a	Commercial/Institutional	liquid	CO_2	90-07	90-07		X
1A4b	Residential	gaseous	CO_2	90-07	90-07	X	X
1A4b	Residential	liquid	CO_2	90-07	90-07	X	X
1A5b	Other - Mobile	liquid	CO_2	98			

Source: Environment Agency

Notes: LA = Level Assessement including respectively exluding LULUCF
TA = Trend Assessement 2007 including respectively excluding LULUCF
MIC = Manufacturing Industries and Construction

3.2.3 Methodological Issues

In general, the IPCC methodologies were applied, except for road transport where the COPERT calculation model was used.

Methodologies used were mostly Tier 1 for liquid and solid fuels (except blast furnace gas) and Tier 2 for gaseous fuel (natural gas), blast furnace gas and waste incineration (Tier 2a, 2006 IPCC Guidelines). For road transportation, the COPERT model is considered as a Tier 3 methodology.

Emissions are estimated by multiplying each activity, according to its fuel input, by an emission factor.

Activity data are taken from energy statistics (STATEC), or obtained directly from plant operators, from the Ministry of Economic Affairs (Energy Directorate) and the Customs and Excise Administration. Activity date obtained through the Emission Trading System (ETS) was used for QA/QC procedures by comparing this data to the data reported by the plant operators.

Net calorific values used for conversion of fuel activity data from physical units into energy units are defaults from the IEA Energy Handbook or the 2006 IPCC Guidelines for solid and liquid fuels and biomass, and country-specific for natural gas.

Emission factors are defaults from 2006 IPCC Guidelines for solid and liquid fuels (except blast furnace gas) and country specific for natural gas. Emission factors for Gasoline, Diesel and Liquefied Petroleum Gas used in Road Transportation are defaults from Copert IV.

3.2.4 Country-Specific Emission Factors

Blast Furnace Gas

A country-specific CO_2 emission factor for the combustion of blast furnace gas was determined based on emission measurement data and on the CO and CO_2 contents of blast furnace gas produced in Luxembourg's blast furnaces in 1990.[66] As no further measurements were available until the closure of the blast furnaces in 1997, the same emission factor, i.e. 257'181 kg CO_2/TJ, was used for the years 1990 to 1997.

Similarly, a country-specific CO_2 emission factor for blast furnace gas lost in distribution and flared was determined: 245'323 kg CO_2/TJ (see section 3.2.5.4 for more details).

Natural Gas

In Luxembourg, one operator, SOTEG S.A.[67], operates the national natural gas network (Figure 3-5). There are four entry points, from where natural gas is imported: two with Belgium (Braz and Pétange) with a capacity of 0.16 and 0.06 Mio Nm^3/h, respectively, one with Germany (Remich) with a capacity of 0.19 Mio Nm^3/h and one with France (Esch/Alzette) with a capacity of 0.02 Mio Nm^3/h.

For the calculation of the country-specific CO_2 emission factor for natural gas, the operator provides the following parameters for each entry point and for each month of a given year:

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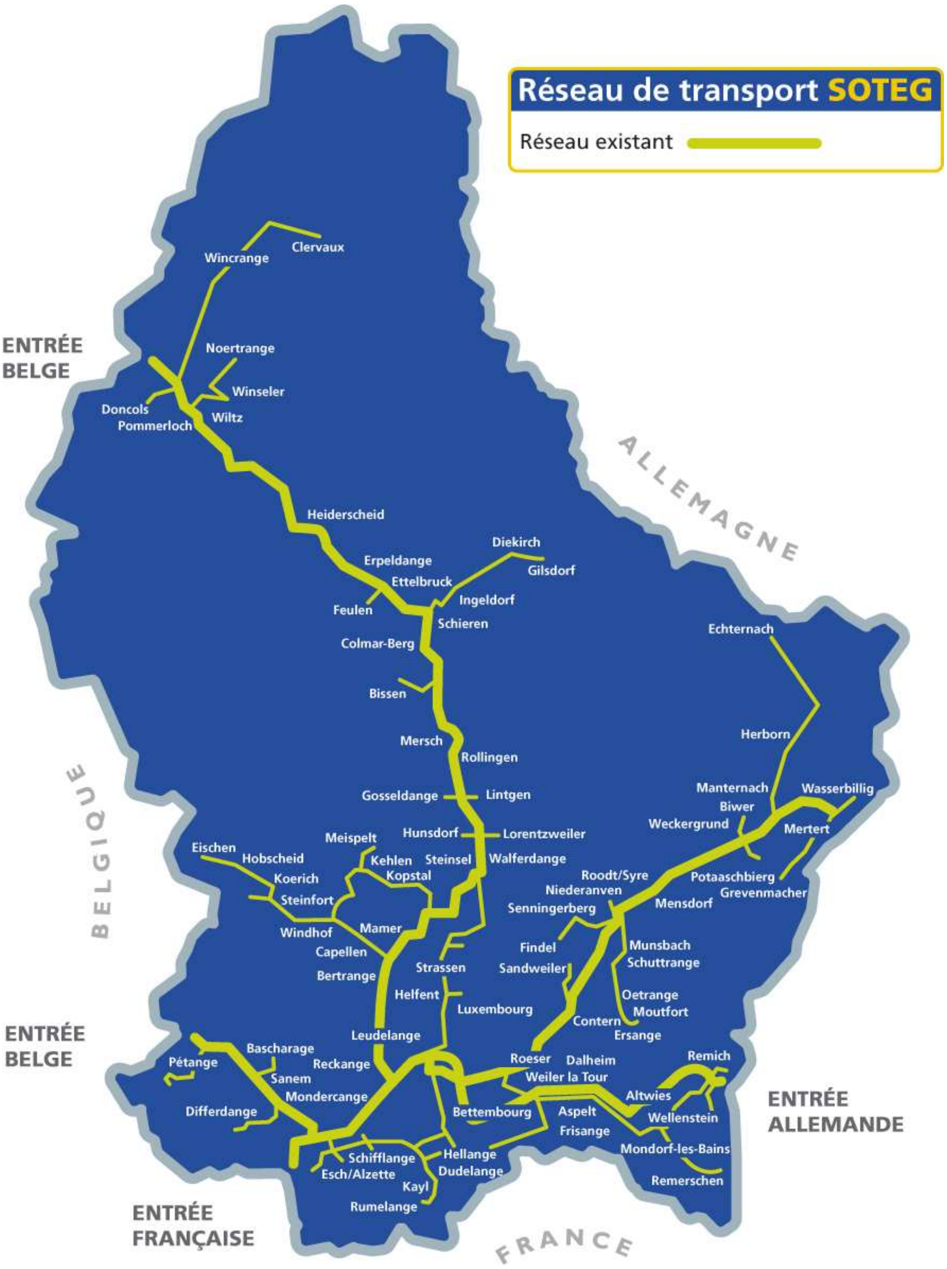
66 TÜV Rheinalnd, 1990, Bericht: 934/651014.

67 http://www.soteg.lu

- chemical composition (methane, ethane, propane, i-butane, n-butane, i-pentane, n-pentane, hexane & higher, CO_2 and N_2) expressed in mol%;
- physical properties: density (kg/Nm³) and gross calorific value (GCV: MJ/Nm³);
- monthly import/consumption (Mio Nm³). [68]

Figure 3-5 - Natural gas network



Source: SOTEG

68 Nm³ is defined at a pressure of 1035 mbar and 0 degree Celsius.

The monthly consumption is converted into energy units (TJ) using the respective NCV, which is calculated by multiplying the GCV with a conversion factor of 0.90 [69].

From the monthly chemical composition, a monthly average "molecular" weight for natural gas (g/mol), "molecular" density (mol/Nm3) and monthly carbon content (mol C/ mol NG) are derived for each entry point. The monthly carbon content is then converted into a monthly emission factor (g CO_2/MJ) assuming full oxidation of carbon to carbon dioxide. By multiplying the monthly emission factor with the respective monthly natural gas consumption, a monthly CO_2 emission is obtained. Finally, by dividing the yearly national emissions (sum of the monthly emissions of all 4 entry points) by the yearly national consumption (sum of the monthly consumptions of all 4 entry points), the country-specific emission factor for the respective year is obtained.

Country-specific emission factors have, thus, been calculated for the years 1991, 1995, 2000, 2005, 2006 and 2007 (Table 3-7). For the years in-between, the values have been interpolated.

Table 3-7 - Country-specific Emission Factors for Natural Gas: 1990-2007 (t CO_2/TJ)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
EF	57.76	57.74	57.85	57.89	57.94	57.93	57.55	57.20	56.86	56.52
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
EF	56.22	56.26	56.40	56.53	56.67	56.91	57.01	56.79		

Source: Environment Agency

3.2.5 Energy Industries (1A): Public Electricity and Heat Production (1A1a)

This section describes GHG emissions resulting from fuel combustion activities in energy industry.

In fact, emissions are reported only from public electricity and heat production. Hence, IPCC Sub-Category 1A1 = IPCC Sub-category *1A1a – Public Electricity and Heat Production*. In this category CO_2, CH_4 and N_2O emissions from combustion activities for electricity and heat production are reported, as well as CO_2, CH_4 and N_2O emissions from municipal waste incineration. In Luxembourg, municipal waste is combusted with energy recovery at the sole combustion pant (SIDOR) where heat is distributed to the urban district heating network. Therefore, the emissions are reported as fuel combustion emissions.

In 2007, this source category was responsible for 12.1% of GHG emissions from fuel combustion activities (12.2% in 1990) and represented 10.5% of the national total GHG emissions in CO_2e, excluding LULUCF (9.9% in 1990). Table 3-8 summarizes GHG emissions for IPCC Sub-category 1A1.

[69] IEA Energy Statistics Manual, 2005, Table A3.12, p.183

Table 3-8 – GHG emission trends in CO_2e for IPCC Sub-category 1A1 – Fuel Combustion Activities – Energy Industries: 1990-2007

1A1 - Energy Industries *GHG emissions by source & sink category (Gg)*												
Year	**1A1a - Public Electricity & Heat Production**				**1A1b - Petroleum Refining**				**1A1c - Manuf. of Solid Fuels & Other Energy Ind.**			
	Total $CO_{2\,eq}$	*CO_2 (excl. biomass)*	*CH_4 (incl. biomass)*	*N_2O (incl. biomass)*	Total $CO_{2\,eq}$	*CO_2 (excl. biomass)*	*CH_4 (incl. biomass)*	*N_2O (incl. biomass)*	Total $CO_{2\,eq}$	*CO_2 (excl. biomass)*	*CH_4 (incl. biomass)*	*N_2O (incl. biomass)*
1990	1 301.82	*1 299.25*	*0.042*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1991	1 245.54	*1 242.90*	*0.043*	*0.006*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1992	1 142.94	*1 140.24*	*0.044*	*0.006*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1993	1 230.48	*1 227.91*	*0.042*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1994	979.98	*977.54*	*0.040*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1995	835.43	*833.07*	*0.039*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1996	722.03	*720.17*	*0.031*	*0.004*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1997	448.86	*446.75*	*0.034*	*0.004*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1998	166.66	*164.20*	*0.040*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1999	185.20	*182.38*	*0.046*	*0.006*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2000	188.84	*186.10*	*0.044*	*0.006*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2001	214.34	*211.59*	*0.044*	*0.006*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2002	1 168.02	*1 164.36*	*0.062*	*0.008*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2003	1 199.55	*1 195.78*	*0.064*	*0.008*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2004	1 442.29	*1 438.08*	*0.072*	*0.009*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2005	1 456.83	*1 452.84*	*0.068*	*0.008*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2006	1 526.88	*1 522.69*	*0.072*	*0.009*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2007	1 362.66	*1 358.55*	*0.070*	*0.009*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
Trend 1990-2007	*4.67%*	*4.56%*	*66.32%*	*56.85%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency.

Notes:

CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

N_2O emissions are converted in CO_2e by multiplying the emissions by 310, i.e. the global warming potential (*GWP*) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

3.2.5.1 Key source

Public electricity and heat production is a key source with regard to CO_2 emissions. It has been a key source for solid fuels between 1990 and 1997, for gaseous fuels from 1995 onwards and for other solid fuels (MSW) between 1998 and 2004 and for 2007: see Table 3-6 in Section 3.2.2.

3.2.5.2 Activity data

In his source category, activity data various installations are considered:

- one power plant, operated until 1997 by the iron and steel industry, located on a site called *Terres Rouges,* and fed with blast furnace gas, residual fuel oil or natural gas. The activity rates are based on information received from the plant operator[70] and from a study (TÜV (1990));
- combined heat and power (*CHP*) installations which have appeared at the beginning of the 1990s. Those installations generally use combustion engines, and they are operated with natural gas and/or gasoil and to a smaller extent with biogas. The activity rates are based on information received from the operators and from energy statistics (STATEC).
- CHP gas turbine (350MW) running on natural gas and operated since 2002 by Twinerg. Since heat is not yet recovered, this unit is counted as a thermal power plant and not as a cogeneration one in official statistics. However, this classification issue has no impact on the GHG emission estimates since it is the fuel(s) used and the technology(ies) that matter. There are several smaller CHP gas turbines, which are operated on industrial sites, but which produce heat and electricity mainly for the respective industries. Emissions related to these are accounted for in *1A2-Manufacturing Industries and Construction*, as these installations are considered as autoproducers.
- waste incinerator (SIDOR) is fed with natural gas and/or gas oil and high calorific municipal solid waste (MSW). MSW incinerated is composed of paper/cardboard, textiles, food waste, wood, garden & park waste, nappies, rubber & leather, plastics, multilayer composite material, metal, glass, other inert waste. The MSW is untreated and partially split into a high calorific fraction which is incinerated and a low calorific fraction is deposited on land[71]). No industrial and hazardous waste is incinerated because it is exported. Activity data on municipal waste are taken from the following studies and for the years in-between an interpolation has been carried out:
    - o Waste Division of the Environment Agency, Restabfallanalyse 2004/05 im Großherzogtum Luxemburg, Band 1: Kompendium, Luxembourg, 2005;
    - o Waste Division of the Environment Agency, Restabfallanalyse 2001 im SIDOR, Luxembourg, 2002;
    - o Waste Division of the Environment Agency, Restabfallanalyse 1992/1994, Luxembourg, 2002.

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70 Later Arcelor-Arbed, and now Arcelor-Mittal.

71 For the different waste treatment schemes, see Chapter 8 on waste.

Table 3-9 gives an overview of the energy consumptions by fuel type in *1A1a – Public Electricity and Heat Production*.

Table 3-9 - Activity data for IPCC Sub-category 1A1a – Public Electricity and Heat Production: 1990-2007

1A1a - Public Electricity & Heat Production *Activity Data by fuel type (GJ)*						
Year	Activity Total (incl. biomass)	Solid	Liquid	Gaseous	Biomass	Other
		Blast furnace gas	*Residual fuel oil & Gas Oil*	*Natural Gas*	*Biogas & MSW (biogenic fraction)*	*MSW (fossil fraction)*
1990	5 360 334	*4 784 265*	*115 302*	*460 767*	*877 003*	*336 290*
1991	5 178 566	*4 534 554*	*280 012*	*364 000*	*895 973*	*343 564*
1992	4 876 309	*4 092 601*	*390 708*	*393 000*	*931 942*	*350 838*
1993	5 132 835	*4 477 919*	*272 700*	*382 216*	*887 411*	*333 762*
1994	4 217 453	*3 510 531*	*72 922*	*634 000*	*868 596*	*326 548*
1995	4 653 191	*2 666 289*	*70 902*	*1 916 000*	*832 290*	*311 859*
1996	4 355 269	*2 227 745*	*46 524*	*2 081 000*	*648 213*	*241 274*
1997	3 178 829	*1 176 200*	*72 629*	*1 930 000*	*760 358*	*285 810*
1998	1 929 935	*NO*	*30 935*	*1 899 000*	*691 092*	*584 722*
1999	2 124 747	*NO*	*31 747*	*2 093 000*	*787 767*	*669 441*
2000	2 236 789	*NO*	*20 789*	*2 216 000*	*776 629*	*650 338*
2001	2 697 369	*NO*	*35 369*	*2 662 000*	*828 119*	*642 130*
2002	19 570 727	*NO*	*29 727*	*19 541 000*	*851 579*	*652 020*
2003	20 058 658	*NO*	*19 658*	*20 039 000*	*997 106*	*629 912*
2004	24 197 730	*NO*	*20 730*	*24 177 000*	*1 099 584*	*680 725*
2005	24 452 936	*NO*	*20 936*	*24 432 000*	*1 127 333*	*623 970*
2006	25 579 590	*NO*	*15 590*	*25 564 000*	*1 233 569*	*657 783*
2007	22 759 278	*NO*	*17 278*	*22 742 000*	*1 298 901*	*673 324*
Trend 1990-2007	*324.59%*	*NA*	*-85.01%*	*4835.68%*	*48.11%*	*100.22%*

Source: Environment Agency.

3.2.5.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied for liquid and solid fuels. For natural gas, the methodological approach is classified as a Tier 2 methodology as a country specific emission factor is used.

For waste incineration, the IPCC methodology Tier 2a (2006 IPCC Guidelines) has been applied. For MSW, it is good practice to calculate CO_2 emissions on the basis of waste fractions (such as paper, wood, plastics) in the waste incinerated as the following equation shows:

$$CO_2\ emission = MSW \bullet \sum_j (WF_j \bullet dm_j \bullet CF_j \bullet FCF_j \bullet OF_j) \bullet \frac{44}{12}$$

with:

CO_2 emissions = CO_2 emissions in inventory year (Gg/yr)

MSW = total amount of municipal solid waste as wet weight incinerated or open-burned (Gg/yr)

WF_j = fraction of waste type/material of component j in the MSW (as wet weight incinerated or open-burned)

dm_j = dry matter content in the component j of the MSW incinerated or open-burned (fraction)

CF_j = fraction of carbon in the dry matter (i.e., carbon content) of component j

FCF_j = fraction of fossil carbon in the total carbon of component j

OF_j = oxidation factor (fraction)

44/12 = molecular weight ratio $M_{CO2}(g/mol)/M_C(g/mol)$

with:

$$\sum_j WF_j = 1$$

j = component of the MSW incinerated such as paper/cardboard, textiles, food waste, wood, garden (yard) and park waste, disposable nappies, rubber and leather, plastics, metal, glass, other inert waste.

IPCC default values for dm_j, CF_j, FCF_j and OF_j were taken.[72]

Reported CO_2 emissions of waste incineration are only CO_2 emissions from fossil MSW. However the activity data includes biogenic and fossil MSW. This means that biogenic CO_2 emissions are reported under Memo Items.

Calorific values used for conversion of fuel activity data from tonnes into GJ are country specific and derive from the Waste Division of the Environment Agency (see Table 3-10).[73]

Table 3-10 – Calorific values for MSW components

MSW component	Heating value [GJ/t]
Paper/cardboard	13
Textiles	13
Food waste	5
Wood	5
Garden and Park waste	5
Nappies	10
Rubber and Leather	5
Multilayer composite material	15
Plastics	30
Metal	0
Glass	0
Other, Inert waste	7

CH_4 emissions were estimated using 2006 IPCC Guidelines Tier 1 methodology. CH_4 emissions from incineration of waste are a result of incomplete combustion. Important factors affecting the

72 2006 IPCC Guidelines, Vol. 5, Chap. 2, Tab. 2.4, p2.14

73 *Restabfallanalyse 2004/05 im Großherzogtum Luxemburg, Band 1: Kompendium*, Luxembourg, 2005.

emissions are temperature, residence time, and air ratio (i.e., air volume in relation to the waste amount). CH_4 emissions are calculated according to the following equation:

$$CH_4\ Emissions = Fuel\ Consumption_{MSW} \bullet Emission\ Factor_{MSW}$$

with:

CH_4 Emissions = CH_4 emissions (kg GHG)

Fuel $Consumption_{MSW}$ = amount of incinerated MSW (TJ)

Emission $Factor_{MSW}$ = emission factor (kg gas/TJ)

The CH_4 emissions are relative to total MSW (biogenic + fossil).

Nitrous oxide is emitted in combustion processes at relatively low combustion temperatures between 500 and 950°C. Other important factors affecting the emissions are the type of air pollution control device, nitrogen type and content of the waste and the fraction of excess air. The N_2O emissions are calculated according to the following equation:

$$N_2O\ emission = \sum_j (IW_j \bullet EF_j) \bullet 10^{-6}$$

with:

N_2O Emissions	= N_2O emissions in inventory year (Gg/yr)
IW_i	= amount of incinerated waste of type i (Gg/yr)
EF_i	= N_2O emission factor (kg N2O /Gg of waste) for waste of type i
10^{-6}	= conversion from kilogram to gigagram
i	= category or type of waste incinerated (MSW)

The N_2O emissions are relative to total MSW (biogenic + fossil).

3.2.5.4 Emission factors

Default emission factors are derived from IPCC 2006 Guidelines (Table 3-11). Country specific or plant specific emission factors were determined by the Environment Agency and are either derived from a study (Blast Furnace Gas) or were calculated from specific data accessible to the Environment Agency (natural gas) from the operator (SOTEG).

For MSW, CO_2 emissions were not calculated using an emission factor, but instead, the calculation is based on the carbon content of the waste. CO_2 emissions are calculated, as described in section 3.2.5.3, by applying the default values listed in Table 3-13 of the 2006 IPCC Guidelines for:

- dry matter content in % of wet weight;

- DOC content in % of wet waste;
- DOC content in % of dry waste;
- total carbon content in % of dry weight;
- fossil carbon fraction in % of total carbon.

For CO_2, implied emission factors (IEFs) for the different waste components were then calculated by dividing the calculated emission by the energy content of the MSW waste fraction.

For CH_4, it is good practice to apply the CH_4 emission factors provided in Volume 2, Chapter 2 of the 2006 IPCC Guidelines. The CH_4 default emission factor of 30 kg CH_4/TJ is applied.

For N_2O, the default emission factor of 4.0 kg N_2O/TJ is applied. However, this emission factor might be revised in the next submission, as the 2006 IPCC guidelines recommend to use an EF of 50 g N_2O/t MSW on a wet basis (Vol.5, Chap.5, Table 5.6).

Table 3-11 gives an overview of the different emission factors used for 2007.

Table 3-11 – Emission factors for IPCC Sub-category 1A1a – Public Electricity and Heat Production

1A1a - Public Electricity & Heat Production *Emission Factors for 2007 (kg/TJ)*								
Fuel	Fuel Type	CO_2 EF	CO_2 type	CH_4 EF	CH_4 type	N_2O EF	N_2O type	Source
Blast furnace gas	solid	*257 181*	*PS, CS*	*1.00*	*D*	*0.10*	*D*	*TüV 1990, 2006 IPCC GL*
Residual Fuel Oil	liquid	*77 400*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Gas Oil	liquid	*74 100*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Natural Gas	gaseous	*56 793*	*CS*	*1.00*	*D*	*0.10*	*D*	*AEV, 2006 IPCC GL*
Biogas	biomass	*54 600*	*D*	*1.00*	*D*	*0.10*	*D*	*2006 IPCC GL*
MSW (biogenic)	biomass	*97 547*	*IEF (D)*	*30.00*	*D*	*4.00*	*D*	*AEV, 2006 IPCC GL*
MSW (fossil)	other	*97 547*	*IEF (D)*	*30.00*	*D*	*4.00*	*D*	*AEV, 2006 IPCC GL*

Source: Environment Agency.

Notes: AEV: IEFs and CS or PS EFs were determined by the Environment Agency. TüV 1990: EF was derived from study by TüV Rheinland.

Table 3-12 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3-12 – Implied emission factors for IPCC Sub-category 1A1a – Public Electricity and Heat Production

1A1a - Public Electricity & Heat Production *Implied Emission Factors (kg/TJ)*															
Year	Solid *Blast furnace gas*			Liquid *Residual fuel oil & Gas Oil*			Gaseous *Natural Gas*			Biomass *Biogas & MSW (biogenic fraction)*			Other *MSW (fossil fraction)*		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1990	257 181	1.00	0.10	77 400	3.00	0.60	57 755	1.00	0.10	98 984	30.00	4.00	98 984	30.00	4.00
1991	257 181	1.00	0.10	77 400	3.00	0.60	57 743	1.00	0.10	98 984	30.00	4.00	98 984	30.00	4.00
1992	257 181	1.00	0.10	77 400	3.00	0.60	57 848	1.00	0.10	98 175	29.47	3.93	98 984	30.00	4.00
1993	257 181	1.00	0.10	77 400	3.00	0.60	57 894	1.00	0.10	98 134	29.44	3.93	98 984	30.00	4.00
1994	257 181	1.00	0.10	77 400	3.00	0.60	57 940	1.00	0.10	98 116	29.43	3.92	98 984	30.00	4.00
1995	257 181	1.00	0.10	77 400	3.00	0.60	57 929	1.00	0.10	97 971	29.34	3.91	98 984	30.00	4.00
1996	257 181	1.00	0.10	77 335	3.00	0.60	57 546	1.00	0.10	97 684	29.15	3.89	98 984	30.00	4.00
1997	257 181	1.00	0.10	76 536	3.00	0.60	57 205	1.00	0.10	98 109	29.43	3.92	98 984	30.00	4.00
1998	NO	NO	NO	74 100	3.00	0.60	56 863	1.00	0.10	91 480	29.43	3.92	92 215	30.00	4.00
1999	NO	NO	NO	74 100	3.00	0.60	56 522	1.00	0.10	91 642	29.56	3.94	92 215	30.00	4.00
2000	NO	NO	NO	74 100	3.00	0.60	56 221	1.00	0.10	91 101	29.14	3.88	92 215	30.00	4.00
2001	NO	NO	NO	74 100	3.00	0.60	56 258	1.00	0.10	88 400	27.06	3.60	92 215	30.00	4.00
2002	NO	NO	NO	74 100	3.00	0.60	56 396	1.00	0.10	87 975	26.73	3.56	92 215	30.00	4.00
2003	NO	NO	NO	74 100	3.00	0.60	56 533	1.00	0.10	90 096	24.97	3.32	97 547	30.00	4.00
2004	NO	NO	NO	74 100	3.00	0.60	56 671	1.00	0.10	89 384	24.49	3.26	97 547	30.00	4.00
2005	NO	NO	NO	74 100	3.00	0.60	56 910	1.00	0.10	85 699	22.00	2.92	97 547	30.00	4.00
2006	NO	NO	NO	74 100	3.00	0.60	57 008	1.00	0.10	84 561	21.23	2.82	97 547	30.00	4.00
2007	NO	NO	NO	74 100	3.00	0.60	56 793	1.00	0.10	83 726	20.67	2.74	97 547	30.00	4.00

Source: Environment Agency.

3.2.5.5 Recalculations

Table 3-13 presents the main revisions and recalculations done since submission 2008v1.2 and the ICR of October 2008 relevant to IPCC sub-category *1A1a - Public Electricity and Heat Production*.

Table 3-13 – Recalculations done since submission 2008v1.2

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
1A1a	Revision of the energy balance using IEA Joint Questionnaires provided by the Energy Directorate of the Ministry of Economic Affairs[74]	updated source allocation updated AD inclusion of biomass
1A1a	Natural gas : NCV and EF were changed to country specific values over the entire time series[75]	updated EF
1A1a	Complete revision and documentation of AD and EF to increase transparency[76]	updated documentation
1A1a	Minor discrepancies between EU-ETS data and data provided under Operational Permits have been clarified. Data provided under operational permits is very detailed and comprehensive and may sometimes include consumptions of small combustion plants, offices and off-road, which is not included under EU-ETS [77]	clarification of data

3.2.5.6 Category specific QA/QC procedures

AD for large facilities that are under the European Union Emission Trading Scheme (EU-ETS) is cross-checked from two sources: reports obtained directly from the operator under its operational permit obligations and the EU-ETS registry operator. Both are hosted at the Environment Agency. A list with the large energy consuming facilities along with their respective fuel consumption has been compiled and enables the Single National Entity to quickly cross-check this data with the EU-ETS data.[78] Thus, completeness can be checked on a more systematic basis.

Additionally, cross checks with other relevant sectors, mainly CRF sector 2 – Industrial Processes and 6 – Waste, are performed to avoid double counting.

Finally, consistency and completeness checks are performed using the tools embedded in CRF Reporter.

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74 ARR 2008, § 38, 45
75 ARR 2008, § 39
76 ARR 2008, § 46
77 ARR 2008, § 47
78 ARR 2008, § 45

3.2.5.7 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 3-14 will be explored.

Table 3-14 – Planned improvements for IPCC Sub-category 1A1 – Fuel Combustion Activities – Energy Industries

GHG source & sink category	Planned improvement
1A1a - Public Electricity and Heat Production	waste incineration: revise N_2O EF of MSW
1A1a - Public Electricity and Heat Production	waste incineration: revise interpolation of MSW composition between waste analysis years
1A1a - Public Electricity and Heat Production	Investigate whether it would be feasible to obtain country specific NCV and EF for gas oil[79]
1A1a - Public Electricity and Heat Production	Further consultations with Ministry of Economic Affairs and STATEC regarding energy balance[80]

3.2.6 Manufacturing Industries and Construction (1A2)

This section describes GHG emissions resulting from fuel combustion activities in manufacturing industries and construction. In 2007, this source category was responsible for a bit more than 16.1% of GHG emissions from fuel combustion activities (this share was 48.2% in 1990) and represented 14.1% of the total GHG emissions in CO_2e, excluding LULUCF (39.1% in 1990).

The 2009 GHG inventory includes emissions from IPCC Sub-categories *1A2a – Iron and Steel*, *1A2b – Non-Ferrous Metals*, *1A2c – Chemicals*, *1A2e – Food Processing, Beverages and Tobacco* and *1A2f – Other*. Submission 2009v1.4 does not record any GHG emissions for the IPCC Sub-category *1A2d – Pulp, Paper and Print*.

Table 3-15 summarizes GHG emissions for IPCC Sub-category 1A2.

79 ARR 2008, § 42

80 ARR 2008, § 41

Table 3-15 – GHG emission trends in CO_2e for IPCC Sub-category 1A2 – Fuel Combustion Activities – Manufacturing Industries and Construction: 1990-2007

1A2 - Manufacturing Industries & Construction
GHG emissions by source & sink category (Gg)

Year	1A2a - Iron & Steel				1A2b - Non-Ferrous Metals				1A2c - Chemicals				1A2d - Pulp, Paper & Print			
	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O
1990	4 223.94	*4 216.74*	*0.106*	*0.016*	28.13	*28.11*	*0.0005*	*0.0000*	173.81	*173.05*	*0.006*	*0.002*	NO	*NO*	*NO*	*NO*
1991	3 941.20	*3 934.72*	*0.094*	*0.015*	29.13	*29.11*	*0.0005*	*0.0000*	194.30	*193.37*	*0.007*	*0.003*	NO	*NO*	*NO*	*NO*
1992	3 650.99	*3 644.98*	*0.087*	*0.013*	29.42	*29.39*	*0.0005*	*0.0000*	180.53	*179.70*	*0.006*	*0.002*	NO	*NO*	*NO*	*NO*
1993	3 729.42	*3 722.87*	*0.094*	*0.015*	28.88	*28.86*	*0.0005*	*0.0000*	189.63	*188.76*	*0.006*	*0.002*	NO	*NO*	*NO*	*NO*
1994	3 133.36	*3 127.79*	*0.079*	*0.013*	35.15	*35.12*	*0.0006*	*0.0001*	204.14	*203.34*	*0.006*	*0.002*	NO	*NO*	*NO*	*NO*
1995	1 625.82	*1 622.51*	*0.044*	*0.008*	36.29	*36.26*	*0.0006*	*0.0001*	205.88	*205.00*	*0.005*	*0.002*	NO	*NO*	*NO*	*NO*
1996	1 543.67	*1 540.50*	*0.041*	*0.007*	58.53	*58.48*	*0.0010*	*0.0001*	210.01	*209.08*	*0.006*	*0.003*	NO	*NO*	*NO*	*NO*
1997	1 068.55	*1 066.33*	*0.027*	*0.005*	41.46	*41.42*	*0.0007*	*0.0001*	195.07	*194.33*	*0.005*	*0.002*	NO	*NO*	*NO*	*NO*
1998	404.55	*403.49*	*0.008*	*0.003*	43.29	*43.25*	*0.0008*	*0.0001*	189.89	*189.46*	*0.004*	*0.001*	NO	*NO*	*NO*	*NO*
1999	442.07	*440.38*	*0.009*	*0.005*	42.11	*42.08*	*0.0007*	*0.0001*	178.74	*178.17*	*0.003*	*0.002*	NO	*NO*	*NO*	*NO*
2000	416.75	*415.17*	*0.008*	*0.005*	40.98	*40.94*	*0.0007*	*0.0001*	173.41	*172.86*	*0.003*	*0.002*	NO	*NO*	*NO*	*NO*
2001	415.23	*414.06*	*0.008*	*0.003*	41.57	*41.53*	*0.0007*	*0.0001*	183.29	*182.73*	*0.003*	*0.002*	NO	*NO*	*NO*	*NO*
2002	483.74	*483.26*	*0.009*	*0.001*	40.43	*40.39*	*0.0007*	*0.0001*	183.54	*183.36*	*0.003*	*0.000*	NO	*NO*	*NO*	*NO*
2003	472.20	*471.75*	*0.008*	*0.001*	46.24	*46.20*	*0.0008*	*0.0001*	195.46	*195.27*	*0.004*	*0.000*	NO	*NO*	*NO*	*NO*
2004	492.52	*492.06*	*0.009*	*0.001*	52.69	*52.64*	*0.0009*	*0.0001*	203.82	*203.62*	*0.004*	*0.000*	NO	*NO*	*NO*	*NO*
2005	456.73	*456.30*	*0.008*	*0.001*	51.39	*51.34*	*0.0009*	*0.0001*	200.79	*200.60*	*0.004*	*0.000*	NO	*NO*	*NO*	*NO*
2006	523.04	*522.55*	*0.009*	*0.001*	56.53	*56.48*	*0.0010*	*0.0001*	203.83	*203.64*	*0.004*	*0.000*	NO	*NO*	*NO*	*NO*
2007	569.02	*568.48*	*0.010*	*0.001*	55.20	*55.15*	*0.0010*	*0.0001*	171.13	*170.96*	*0.003*	*0.000*	NO	*NO*	*NO*	*NO*
Trend 1990-2007	*-86.53%*	*-86.52%*	*-90.39%*	*-93.52%*	*96.21%*	*96.20%*	*108.91%*	*108.91%*	*-1.55%*	*-1.21%*	*-44.67%*	*-84.56%*	*NA*	*NA*	*NA*	*NA*

1A2 - Manufacturing Industries & Construction
GHG emissions by source & sink category (Gg)

Year	1A2e - Food Processing, Beverages & Tobacco				1A2f - Other				1A2 - Manufacturing Industries & Construction			
	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Total $CO_{2\,eq}$	CO_2 (excl. biomass)	CH_4 (incl. biomass)	N_2O (incl. biomass)	Total $CO_{2\,eq}$	CO_2 (excl. biomass)	CH_4 (incl. biomass)	N_2O (incl. biomass)
1990	16.75	*16.39*	*0.001*	*0.001*	681.64	*673.58*	*0.044*	*0.023*	**5 124.28**	*5 107.88*	*0.156*	*0.042*
1991	25.14	*24.44*	*0.001*	*0.002*	762.68	*755.69*	*0.044*	*0.020*	**4 952.46**	*4 937.32*	*0.146*	*0.039*
1992	22.27	*21.58*	*0.001*	*0.002*	824.05	*815.42*	*0.046*	*0.025*	**4 707.26**	*4 691.07*	*0.140*	*0.043*
1993	15.47	*15.12*	*0.001*	*0.001*	776.90	*769.63*	*0.040*	*0.021*	**4 740.30**	*4 725.24*	*0.141*	*0.039*
1994	22.30	*21.61*	*0.001*	*0.002*	834.22	*827.00*	*0.046*	*0.020*	**4 229.17**	*4 214.86*	*0.132*	*0.037*
1995	22.48	*21.79*	*0.001*	*0.002*	783.42	*777.14*	*0.044*	*0.017*	**2 673.88**	*2 662.70*	*0.095*	*0.030*
1996	18.99	*18.47*	*0.001*	*0.002*	777.89	*771.06*	*0.047*	*0.019*	**2 609.10**	*2 597.58*	*0.095*	*0.031*
1997	23.32	*22.47*	*0.001*	*0.003*	876.34	*867.66*	*0.049*	*0.025*	**2 204.73**	*2 192.20*	*0.082*	*0.035*
1998	20.50	*19.82*	*0.001*	*0.002*	894.60	*883.41*	*0.054*	*0.032*	**1 552.83**	*1 539.43*	*0.068*	*0.039*
1999	22.09	*21.28*	*0.001*	*0.003*	989.78	*975.32*	*0.058*	*0.043*	**1 674.79**	*1 657.23*	*0.073*	*0.052*
2000	20.09	*19.29*	*0.001*	*0.003*	1 051.50	*1 034.13*	*0.063*	*0.052*	**1 702.73**	*1 682.39*	*0.076*	*0.060*
2001	16.35	*15.94*	*0.001*	*0.001*	932.73	*919.56*	*0.062*	*0.038*	**1 589.17**	*1 573.82*	*0.074*	*0.044*
2002	18.90	*18.48*	*0.001*	*0.001*	810.43	*798.84*	*0.060*	*0.033*	**1 537.04**	*1 524.34*	*0.073*	*0.036*
2003	18.56	*18.15*	*0.001*	*0.001*	750.90	*739.66*	*0.055*	*0.033*	**1 483.36**	*1 471.03*	*0.068*	*0.035*
2004	23.14	*22.32*	*0.001*	*0.003*	847.06	*833.24*	*0.062*	*0.040*	**1 619.23**	*1 603.89*	*0.076*	*0.044*
2005	22.21	*21.41*	*0.001*	*0.003*	978.24	*957.84*	*0.068*	*0.061*	**1 709.35**	*1 687.48*	*0.082*	*0.065*
2006	21.87	*21.07*	*0.001*	*0.003*	908.03	*887.73*	*0.066*	*0.061*	**1 713.30**	*1 691.46*	*0.081*	*0.065*
2007	25.10	*24.29*	*0.001*	*0.003*	998.90	*978.72*	*0.071*	*0.060*	**1 819.34**	*1 797.60*	*0.086*	*0.064*
Trend 1990-2007	*49.78%*	*48.15%*	*46.58%*	*126.67%*	*46.54%*	*45.30%*	*61.00%*	*162.12%*	*-64.50%*	*-64.81%*	*-45.02%*	*51.96%*

Source: Environment Agency.

Notes:

CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

N_2O emissions are converted in CO_2e by multiplying the emissions by 310, i.e. the global warming potential (*GWP*) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

3.2.6.1 Iron and Steel (1A2a)

In 2007, fuel combustion in iron and steel was responsible for 5.0% of GHG emissions from fuel combustion activities (this share was 39.8% in 1990) and represented 4.4% of the total GHG emissions in CO_2e, excluding LULUCF (32.2% in 1990).

3.2.6.1.1 Key source

Iron and steel fuel combustion is a key source with regard to CO_2 emissions. It has been a key source for solid fuels between 1990 and 1997, for gaseous fuels without interruption since 1990 and for liquid fuels between 1991 and 1995 and from 1997-1999: see Table 3-6 in Section 3.2.2.

3.2.6.1.2 Activity Data

The iron and steel industry has been among the most important industrial activities in Luxembourg, both in terms of energy consumption and in terms of added value. As already stressed earlier in this report, important technological changes took place between 1993 and 1997 with the move from blast furnaces to electric arc furnaces. This led to big changes in air emissions. Today, the iron and steel industry has a specific energy consumption which is much lower than it was in 1990 but it is still a relatively high consumption at Luxembourg's scale, hence the presence of this activity amongst the key sources.

Emissions from fuel combustion activities in the iron and steel industry are accounted for under IPCC Sub-category 1A2a. CO_2 process related emissions are included under IPCC Sub-category 2C1: see Section 4.4.1 in Chapter 4.

Blast furnace gas is a side product of the iron produced in blast furnaces and can be used as fuel for combustion purposes. That was the case in Luxembourg up to 1997 when the last blast furnace was stopped. Blast furnace gas was used by the iron and steel industry for heating purposes and for electricity production.

In CORINAIR, solid fuels, coke in particular, do not appear as fuel of blast furnaces and blast furnace gas is seen as gaseous fuel. Hence, as solid fuels of the iron and steel industry do not appear explicitly in the inventory compilation, those fuels are not included in the energy balance for the emission inventories. Instead of solid fuels, blast furnace gas appears in this balance (see also Section 4.4.1.3 in the next chapter). This has to be taken into account when comparing common energy balances with those resulting from the emission inventories.

Table 3-16 gives a summary of which combustion activities are included for estimating GHG emissions pertaining from IPCC Sub-category 1A2a.

Table 3-16 – Iron and steel combustion activities included in the GHG inventory

Combustion activity	SNAP code
Combustion plants <50 MW	030103
Blast furnace cowpers	030203
Sinter and pelletizing plants	030301
Reheating furnaces steel and iron	030302
Grey iron foundries	030303
Electric furnace steel plants	040207
Mobile Sources and Machinery in Industry	080800
Blast furnace gas distribution losses and flaring	NA

Combustion plants <50 MW

Various combustion plants were operated in the iron and steel industry mainly for heating purposes until 1997, when the last blast furnace was shut down. They were fed with blast furnace gas, residual fuel oil and/or natural gas. After 1997 these combustion plants were replaced by installations running on natural gas or gasoil. The related fuel consumption data were and still are received directly from the operator.

Blast furnace cowpers

Blast furnace cowpers have been used until 1997. They were fed with blast furnace gas and with natural gas. The related fuel consumption data were received directly from the operator.

Sinter and pelletizing plants

The sole sinter plant has been used until 1997. Its activity data, i.e. fuel consumption (coke oven coke, coal, blast furnace gas and natural gas) and production, have been established in detail for the year 1990 based on information received from the operator. The fuel consumptions of the following years have been extrapolated based on the consumption data of 1990 and on the sintered ore production from 1990 - 1997.

Reheating furnaces steel and iron

The reheating furnaces have been used during the whole period 1990 - 2007. Their operation is directly related to steel rolling. Their activity data (fuel combustion of natural gas) were received from the operator.

Grey iron foundries

The activity data (coking coke consumption) of those foundries have been estimated in the early 1990s (TÜV 1990), and no new data has been received since. Therefore, the values in the inventories have been kept rather constant. In 1997, grey iron production was stopped simultaneously with the last blast furnace.

Electric furnace steel plants

The first electric furnace steel plant has appeared in 1994. Beside electric energy, natural gas is used for the fusion of scrap. The related fuel consumption data were received directly from the operator.

Blast Furnace Gas Distribution Losses and Flaring

A certain amount of blast furnace gas (BFG) is either lost during distribution or vented to avoid over-pressurization of the pipes or flared. The amount of BFG lost, vented or flared was obtained from official statistics (STATEC - IEA joint Questionnaire).

Mobile Sources and Machinery in Industry

Activity data on the consumption of diesel oil, used in mobile sources and machinery was derived from official statistics (STATEC - IEA joint Questionnaire).

The fuel consumption data obtained by the operators (bottom-up) was then matched with the top-down data obtained from official statistics (STATEC - IEA joint Questionnaire), in order to avoid double counting or underestimation.

Table 3-17 gives a summary of the amount of energy used in IPCC Sub-category 1A2a.

Table 3-17 – Activity data for IPCC Sub-category 1A2a – Iron and Steel: 1990-2007

1A2a - Iron & Steel *Activity Data by fuel type (GJ)*						
		Solid	Liquid	Gaseous	Biomass	Other
Year	Activity Total	*Blast Furnace Gas, Coke Oven Coke, Coking Coke, Other Bituminous Coal*	*Residual Fuel Oil, Gas Oil, Diesel Oil*	*Natural Gas*		
1990	27 716 547	*19 579 669*	*669 878*	*7 467 000*	*NO*	*NO*
1991	25 149 501	*18 049 387*	*980 114*	*6 120 000*	*NO*	*NO*
1992	23 689 098	*16 489 127*	*1 313 971*	*5 886 000*	*NO*	*NO*
1993	24 393 216	*17 172 390*	*1 297 826*	*5 923 000*	*NO*	*NO*
1994	21 044 589	*14 142 679*	*1 376 910*	*5 525 000*	*NO*	*NO*
1995	13 573 647	*6 571 000*	*794 648*	*6 208 000*	*NO*	*NO*
1996	13 544 001	*5 993 886*	*748 114*	*6 802 000*	*NO*	*NO*
1997	10 924 287	*3 386 073*	*686 214*	*6 852 000*	*NO*	*NO*
1998	6 853 618	*NO*	*753 618*	*6 100 000*	*NO*	*NO*
1999	7 501 477	*NO*	*900 477*	*6 601 000*	*NO*	*NO*
2000	7 256 137	*NO*	*388 137*	*6 868 000*	*NO*	*NO*
2001	7 275 804	*NO*	*250 804*	*7 025 000*	*NO*	*NO*
2002	8 511 468	*NO*	*168 468*	*8 343 000*	*NO*	*NO*
2003	8 315 846	*NO*	*84 846*	*8 231 000*	*NO*	*NO*
2004	8 655 701	*NO*	*87 701*	*8 568 000*	*NO*	*NO*
2005	7 991 952	*NO*	*85 952*	*7 906 000*	*NO*	*NO*
2006	9 140 259	*NO*	*86 259*	*9 054 000*	*NO*	*NO*
2007	9 983 455	*NO*	*86 060*	*9 897 395*	*NO*	*NO*
Trend 1990-2007	*-63.98%*	*NA*	*-87.15%*	*32.55%*	*NA*	*NA*

Source: Environment Agency

3.2.6.1.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied for liquid and solid fuels except for blast furnace gas (recorded under solid fuels according to the 2006 IPCC Guidelines), where a Tier

2 methodology was used (a country-specific emission factor was used). For natural gas, the methodological approach is classified as a Tier 2 methodology as a country specific emission factor is used.

Special care was taken with solid fuels to avoid double counting with IPCC sub-category *2C1 - Iron and Steel Production*. As already stated (§ 3.2.6.1.2), the use of natural gas and BFG was considered as a combustion activity under 1A2a, whereas the use of coal (other bituminous coal), coke oven coke and some residual fuel oil was used in the blast furnaces to produce BFG and for reduction purposes. These emissions are accounted for in IPCC sub-category 2C1.

3.2.6.1.4 Emission factors

Default emission factors are derived from 2006 IPCC Guidelines. Country specific or plant specific emission factors were determined by the Environment Agency and are either derived from a study or were calculated from specific data accessible to the Environment Agency from the operator (Table 3-18).

For blast furnace gas combusted in blast furnaces or combustion plants, a plant specific CO_2 emission factor, which is at the same time country-specific as there was only one plant in Luxembourg, was applied. This EF was derived from a study in the year 1990 and is based on measurements BFG composition (see also section 3.2.4). The CH_4 and N_2O emission factors are default values from the 2006 IPCC Guidelines. The CO_2 EF for BFG lost in distribution and flaring is also plant specific and was based on measurements and BFG composition.[66] Generally, BFG consists of about 60 percent nitrogen, 18-20% carbon dioxide and some oxygen. The rest is mostly carbon monoxide, which has a fairly low heating value. When calculating the emissions from distribution losses, it is assumed that BFG is completely oxidised to CO_2 in the atmosphere. Therefore, the same emission factor as for flaring was used. No default values for CH_4 and N_2O from BFG lost in distribution and flaring are given in the 1996 Revised IPCC Guidelines nor in the 2006 IPCC Guidelines, therefore, the default values for coal were applied.

Table 3-18 gives an overview of the different emission factors used for 2007.

Table 3-18 – Emission factors for IPCC Sub-category 1A2a – Iron and Steel

1A2a Iron & Steel — *Emission Factors for 2007 (kg/TJ)*								
Fuel	**Fuel Type**	*CO_2*		*CH_4*		*N_2O*		*Source*
		EF	*type*	*EF*	*type*	*EF*	*type*	
Blast furnace gas	solid	*257 181*	*PS, CS*	*1.00*	*D*	*0.10*	*D*	*TüV 1990* *2006 IPCC GL*
BFG (DistLoss&Flar)	solid	*245 323*	*PS, CS*	*10.00*	*D*	*1.50*	*D*	*TüV 1990* *2006 IPCC GL*
Coke Oven Coke	solid	*107 000*	*D*	*10.00*	*D*	*1.50*	*D*	*2006 IPCC GL*
Other Bituminous Coal	solid	*94 600*	*D*	*10.00*	*D*	*1.50*	*D*	*2006 IPCC GL*
Coking Coke	solid	*94 600*	*D*	*10.00*	*D*	*1.50*	*D*	*2006 IPCC GL*
Residual Fuel Oil	liquid	*77 400*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Gas Oil	liquid	*74 100*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Diesel Oil	liquid	*74 100*	*D*	*4.15*	*D*	*28.60*	*D*	*2006 IPCC GL*
Natural Gas	gaseous	*56 793*	*CS*	*1.00*	*D*	*0.10*	*D*	*AEV* *2006 IPCC GL*

Source: Environment Agency

Table 3-19 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3-19 – Emission factors for IPCC Sub-category 1A2a – Iron and Steel

1A2a Iron & Steel *Implied Emission Factors (kg/TJ)*									
Year	Solid			Liquid			Gaseous		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1990	190 740	4.91	0.71	75 913	3.06	2.15	57 755	1.00	0.10
1991	194 278	4.69	0.67	76 240	3.05	1.81	57 743	1.00	0.10
1992	194 297	4.68	0.67	76 644	3.03	1.39	57 848	1.00	0.10
1993	191 051	4.88	0.70	76 416	3.04	1.63	57 894	1.00	0.10
1994	191 080	4.87	0.70	76 472	3.04	1.57	57 940	1.00	0.10
1995	183 047	5.37	0.78	75 614	3.08	2.46	57 929	1.00	0.10
1996	182 305	5.38	0.78	75 318	3.09	2.77	57 546	1.00	0.10
1997	183 933	5.31	0.77	75 124	3.10	2.97	57 205	1.00	0.10
1998	NO	NO	NO	75 140	3.10	2.95	56 863	1.00	0.10
1999	NO	NO	NO	74 719	3.16	4.61	56 522	1.00	0.10
2000	NO	NO	NO	74 841	3.38	9.91	56 221	1.00	0.10
2001	NO	NO	NO	75 137	3.39	10.20	56 258	1.00	0.10
2002	NO	NO	NO	75 716	3.00	0.60	56 396	1.00	0.10
2003	NO	NO	NO	75 740	3.00	0.60	56 533	1.00	0.10
2004	NO	NO	NO	74 100	3.00	0.60	56 671	1.00	0.10
2005	NO	NO	NO	74 100	3.00	0.60	56 910	1.00	0.10
2006	NO	NO	NO	74 100	3.00	0.60	57 008	1.00	0.10
2007	NO	NO	NO	74 100	3.00	0.60	56 793	1.00	0.10

Source: Environment Agency

3.2.6.2 Non-Ferrous Metals (1A2b)

In 2007, fuel combustion due to non-ferrous metal processing or production was responsible for 0.49% of GHG emissions from fuel combustion activities (0.26% in 1990) and represented 0.43% of the total GHG emissions in CO_2e, excluding LULUCF (0.21% in 1990). In Luxembourg, non-ferrous metals activities cover basically secondary aluminium production from aluminium scrap.

3.2.6.2.1 Key source

Fuel combustion from non-ferrous metal processing or production is a key source only in the Trend Assessment (for CO_2 from gaseous fuel).

3.2.6.2.2 Activity data

Liquefied petroleum gas (*LPG*) was an important fuel used in the secondary aluminium production. It has been slowly substituted by natural gas. Generally, the fuel consumption data were obtained from the operators. The activity data for secondary aluminium production are listed in Table 3-20.

The activity data reported here is the data reported by the operators to the Environment Agency through the annual reporting obligation in their operational permits. This bottom-up data could not be matched to top-down data from official statistics as no such data is reported for this category. To avoid double counting, the bottom-up data was subtracted from the top-down data from official statistics reported for IPCC sub-category *1A2f - Other* (category Non-Specified Industry in the IEA Joint Questionnaires).

Table 3-20 - Activity data for IPCC sub-category 1A2b - Non-Ferrous Metals: 1990-2007

1A2b - Non-Ferrous Metals *Activity Data by fuel type (GJ)*						
Year	Activity Total	Solid	Liquid *LPG*	Gaseous *Natural Gas*	Biomass	Other
1990	464 796	*NO*	*236 500*	*228 296*	*NO*	*NO*
1991	482 121	*NO*	*236 500*	*245 621*	*NO*	*NO*
1992	486 633	*NO*	*236 500*	*250 133*	*NO*	*NO*
1993	477 186	*NO*	*236 500*	*240 686*	*NO*	*NO*
1994	577 949	*NO*	*316 059*	*261 890*	*NO*	*NO*
1995	597 008	*NO*	*323 485*	*273 524*	*NO*	*NO*
1996	985 026	*NO*	*323 485*	*661 541*	*NO*	*NO*
1997	718 066	*NO*	*58 560*	*659 506*	*NO*	*NO*
1998	750 748	*NO*	*89 918*	*660 830*	*NO*	*NO*
1999	734 042	*NO*	*89 249*	*644 793*	*NO*	*NO*
2000	717 174	*NO*	*90 745*	*626 429*	*NO*	*NO*
2001	727 429	*NO*	*89 249*	*638 180*	*NO*	*NO*
2002	716 203	*NO*	*NO*	*716 203*	*NO*	*NO*
2003	817 173	*NO*	*NO*	*817 173*	*NO*	*NO*
2004	928 902	*NO*	*NO*	*928 902*	*NO*	*NO*
2005	902 177	*NO*	*NO*	*902 177*	*NO*	*NO*
2006	990 701	*NO*	*NO*	*990 701*	*NO*	*NO*
2007	971 026	*NO*	*NO*	*971 026*	*NO*	*NO*
Trend 1990-2007	*108.91%*	*NA*	*NA*	*325.34%*	*NA*	*NA*

Source: Environment Agency

3.2.6.2.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied for liquid fuels whereas the 2006 IPCC Guidelines Tier 2 approach was applied for natural gas.

3.2.6.2.4 Emission factors

The 2006 IPCC Guidelines default EF has been applied for CO_2 for LPG, whereas for natural gas the country specific EF was used. Default EFs have been applied for CH_4 and N_2O (Table 3-21).

Table 3-21 – Emission factors for Sub-category 1A2b – Non-Ferrous Metals

1A2b - Non-Ferrous Metals *Emission Factors for 2007 (kg/TJ)*								
Fuel	Fuel Type	CO_2		CH_4		N_2O		Source
		EF	*type*	*EF*	*type*	*EF*	*type*	
LPG	liquid	*63 100*	*D*	*1.00*	*D*	*0.10*	*D*	*2006 IPCC GL*
Natural Gas	gaseous	*56 793*	*CS*	*1.00*	*D*	*0.10*	*D*	*AEV* *2006 IPCC GL*

Source: Environment Agency

3.2.6.3 Chemicals (1A2c)

This subcategory has been reallocated from *1A2f - Other*, where the emissions were reported in submission 2008v1.2.[81] In 2007, fuel combustion from the chemical industry was responsible for 1.5% of GHG emissions from fuel combustion activities (1.6% in 1990) and represented 1.3% of the total GHG emissions in CO_2e, excluding LULUCF (1.3% in 1990). In Luxembourg, chemical activities cover mainly the production of tyres and various plastic films and synthetic non-woven textiles. Also included in this sub-category are the emissions of two gas turbines operated by the chemical industriy for heat and electricity production (autoproducers).

3.2.6.3.1 Key source

Combustion in *1A2c – Chemicals* is a key source with regard to CO_2 emissions. It has been a key source for gaseous fuels for 1990, 1992 and between 1994 and 2007 and for liquid fuels between 1990 and 1997: see Table 3-6 in Section 3.2.2.

3.2.6.3.2 Activity data

Annual fuel consumption data of residual fuel oil, gas- and diesel oil and natural gas were obtained from the operators. Diesel oil is mainly used by mobile sources and machinery, whereas the remaining fuels are mainly combusted in stationary units.

The activity data reported here is the data reported by the operators to the Environment Agency through the annual reporting obligation in their operational permits. The bottom-up data on natural gas could not be matched to the top-down data from official statistics as no such data is reported for this category. To avoid double counting, the bottom-up data on natural gas was subtracted from the top-down data from official statistics reported for IPCC sub-category *1A2f - Other* (category Non-Specified Industry in the IEA Joint Questionnaires). For liquid fuels (residual fuel oil, gas oil, diesel oil) the matching exercise was done within the IPCC subcategory 1A2c as top-down data is reported for this sub-category in official statistics. Activity data for the chemical industry are listed in Table 3-22.

81 ARR 2008, § 53: reallocation from 1A2f

Table 3-22- Activity data for IPCC sub-category 1A2c - Chemicals: 1990-2007

1A2c - Chemicals *Activity Data by fuel type (GJ)*						
Year	Activity Total	Solid	Liquid *Residual Fuel Oil, Gas Oil, Diesel Oil*	Gaseous *Natural Gas*	Biomass	Other
1990	2 495 286	*NO*	*1 516 466*	*978 820*	*NO*	*NO*
1991	2 657 579	*NO*	*2 080 998*	*576 581*	*NO*	*NO*
1992	2 599 293	*NO*	*1 551 190*	*1 048 103*	*NO*	*NO*
1993	2 699 759	*NO*	*1 715 110*	*984 650*	*NO*	*NO*
1994	3 002 168	*NO*	*1 554 403*	*1 447 765*	*NO*	*NO*
1995	3 207 508	*NO*	*1 051 529*	*2 155 979*	*NO*	*NO*
1996	3 286 253	*NO*	*1 076 995*	*2 209 258*	*NO*	*NO*
1997	3 177 824	*NO*	*677 313*	*2 500 511*	*NO*	*NO*
1998	3 265 393	*NO*	*211 625*	*3 053 767*	*NO*	*NO*
1999	3 096 513	*NO*	*171 334*	*2 925 179*	*NO*	*NO*
2000	3 047 254	*NO*	*86 006*	*2 961 248*	*NO*	*NO*
2001	3 220 801	*NO*	*86 012*	*3 134 789*	*NO*	*NO*
2002	3 237 821	*NO*	*42 979*	*3 194 842*	*NO*	*NO*
2003	3 440 880	*NO*	*42 676*	*3 398 204*	*NO*	*NO*
2004	3 579 589	*NO*	*43 851*	*3 535 738*	*NO*	*NO*
2005	3 511 808	*NO*	*42 976*	*3 468 832*	*NO*	*NO*
2006	3 559 086	*NO*	*43 129*	*3 515 957*	*NO*	*NO*
2007	2 997 177	*NO*	*43 030*	*2 954 147*	*NO*	*NO*
Trend 1990-2007	*20.11%*	*NA*	*-97.16%*	*201.81%*	*NA*	*NA*

Source: Environment Agency

3.2.6.3.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied for liquid fuels whereas the 2006 IPCC Guidelines Tier 2 approach was applied for natural gas.

3.2.6.3.4 Emission factors

The 2006 IPCC Guidelines default EFs have been applied for CO_2 for residual fuel oil, gasoil and diesel oil, whereas for natural gas, the country specific EF was used. Default EFs have been applied for CH_4 and N_2O (Table 3-23).

Table 3-23 – Emission factors for Sub-category 1A2c – Chemicals

1A2c - Chemicals *Emission Factors for 2007 (kg/TJ)*								
Fuel	Fuel Type	*CO_2*		*CH_4*		*N_2O*		*Source*
		EF	*type*	*EF*	*type*	*EF*	*type*	
Residual Fuel Oil	liquid	*77 400*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Gas Oil	liquid	*74 100*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Diesel Oil	liquid	*74 100*	*D*	*4.15*	*D*	*28.60*	*D*	*2006 IPCC GL*
Natural Gas	gaseous	*56 793*	*CS*	*1.00*	*D*	*0.10*	*D*	*AEV 2006 IPCC GL*

Source: Environment Agency

Table 3-24 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3-24 – Implied emission factors for Sub-category 1A2c – Chemicals

1A2c - Chemicals *Implied Emission Factors (kg/TJ)*						
Year	Liquid			Gaseous		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1990	76 837	3.03	1.31	57 755	1.00	0.10
1991	76 922	3.02	1.20	57 743	1.00	0.10
1992	76 760	3.03	1.40	57 848	1.00	0.10
1993	76 821	3.03	1.33	57 894	1.00	0.10
1994	76 852	3.03	1.29	57 940	1.00	0.10
1995	76 185	3.06	2.13	57 929	1.00	0.10
1996	76 086	3.07	2.25	57 546	1.00	0.10
1997	75 723	3.09	2.71	57 205	1.00	0.10
1998	74 717	3.14	3.97	56 863	1.00	0.10
1999	74 914	3.29	7.63	56 522	1.00	0.10
2000	74 100	3.58	14.60	56 221	1.00	0.10
2001	74 100	3.58	14.60	56 258	1.00	0.10
2002	74 100	3.00	0.60	56 396	1.00	0.10
2003	74 100	3.00	0.60	56 533	1.00	0.10
2004	74 100	3.00	0.60	56 671	1.00	0.10
2005	74 100	3.00	0.60	56 910	1.00	0.10
2006	74 100	3.00	0.60	57 008	1.00	0.10
2007	74 100	3.00	0.60	56 793	1.00	0.10

Source: Environment Agency

3.2.6.4 Pulp, Paper and Print (1A2d)

On the basis of the information used so far for realising the GHG inventory, this source category does not exist in Luxembourg.

3.2.6.5 Food Processing, Beverages and Tobacco (1A2e)

This subcategory has been reallocated from *1A2f - Other*, where the emissions were reported in submission 2008v1.2.[82] In 2007, fuel combustion from the food processing, beverages and tobacco industry was responsible for 0.22% of GHG emissions from fuel combustion activities (0.16% in 1990) and represented 0.19% of the total GHG emissions in CO_2e, excluding LULUCF (0.13% in 1990). In Luxembourg, these activities cover mainly the production of milk, milk products, and tobacco products. Included in this sub-category are the emissions from combustion plants (<50 MW) and from mobile sources and machinery operated by the food processing, beverages and tobacco industry.

3.2.6.5.1 Key source

Fuel combustion from *1A2e - Food Processing, Beverages and Tobacco* is not a key source.

82 ARR2008, § 53: reallocation from 1A2f

3.2.6.5.2 Activity data

Annual fuel consumption data of residual fuel oil, gas- and diesel oil and natural gas were obtained from the operators. Diesel oil is mainly used by mobile sources and machinery, whereas the remaining fuels are mainly combusted in stationary units. The use of residual fuel oil stopped in 2002.

The activity data reported here is the data reported by the operators to the Environment Agency through the annual reporting obligation in their operational permits. The bottom-up data on natural gas could not be matched to the top-down data from official statistics as no such data is reported for this category. To avoid double counting, the bottom-up data on natural gas was subtracted from the top-down data from official statistics reported for IPCC sub-category *1A2f - Other* (category Non-Specified Industry in the IEA Joint Questionnaires). For liquid fuels (residual fuel oil, gas oil, diesel oil) the matching exercise was done within the IPCC sub-category 1A2e as top-down data is available for this sub-category in official statistics. Activity data for the food processing, beverages and tobacco industry are listed in Table 3-25.

Table 3-25- Activity data for IPCC sub-category 1A2e - Food Processing, Beverages and Tobacco: 1990-2007

1A2e - Food Processing, Beverages & Tobacco *Activity Data by fuel type (GJ)*						
Year	Activity Total	Solid	Liquid *Residual fuel oil, Gas Oil, Diesel Oil*	Gaseous *Natural Gas*	Biomass	Other
1990	231 910	*NO*	*167 150*	*64 760*	*NO*	*NO*
1991	346 910	*NO*	*253 192*	*93 718*	*NO*	*NO*
1992	311 055	*NO*	*212 299*	*98 755*	*NO*	*NO*
1993	223 414	*NO*	*126 418*	*96 996*	*NO*	*NO*
1994	311 434	*NO*	*212 523*	*98 910*	*NO*	*NO*
1995	314 555	*NO*	*212 305*	*102 250*	*NO*	*NO*
1996	269 987	*NO*	*169 200*	*100 788*	*NO*	*NO*
1997	326 505	*NO*	*222 688*	*103 817*	*NO*	*NO*
1998	292 039	*NO*	*184 128*	*107 911*	*NO*	*NO*
1999	309 323	*NO*	*215 970*	*93 352*	*NO*	*NO*
2000	288 093	*NO*	*172 846*	*115 246*	*NO*	*NO*
2001	242 367	*NO*	*129 135*	*113 232*	*NO*	*NO*
2002	287 289	*NO*	*128 936*	*158 352*	*NO*	*NO*
2003	281 227	*NO*	*128 028*	*153 198*	*NO*	*NO*
2004	339 913	*NO*	*175 403*	*164 510*	*NO*	*NO*
2005	324 282	*NO*	*171 904*	*152 378*	*NO*	*NO*
2006	317 793	*NO*	*172 517*	*145 275*	*NO*	*NO*
2007	362 051	*NO*	*215 149*	*146 902*	*NO*	*NO*
Trend 1990-2007	*56.12%*	*NA*	*28.72%*	*126.84%*	*NA*	*NA*

Source: Environment Agency

3.2.6.5.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied for liquid fuels whereas the 2006 IPCC Guidelines Tier 2 approach was applied for natural gas.

3.2.6.5.4 Emission factors

The 2006 IPCC Guidelines default EFs have been applied for CO_2 for residual fuel oil, gasoil and diesel oil, whereas for natural gas, the country specific EF was used. Default EFs have been applied for CH_4 and N_2O (Table 3-26).

Table 3-26 – Emission factors for Sub-category 1A2e – Food Processing, Beverages and Tobacco

1A2c - Chemicals *Emission Factors for 2007 (kg/TJ)*								
Fuel	**Fuel Type**	CO_2		CH_4		N_2O		**Source**
		EF	*type*	*EF*	*type*	*EF*	*type*	
Residual Fuel Oil	liquid	*77 400*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Gas Oil	liquid	*74 100*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Diesel Oil	liquid	*74 100*	*D*	*4.15*	*D*	*28.60*	*D*	*2006 IPCC GL*
Natural Gas	gaseous	*56 793*	*CS*	*1.00*	*D*	*0.10*	*D*	*AEV* *2006 IPCC GL*

Source: Environment Agency

Table 3-27 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3-27 – Implied emission factors for Sub-category 1A2e – Food Processing, Beverages and Tobacco

1A2e - Food Processing, Beverages & Tobacco *Implied Emission Factors (kg/TJ)*						
Year	**Liquid**			**Gaseous**		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1990	*75 697*	*3.25*	*6.70*	*57 755*	*1.00*	*0.10*
1991	*75 154*	*3.33*	*8.65*	*57 743*	*1.00*	*0.10*
1992	*74 727*	*3.39*	*10.18*	*57 848*	*1.00*	*0.10*
1993	*75 155*	*3.33*	*8.64*	*57 894*	*1.00*	*0.10*
1994	*74 729*	*3.39*	*10.17*	*57 940*	*1.00*	*0.10*
1995	*74 726*	*3.39*	*10.18*	*57 929*	*1.00*	*0.10*
1996	*74 890*	*3.37*	*9.59*	*57 546*	*1.00*	*0.10*
1997	*74 213*	*3.47*	*12.02*	*57 205*	*1.00*	*0.10*
1998	*74 317*	*3.45*	*11.65*	*56 863*	*1.00*	*0.10*
1999	*74 113*	*3.46*	*11.76*	*56 522*	*1.00*	*0.10*
2000	*74 116*	*3.57*	*14.53*	*56 221*	*1.00*	*0.10*
2001	*74 103*	*3.38*	*9.92*	*56 258*	*1.00*	*0.10*
2002	*74 100*	*3.38*	*9.93*	*56 396*	*1.00*	*0.10*
2003	*74 100*	*3.38*	*9.93*	*56 533*	*1.00*	*0.10*
2004	*74 100*	*3.58*	*14.60*	*56 671*	*1.00*	*0.10*
2005	*74 100*	*3.58*	*14.60*	*56 910*	*1.00*	*0.10*
2006	*74 100*	*3.58*	*14.60*	*57 008*	*1.00*	*0.10*
2007	*74 100*	*3.46*	*11.80*	*56 793*	*1.00*	*0.10*

Source: Environment Agency

3.2.6.6 Other (1A2f)

In this submission, sub-categories *1A2c - Chemicals* and *1A2e - Food Processing, Beverages and Tobacco* have been reallocated from *1A2f - Other*, where the emissions were reported in submission 2008v1.2.[83] Fuel combustion emissions reported under *1A2f - Other* manufacturing industries and construction were responsible for 8.8% of GHG emissions from fuel combustion activities (this share was 6.4% in 1990) and represented 7.7% of the total GHG emissions in CO_2e, excluding LU-LUCF (5.2% in 1990).

3.2.6.6.1 Key source

Fuel combustion emissions reported under other manufacturing industries and construction are a key source, with regard to CO_2 emissions, for the 3 main energy carriers – gaseous, liquid and solid

83 see footnotes 81 & 82 and ARR 2008, § 53

fuels – without interruption since 1990, and for other solid fuels from 2005-2006: see Table 3-6 in Section 3.2.2.

3.2.6.6.2 Activity data

Under other manufacturing industries and construction, the following activities have been classified (Table 3-28):

Table 3-28 – Combustion activities included in 1A2f - Other

Description	SNAP code
Combustion plants < 50 MW	030103
Gas Turbines	030104
Cement (Clinker)	030311
Asphalt concrete plants[84]	030313
Flat glass	030314
Fine ceramic materials	030320
Other mobile sources and machinery in Industry	080800
Other mobile equipment	081000

Combustion plants <50 MW

This source includes all kinds of smaller combustion installations for heat or steam production. As the number of this kind of boilers is quite important, they have not always been treated individually. Various types of fuel were and still are used: anthracite, residual fuel oil, gas oil, LPG, natural gas. Where information about the fuel combustion in these boilers was available, it was received directly from the operator.

Gas Turbines

This source includes one gas turbine used in the wood processing industry for heat and electricity production running on natural gas. The information about the fuel combustion is received directly from the operator.

Cement (Clinker)

One industrial site produces clinker in Luxembourg. Its major fuel is hard coal (other bituminous coal), but use is also made of residual oil, natural gas and special types of waste: shredded tyres, fluff and sewage sludge. These waste types contain a certain biogenic fraction , which is annually reported by the operator. This was taken into consideration when estimating the emissions. The consumption data of these fuels are transmitted annually to the Environment Agency by the operator.

84 ARR 2008, § 40

Asphalt concrete plants

There are three asphalt concrete plants in Luxembourg. Their main fuel is lignite (brown coal briquettes) followed by natural gas and gas oil. Fuel consumption data was obtained by the operators.

Flat glass

There are two flat glass plants in Luxembourg. Their main fuel is natural gas. LPG was used too, but on a minor scale.

Fine ceramic materials

One major production site of ceramic materials exists in Luxembourg (Villeroy & Boch) using natural gas as fuel. However this production site will be closed down by 2010.

Mobile Sources and Machinery in Industry and Other Mobile Equipment

Activity data on the consumption of gas oil, diesel oil and gasoline used in these sources were derived from official statistics (STATEC - IEA joint Questionnaire).

The activity data described here is the data reported by the operators to the Environment Agency through the annual reporting obligation in their operational permits. This bottom-up data combined with the bottom-up data which could not be matched with the top-down data elsewhere (*1A2b - Non-Ferrous Metals*: natural gas and LPG ; *1A2c - Chemicals*: natural gas, *1A2e - Food Processing, Beverages and Tobacco*: natural gas) was then matched with the top-down data from official statistics (STATEC, IEA Joint Questionnaires). To avoid double counting, the bottom-up data was subtracted from the top-down data. Activity data for other manufacturing industry and construction are listed in Table 3-29 and Table 3-30.

Table 3-29 – Activity data by fuel type of IPCC Sub-category 1A2f – Other: 1990-2007

1A2f - Other *Activity Data by fuel type (GJ)*						
		Solid	Liquid	Gaseous	Biomass	Other
Year	Activity Total (excl. biomass)	*Other Bituminous Coal, Brown Coal Briquettes*	*Residual fuel oil, Gas Oil, Diesel Oil, Gasoline, LPG*	*Natural Gas*	*Sewage sludge,Tyres (bio. frac.), Fluff (bio. frac.)*	*Tyres (fossil frac.), Fluff (fossil frac.)*
1990	9 043 361	3 568 644	1 224 593	4 250 124	NO	NO
1991	10 566 769	3 402 999	1 181 690	5 982 080	NO	NO
1992	11 454 138	3 475 055	1 484 075	6 495 009	NO	NO
1993	11 097 189	2 853 727	1 337 794	6 905 668	NO	NO
1994	11 678 287	3 459 727	1 366 126	6 852 434	NO	NO
1995	11 081 661	3 078 285	1 331 129	6 672 247	NO	NO
1996	10 974 127	3 134 181	1 378 532	6 461 414	NO	NO
1997	12 591 281	3 150 791	1 761 324	7 679 166	NO	NO
1998	12 654 346	2 967 863	2 229 991	7 456 492	NO	179 572
1999	14 099 964	3 199 393	2 655 895	8 244 676	NO	175 064
2000	14 900 243	3 194 494	3 085 671	8 620 077	NO	268 442
2001	13 048 064	2 354 312	2 715 953	7 977 799	NO	583 715
2002	10 907 311	2 352 894	2 123 814	6 430 603	13 783	688 646
2003	10 137 828	2 047 162	2 194 241	5 896 424	41 709	626 431
2004	11 446 806	2 212 874	2 582 081	6 651 850	86 405	674 388
2005	13 091 985	2 353 506	3 715 865	7 022 613	51 529	722 346
2006	12 070 995	2 037 637	3 437 291	6 596 066	85 055	756 579
2007	13 869 394	2 258 771	3 386 929	8 223 694	313 212	572 010
Trend 1990-2007	*53.37%*	*-36.71%*	*176.58%*	*93.49%*	*NA*	*NA*

Source: Environment Agency

Table 3-30 – Activity data by fuel type and source categories of IPCC Sub-category 1A2f – Other: 1990-2007

1A2f - Other *Activity Data by type of Industry (GJ)*																
Year	**Activity Total (incl.biomass)**	**Non-Metallic Minerals (Cement, Flatglass & Fine Ceramics)**			**Mining and Quayrring**			**Wood & Wood Products**			**Construction (Asphalt Concrete Plants)**			**Non-specified Industry**		
		Solid (incl.biomass & other fuels)	***Liquid***	***Gaseous***	***Solid (incl.biomass & other fuels)***	***Liquid***	***Gaseous***	***Solid (incl.biomass & other fuels)***	***Liquid***	***Gaseous***	***Solid (incl.biomass & other fuels)***	***Liquid***	***Gaseous***	***Solid (incl.biomass & other fuels)***	***Liquid***	***Gaseous***
1990	9 046 080	*3 361 766*	*318 902*	*3 482 830*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*198 557*	*560 666*	*NO*	*8 321*	*347 744*	*767 294*
1991	10 570 049	*3 202 631*	*381 868*	*3 089 878*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*193 628*	*215 384*	*NO*	*6 739*	*587 718*	*2 892 202*
1992	11 457 759	*3 256 579*	*452 262*	*1 657 702*	*NO*	*85 984*	*NO*	*NO*	*NO*	*NO*	*211 766*	*257 953*	*NO*	*6 710*	*691 496*	*4 837 307*
1993	11 100 880	*2 691 611*	*477 626*	*3 147 461*	*NO*	*86 017*	*NO*	*NO*	*NO*	*NO*	*154 556*	*344 067*	*NO*	*7 559*	*433 776*	*3 758 207*
1994	11 681 978	*3 138 622*	*542 784*	*3 275 872*	*NO*	*86 006*	*NO*	*NO*	*NO*	*NO*	*313 575*	*387 025*	*NO*	*7 530*	*354 002*	*3 576 562*
1995	11 085 194	*2 917 490*	*548 942*	*3 362 503*	*NO*	*86 016*	*NO*	*NO*	*NO*	*NO*	*153 180*	*344 062*	*NO*	*7 615*	*355 642*	*3 309 744*
1996	10 977 821	*2 878 609*	*537 203*	*3 398 099*	*NO*	*85 800*	*NO*	*NO*	*NO*	*NO*	*248 862*	*300 300*	*NO*	*6 710*	*458 924*	*3 063 314*
1997	12 595 264	*2 925 256*	*621 717*	*3 261 173*	*NO*	*86 034*	*NO*	*NO*	*NO*	*NO*	*221 023*	*344 134*	*NO*	*4 512*	*713 422*	*4 417 994*
1998	12 838 217	*2 962 876*	*524 491*	*2 949 183*	*NO*	*86 022*	*NO*	*NO*	*17 019*	*1 031 959*	*177 644*	*559 146*	*NO*	*6 915*	*1 047 612*	*3 475 350*
1999	14 318 056	*3 155 944*	*506 725*	*3 446 415*	*NO*	*86 056*	*NO*	*NO*	*294*	*1 054 299*	*213 941*	*516 336*	*NO*	*4 571*	*1 589 514*	*3 743 962*
2000	15 168 686	*3 250 535*	*442 696*	*3 555 572*	*NO*	*215 015*	*NO*	*NO*	*298*	*1 103 666*	*210 878*	*645 046*	*NO*	*1 524*	*1 782 616*	*3 960 839*
2001	13 631 779	*2 801 534*	*416 365*	*3 542 920*	*NO*	*172 024*	*NO*	*NO*	*13 905*	*1 044 398*	*134 998*	*602 086*	*NO*	*1 494*	*1 511 573*	*3 390 481*
2002	11 609 740	*2 915 863*	*276 310*	*3 481 985*	*NO*	*128 936*	*NO*	*NO*	*17 781*	*845 525*	*139 460*	*558 725*	*NO*	*NO*	*1 142 061*	*2 103 092*
2003	10 805 967	*2 564 852*	*287 030*	*2 900 279*	*NO*	*128 028*	*NO*	*NO*	*17 781*	*872 221*	*150 449*	*554 790*	*NO*	*NO*	*1 206 612*	*2 123 924*
2004	12 207 599	*2 826 393*	*398 929*	*3 310 837*	*NO*	*175 403*	*NO*	*NO*	*19 160*	*1 010 482*	*147 275*	*701 611*	*66 317*	*NO*	*1 286 979*	*2 264 214*
2005	13 908 835	*2 983 103*	*283 480*	*3 333 003*	*NO*	*214 880*	*NO*	*NO*	*15 918*	*980 072*	*144 278*	*902 498*	*56 388*	*NO*	*2 342 065*	*2 653 150*
2006	12 998 887	*2 743 430*	*240 389*	*3 286 165*	*NO*	*258 776*	*NO*	*NO*	*14 986*	*1 088 968*	*135 842*	*948 845*	*70 330*	*NO*	*2 060 553*	*2 150 603*
2007	14 840 676	*2 988 593*	*235 668*	*3 384 549*	*NO*	*301 209*	*NO*	*NO*	*15 804*	*884 294*	*155 400*	*989 686*	*61 686*	*NO*	*1 930 621*	*3 893 165*
Trend 1990-2007	*64.06%*	*-11.10%*	*-26.10%*	*-2.82%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*-21.74%*	*76.52%*	*NA*	*NA*	*455.18%*	*407.39%*

Source: Environment Agency

3.2.6.6.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied for solid and liquid fuels, whereas the 2006 IPCC Guidelines Tier 2 approach was applied for natural gas. CO_2 emissions from the biogenic factions of tires, fluff and sewage sludge are reported under memory items.

3.2.6.6.4 Emission factors

The 2006 IPCC Guidelines default CO_2 EFs have been applied for solid and liquid fuels except for tires and fluff, where plant-specific emission factors were used. For natural gas, the country specific EF was used. IPCC default EFs have been applied for CH_4 and N_2O (Table 3-31).

Table 3-31 – Emission factors for IPCC Sub-category 1A2f – Other

1A2f - Other *Emission Factors for 2007 (kg/TJ)*								
Fuel	**Fuel Type**	***CO_2***		***CH_4***		***N_2O***		***Source***
		EF	***type***	***EF***	***type***	***EF***	***type***	
Other Bituminous Coal	solid	*94 600*	*D*	*10.00*	*D*	*1.50*	*D*	*2006 IPCC GL*
Brown Coal Briquettes	solid	*97 500*	*D*	*10.00*	*D*	*1.50*	*D*	*2006 IPCC GL*
Residual Fuel Oil	liquid	*77 400*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Gas Oil	liquid	*74 100*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Diesel Oil	liquid	*74 100*	*D*	*4.15*	*D*	*28.60*	*D*	*2006 IPCC GL*
Gasoline	liquid	*69 300*	*D*	*50.00*	*D*	*2.00*	*D*	*2006 IPCC GL*
LPG	liquid	*63 100*	*D*	*1.00*	*D*	*0.10*	*D*	*2006 IPCC GL*
Natural Gas	gaseous	*56 793*	*CS*	*1.00*	*D*	*0.10*	*D*	*AEV 2006 IPCC GL*
Sewage Sludge	biomass	*100 000*	*D*	*30.00*	*D*	*4.00*	*D*	*2006 IPCC GL*
Tyres	other/biomass	*88 000*	*PS*	*30.00*	*D*	*4.00*	*D*	*2006 IPCC GL*
Fluff	other/biomass	*85 260*	*PS*	*30.00*	*D*	*4.00*	*D*	*AEV 2006 IPCC GL*

Source: Environment Agency

Table 3-32 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3-32 – Implied emission factors for Sub-category 1A2f – Other

Year	Solid			Liquid			Gaseous			Biomass			Other		
	1A2f - Other *Implied Emission Factors (kg/TJ)*														
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1990	94 761	10.00	1.50	73 449	3.34	14.07	57 755	1.00	0.10	NO	NO	NO	NO	NO	NO
1991	94 765	10.00	1.50	74 280	3.41	11.74	57 743	1.00	0.10	NO	NO	NO	NO	NO	NO
1992	94 777	10.00	1.50	74 354	3.46	12.69	57 848	1.00	0.10	NO	NO	NO	NO	NO	NO
1993	94 757	10.00	1.50	74 322	3.42	11.79	57 894	1.00	0.10	NO	NO	NO	NO	NO	NO
1994	94 863	10.00	1.50	74 491	3.38	10.46	57 940	1.00	0.10	NO	NO	NO	NO	NO	NO
1995	94 744	10.00	1.50	74 356	4.87	9.02	57 929	1.00	0.10	NO	NO	NO	NO	NO	NO
1996	94 830	10.00	1.50	73 998	6.39	9.83	57 546	1.00	0.10	NO	NO	NO	NO	NO	NO
1997	94 803	10.00	1.50	73 619	5.70	10.88	57 205	1.00	0.10	NO	NO	NO	NO	NO	NO
1998	94 774	10.00	1.50	72 793	5.11	11.90	56 863	1.00	0.10	NO	NO	NO	88 000	30.00	4.00
1999	94 794	10.00	1.50	71 775	4.72	13.70	56 522	1.00	0.10	NO	NO	NO	88 000	30.00	4.00
2000	94 791	10.00	1.50	72 292	4.57	14.60	56 221	1.00	0.10	NO	NO	NO	88 000	30.00	4.00
2001	94 766	10.00	1.50	72 267	4.64	11.64	56 258	1.00	0.10	NO	NO	NO	88 000	30.00	4.00
2002	94 772	10.00	1.50	71 849	4.02	12.42	56 396	1.00	0.10	100 000	30.00	4.00	88 000	30.00	4.00
2003	94 813	10.00	1.50	71 590	3.92	11.94	56 533	1.00	0.10	100 000	30.00	4.00	88 000	30.00	4.00
2004	94 793	10.00	1.50	72 486	3.99	12.91	56 671	1.00	0.10	100 000	30.00	4.00	88 000	30.00	4.00
2005	94 778	10.00	1.50	73 080	3.90	14.49	56 910	1.00	0.10	100 000	30.00	4.00	88 000	30.00	4.00
2006	94 793	10.00	1.50	73 344	4.04	15.69	57 008	1.00	0.10	96 273	30.00	4.00	87 821	30.00	4.00
2007	94 800	10.00	1.50	73 179	3.99	15.51	56 793	1.00	0.10	90 128	30.00	4.00	86 870	30.00	4.00

Source: Environment Agency

3.2.6.7 Recalculations

Table 3-33 presents the main revisions and recalculations done since submission 2008v1.2 and the ICR of October 2008 relevant to IPCC sub-category *1A2 - Manufacturing Industries and Construction*.

Table 3-33 – Recalculations done since submission 2008v1.2

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
1A2	Revision of the energy balance using IEA Joint Questionnaires provided by the Energy Directorate of the Ministry of Economic Affairs[85]	updated AD inclusion of biomass
1A2	Natural gas : NCV and EF were changed to country specific values over the entire time series[86]	updated EF
1A2	Complete revision and documentation of AD and EF to increase transparency[87]	updated documentation
1A2	Minor discrepancies between EU-ETS data and data provided under Operational Permits have been clarified. Data provided under operational permits is very detailed and comprehensive and may sometimes include consumptions of small combustion plants, offices and off-road, which is not included under EU-ETS [88]	clarification of data
1A2	Emissions from mobile sources and machinery are reported in the relevant sub-categories.[89]	updated source allocation
1A2a	Blast Furnace Gas: use of plant specific EFs for combustion activities and distribution losses and flaring	updated EF
1A2a	A plant recycling iron from slag and collected dust (direct reduction furnace) is included in Sub-category 1A2a	updated bottom-up AD
1A2b & 1A2e	Reallocation from 1A2f - Other to 1A2b - Chemicals and 1A2e - Food Processing, Beverages and Tobacco[90]	updated source allocation

85 ARR 2008, § 38, 45

86 ARR 2008, § 39

87 ARR 2008, § 46

88 ARR 2008, § 47

89 ARR 2008, § 37

90 ARR 2008, § 53

3.2.6.8 Category specific QA/QC procedures

AD for large facilities that are under the European Union Emission Trading Scheme (EU-ETS) is cross-checked from two sources: reports obtained directly from the operator under its operational permit obligations and the EU-ETS registry operator. Both are hosted at the Environment Agency. A list with the large energy consuming facilities along with their respective fuel consumption has been compiled and enables the Single National Entity to quickly cross-check this data with the EU-ETS data.[91] Thus, completeness can be checked on a more systematic basis.

Additionally, cross checks with other relevant sectors, mainly CRF sector 2 – Industrial Processes and 6 – Waste, are performed to avoid double counting.

Finally, consistency and completeness checks are performed using the tools embedded in CRF Reporter.

3.2.6.9 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 3-34 will be explored.

Table 3-34 – Planned improvements for IPCC Sub-category 1A2 – Manufacturing Industries and Construction

GHG source & sink category	Planned improvement
1A2 – Manufacturing Industries and Construction	Investigate whether it would be feasible to obtain country specific NCV and EF for gas oil, diesel oil and gasoline[92]
1A2 – Manufacturing Industries and Construction	Further consultations with Ministry of Economic Affairs and STATEC regarding energy balance[93]
1A2b – Non-Ferrous Metals	include other non-ferrous activities if relevant (copper processing and production from copper scrap) which is now included in 1A2f.

3.2.7 Transport (1A3)

This section describes GHG emissions resulting from transport fuel combustion. In 2007, this source category was responsible for a bit more than 59.2% of GHG emissions from fuel combustion activities (this share was only 26.0% in 1990) and represented 51.7% of the total GHG emissions in CO_2e, excluding LULUCF (coming from 21.1% in 1990).

Table 3-35 summarizes GHG emissions for IPCC Sub-category 1A3.

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91 ARR 2008, § 45

92 ARR 2008, § 42

93 ARR 2008, § 41

Table 3-35 – GHG emission trends in CO_2e for IPCC Sub-category 1A3 – Transport: 1990-2007

1A3 - Transport
GHG emissions by source & sink category (Gg)

Year	1A3a - Civil Aviation				1A3b - Road Transportation				1A3c - Railways			
	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O
1990	0.21	*0.21*	*0.000002*	*0.000006*	2 734.93	*2 675.93*	*1.19*	*0.11*	28.13	*25.10*	*0.0014*	*0.0097*
1991	0.33	*0.32*	*0.000002*	*0.000009*	3 250.99	*3 181.45*	*1.40*	*0.13*	28.13	*25.10*	*0.0014*	*0.0097*
1992	0.46	*0.46*	*0.000003*	*0.000013*	3 557.87	*3 475.46*	*1.39*	*0.17*	28.13	*25.10*	*0.0014*	*0.0097*
1993	0.60	*0.59*	*0.000004*	*0.000017*	3 610.30	*3 520.61*	*1.27*	*0.20*	28.13	*25.10*	*0.0014*	*0.0097*
1994	0.70	*0.70*	*0.000005*	*0.000020*	3 676.98	*3 582.19*	*1.23*	*0.22*	27.31	*24.37*	*0.0014*	*0.0094*
1995	0.76	*0.75*	*0.000005*	*0.000022*	3 494.23	*3 402.41*	*1.10*	*0.22*	22.11	*19.73*	*0.0011*	*0.0076*
1996	0.81	*0.80*	*0.000006*	*0.000023*	3 595.50	*3 500.20*	*1.13*	*0.23*	24.71	*22.05*	*0.0012*	*0.0085*
1997	0.82	*0.82*	*0.000006*	*0.000024*	3 805.90	*3 707.02*	*1.03*	*0.25*	24.29	*21.67*	*0.0012*	*0.0084*
1998	0.71	*0.70*	*0.000005*	*0.000020*	3 971.25	*3 873.11*	*0.99*	*0.25*	24.29	*21.67*	*0.0012*	*0.0084*
1999	0.72	*0.72*	*0.000005*	*0.000021*	4 273.44	*4 173.42*	*0.98*	*0.26*	24.29	*21.67*	*0.0012*	*0.0084*
2000	0.69	*0.69*	*0.000005*	*0.000020*	4 813.93	*4 708.00*	*0.98*	*0.28*	23.90	*21.32*	*0.0012*	*0.0082*
2001	0.69	*0.68*	*0.000005*	*0.000020*	5 108.65	*5 002.48*	*0.94*	*0.28*	25.75	*22.97*	*0.0013*	*0.0089*
2002	0.64	*0.63*	*0.000005*	*0.000018*	5 459.38	*5 354.19*	*0.90*	*0.28*	22.76	*20.30*	*0.0011*	*0.0078*
2003	0.74	*0.73*	*0.000005*	*0.000021*	6 029.95	*5 918.46*	*0.86*	*0.30*	19.84	*17.70*	*0.0010*	*0.0068*
2004	0.65	*0.64*	*0.000005*	*0.000019*	6 899.50	*6 779.31*	*0.82*	*0.33*	15.77	*14.07*	*0.0008*	*0.0054*
2005	0.64	*0.64*	*0.000005*	*0.000018*	7 127.13	*7 006.44*	*0.71*	*0.34*	10.01	*8.93*	*0.0005*	*0.0034*
2006	0.55	*0.54*	*0.000004*	*0.000016*	6 948.64	*6 834.47*	*0.63*	*0.33*	7.47	*6.66*	*0.0004*	*0.0026*
2007	0.55	*0.54*	*0.000004*	*0.000016*	6 680.50	*6 568.65*	*0.52*	*0.33*	1.80	*1.60*	*0.0001*	*0.0006*
Trend 1990-2007	*154.42%*	*154.42%*	*154.42%*	*154.42%*	*144.27%*	*145.47%*	*-56.30%*	*196.99%*	*-93.61%*	*-93.61%*	*-93.61%*	*-93.61%*

1A3 - Transport
GHG emissions by source & sink category (Gg)

Year	1A3d - Navigation				1A3e - Other Transportation				1A3 - Transport			
	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O
1990	0.25	*0.24*	*0.000023*	*0.000007*	NA	*NA*	*NA*	*NA*	**2 763.52**	*2 701.49*	*1.19*	*0.12*
1991	0.25	*0.25*	*0.000024*	*0.000007*	NA	*NA*	*NA*	*NA*	**3 279.71**	*3 207.13*	*1.40*	*0.14*
1992	0.25	*0.24*	*0.000023*	*0.000007*	NA	*NA*	*NA*	*NA*	**3 586.71**	*3 501.26*	*1.39*	*0.18*
1993	0.37	*0.36*	*0.000034*	*0.000010*	NA	*NA*	*NA*	*NA*	**3 639.39**	*3 546.66*	*1.27*	*0.21*
1994	0.33	*0.33*	*0.000031*	*0.000009*	NA	*NA*	*NA*	*NA*	**3 705.32**	*3 607.58*	*1.24*	*0.23*
1995	0.34	*0.33*	*0.000031*	*0.000009*	NA	*NA*	*NA*	*NA*	**3 517.43**	*3 423.22*	*1.10*	*0.23*
1996	0.31	*0.31*	*0.000029*	*0.000008*	NA	*NA*	*NA*	*NA*	**3 621.33**	*3 523.36*	*1.13*	*0.24*
1997	0.38	*0.37*	*0.000035*	*0.000010*	NA	*NA*	*NA*	*NA*	**3 831.39**	*3 729.88*	*1.03*	*0.26*
1998	0.37	*0.36*	*0.000034*	*0.000010*	NA	*NA*	*NA*	*NA*	**3 996.62**	*3 895.85*	*0.99*	*0.26*
1999	0.43	*0.42*	*0.000040*	*0.000011*	NA	*NA*	*NA*	*NA*	**4 298.89**	*4 196.24*	*0.98*	*0.26*
2000	0.44	*0.44*	*0.000041*	*0.000012*	NA	*NA*	*NA*	*NA*	**4 838.96**	*4 730.44*	*0.98*	*0.28*
2001	0.44	*0.44*	*0.000042*	*0.000012*	NA	*NA*	*NA*	*NA*	**5 135.53**	*5 026.57*	*0.95*	*0.29*
2002	0.44	*0.44*	*0.000041*	*0.000012*	NA	*NA*	*NA*	*NA*	**5 483.21**	*5 375.56*	*0.90*	*0.29*
2003	0.45	*0.44*	*0.000042*	*0.000012*	NA	*NA*	*NA*	*NA*	**6 050.98**	*5 937.34*	*0.86*	*0.31*
2004	0.46	*0.46*	*0.000043*	*0.000012*	NA	*NA*	*NA*	*NA*	**6 916.38**	*6 794.48*	*0.82*	*0.34*
2005	0.55	*0.54*	*0.000051*	*0.000015*	NA	*NA*	*NA*	*NA*	**7 138.33**	*7 016.55*	*0.71*	*0.34*
2006	0.51	*0.51*	*0.000048*	*0.000014*	NA	*NA*	*NA*	*NA*	**6 957.17**	*6 842.18*	*0.63*	*0.33*
2007	0.48	*0.48*	*0.000045*	*0.000013*	NA	*NA*	*NA*	*NA*	**6 683.32**	*6 571.27*	*0.52*	*0.33*
Trend 1990-2007	*94.78%*	*94.78%*	*94.78%*	*94.78%*	*NA*	*NA*	*NA*	*NA*	*141.84%*	*143.25%*	*-56.34%*	*173.39%*

Source: Environment Agency

Notes:

CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

N_2O emissions are converted in CO_2e by multiplying the emissions by 310, i.e. the global warming potential (*GWP*) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

3.2.7.1 Civil Aviation (1A3a)

In Luxembourg, civil aviation, excluding international flights, is a very small activity. In 2007, civil aviation fuel consumption was responsible for 0.005% of GHG emissions from fuel combustion activities (0.002% in 1990) and represented 0.004% of the total GHG emissions in CO_2e, excluding LULUCF (0.002% in 1990).

3.2.7.1.1 Key source

Fuel consumption emissions from civil aviation are not a key source.

3.2.7.1.2 Activity data

There is only one airport for commercial aviation in Luxembourg operated by Lux-airport (Findel). Therefore, all flights, either inbound or outbound, are international flights. For that reason, emissions of kerosene consumption are not included in the national total of Luxembourg, but under international bunkers – aviation as a memo item. However, private flights with Luxembourg as a start and return point, are considered as domestic flights. These are mainly leisure or urgency (medical, police) flights made with small-sized propeller planes or helicopters using aviation gasoline.

As there is only one company selling aviation fuels in Luxembourg, calculations are straightforward. Expert judgement has been made for determining the share of aviation gasoline sold by this company that is being exported – outbound flights - and the share that is addressed to the domestic consumption – inbound flights. It has been assumed that 90 % of aviation gasoline sales directed towards inbound flights. Activity data of IPCC sub-category *1A3a – Civil Aviation* are listed in Table 3-36.

Table 3-36– Activity data and emission factors for IPCC Sub-category 1A3a – Civil Aviation: 1990-2007

1A3a - Civil Aviation *Aviation Gasoline*								
Year	Activity (GJ)	Emission Factors (kg/TJ)						
		CO_2	type	CH_4	type	N_2O	type	source
1990	3 069	69 300	D	0.50	D	2.00	D	2006 IPCC GL
1991	4 662	69 300	D	0.50	D	2.00	D	2006 IPCC GL
1992	6 579	69 300	D	0.50	D	2.00	D	2006 IPCC GL
1993	8 514	69 300	D	0.50	D	2.00	D	2006 IPCC GL
1994	10 071	69 300	D	0.50	D	2.00	D	2006 IPCC GL
1995	10 845	69 300	D	0.50	D	2.00	D	2006 IPCC GL
1996	11 577	69 300	D	0.50	D	2.00	D	2006 IPCC GL
1997	11 779	69 300	D	0.50	D	2.00	D	2006 IPCC GL
1998	10 146	69 300	D	0.50	D	2.00	D	2006 IPCC GL
1999	10 362	69 300	D	0.50	D	2.00	D	2006 IPCC GL
2000	9 888	69 300	D	0.50	D	2.00	D	2006 IPCC GL
2001	9 818	69 300	D	0.50	D	2.00	D	2006 IPCC GL
2002	9 105	69 300	D	0.50	D	2.00	D	2006 IPCC GL
2003	10 590	69 300	D	0.50	D	2.00	D	2006 IPCC GL
2004	9 287	69 300	D	0.50	D	2.00	D	2006 IPCC GL
2005	9 190	69 300	D	0.50	D	2.00	D	2006 IPCC GL
2006	7 808	69 300	D	0.50	D	2.00	D	2006 IPCC GL
2007	7 808	69 300	D	0.50	D	2.00	D	2006 IPCC GL
Trend 1990-2007	154.42%	0.00%	NA	0.00%	NA	0.00%	NA	NA

Source: Environment Agency

3.2.7.1.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied for domestic fights. As it is assumed that 90% of aviation gasoline sales are directed towards domestic flights, the emissions of the remaining 10% (international flights) have been accounted for under emissions from international bunker fuels – aviation.[94]

3.2.7.1.4 Emission factors

Default CO_2, CH_4 and N_2O emission factors for aviation gasoline, from the 2006 IPCC Guidelines, have been used (Table 3-36). The IEA default NCV of 45.03 GJ/t Avgas has been applied for converting activity data into energy units.

3.2.7.2 Road Transportation (1A3b)

In 2007, road transportation was responsible for 59.1% of GHG emissions from fuel combustion activities (this share was only 25.7% in 1990) and represented 51.7% of the total GHG emissions in CO_2e, excluding LULUCF (20.8% in 1990). Emission from road transportation, as reported in the CRF tables, are shown in Table 3-37.

Table 3-37 – Emission trends, activity data and implied emission factors of IPCC Sub-category 1A3b – Road Transportation: 1990-2007

1A3b - Road Transportation
Activity Data, Emissions and Implied Emission Factors

Year	Activity (GJ)					Emissions (Gg)				Implied Emission Factors (kg/TJ)		
	Total (excl. biomass)	*Gasoline (fossil)*	*Diesel (fossil)*	*LPG*	*Biomass*	Total $CO_{2\,eq}$	*CO_2 (excl. biomass)*	*CH_4 (incl. biomass)*	*N_2O (incl. biomass)*	*CO_2 (excl. biodmass)*	*CH_4 (incl. biomass)*	*N_2O (incl. biomass)*
1990	37 123 667	18 445 145	18 499 256	179 267	NO	2 734.93	*2 675.93*	*1.19*	*0.11*	*72 082*	*32.08*	*2.95*
1991	44 120 160	21 621 947	22 310 526	187 686	NO	3 250.99	*3 181.45*	*1.40*	*0.13*	*72 109*	*31.78*	*2.93*
1992	48 175 019	23 389 617	24 630 920	154 482	NO	3 557.87	*3 475.46*	*1.39*	*0.17*	*72 142*	*28.85*	*3.56*
1993	48 787 919	23 509 815	25 113 215	164 888	NO	3 610.30	*3 520.61*	*1.27*	*0.20*	*72 162*	*25.95*	*4.17*
1994	49 657 520	24 383 738	25 109 935	163 847	NO	3 676.98	*3 582.19*	*1.23*	*0.22*	*72 138*	*24.84*	*4.47*
1995	47 154 295	22 958 576	24 037 832	157 887	NO	3 494.23	*3 402.41*	*1.10*	*0.22*	*72 155*	*23.25*	*4.71*
1996	48 488 185	23 234 032	25 135 666	118 487	NO	3 595.50	*3 500.20*	*1.13*	*0.23*	*72 187*	*23.35*	*4.76*
1997	51 318 949	24 167 599	27 096 577	54 773	NO	3 805.90	*3 707.02*	*1.03*	*0.25*	*72 235*	*20.06*	*4.86*
1998	53 581 626	24 205 752	29 243 340	132 535	NO	3 971.25	*3 873.11*	*0.99*	*0.25*	*72 284*	*18.43*	*4.66*
1999	57 689 193	25 080 386	32 486 111	122 696	NO	4 273.44	*4 173.42*	*0.98*	*0.26*	*72 343*	*16.96*	*4.44*
2000	64 971 772	25 901 524	38 960 748	109 500	NO	4 813.93	*4 708.00*	*0.98*	*0.28*	*72 462*	*15.13*	*4.23*
2001	68 952 461	25 504 489	43 307 160	140 812	NO	5 108.65	*5 002.48*	*0.94*	*0.28*	*72 550*	*13.69*	*4.04*
2002	73 697 283	24 905 390	48 652 027	139 866	NO	5 459.38	*5 354.19*	*0.90*	*0.28*	*72 651*	*12.16*	*3.78*
2003	81 365 749	25 348 066	55 905 771	111 912	NO	6 029.95	*5 918.46*	*0.86*	*0.30*	*72 739*	*10.52*	*3.71*
2004	93 009 562	24 575 084	68 338 791	95 688	24 435	6 899.50	*6 779.31*	*0.82*	*0.33*	*72 888*	*8.80*	*3.57*
2005	95 965 086	21 721 390	74 192 517	51 179	27 187	7 127.13	*7 006.44*	*0.71*	*0.34*	*73 010*	*7.43*	*3.55*
2006	93 567 946	20 110 208	73 381 726	76 011	24 407	6 948.64	*6 834.47*	*0.63*	*0.33*	*73 043*	*6.78*	*3.48*
2007	89 925 500	19 277 832	70 573 360	74 308	1 900 537	6 680.50	*6 568.65*	*0.52*	*0.33*	*73 045*	*5.74*	*3.55*
Trend 1990-2007	*142.23%*	*4.51%*	*281.49%*	*-58.55%*	*NA*	*144.27%*	*145.47%*	*-56.30%*	*196.99%*	*1.34%*	*-82.11%*	*20.26%*

Source: Environment Agency

Figure 3-6 shows the evolution of fuel sold (i.e. blended fuel) in Luxembourg. Diesel oil is by far the most fuel sold, although during recent years the quantities sold seem to decrease slightly.

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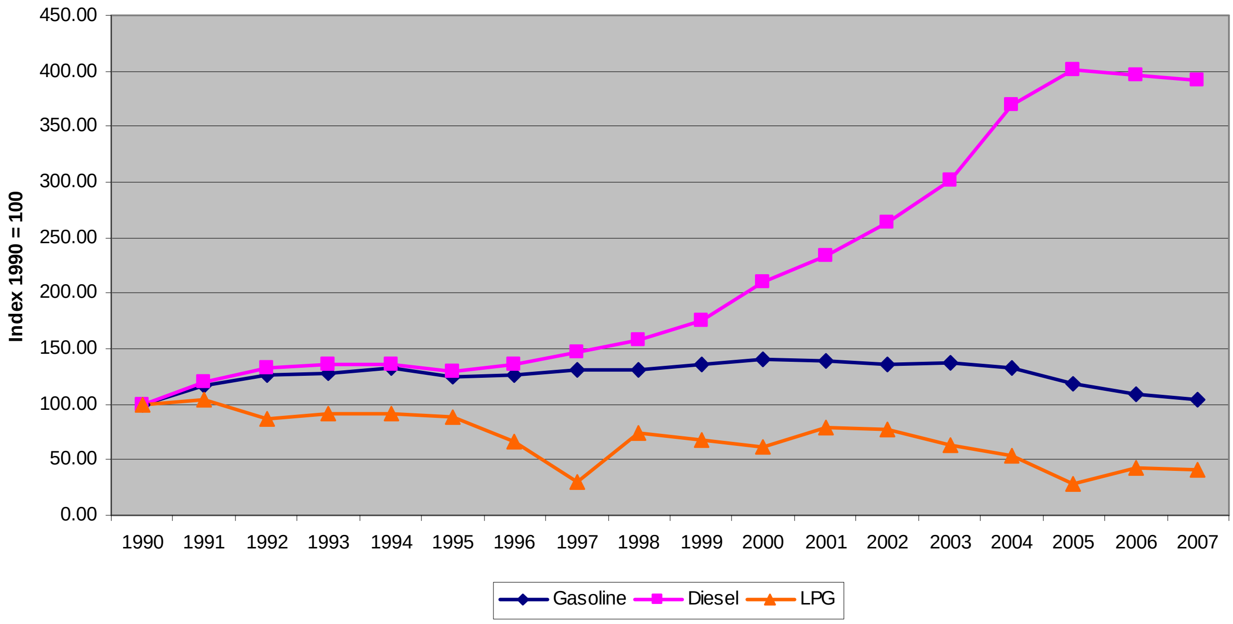
94 ARR 2008, § 49, see also footenote 109

Figure 3-6 – Fuel sold trends - indexes - for IPCC Sub-category 1A3b – Road Transportation by fuel type: 1990-2007



As already explained in previous sections of the NIR (Sections 2.1.3, 2.2.2 or 2.2.5), Luxembourg's situation regarding emissions from *1A3b - Road Transportation* is quite unique, due to the high share of fuel export, also commonly called "tanktourism". In 2007, as shown in Table 3-38, emissions from road fuel export were three times higher than those from the domestic fleet.

Table 3-38 – Domestic and road fuel export emissions for 1A3b - Road Transportation: 1990-2007

1A3b - Road Transportation

CO_2 eq emissions including CO_2, CH_4, N_2O emissions from Biomass (Gg)

Year	National Total	domestic road fuel emissions					road fuel export emissions				
		Total	share (%)	*Blended Gasoline*	*Blended Diesel*	*LPG*	Total	share (%)	*Blended Gasoline*	*Blended Diesel*	*LPG*
1990	2734.93	936.74	34.25%	542.59	392.67	1.48	1798.19	65.75%	806.18	981.92	10.08
1991	3250.99	944.67	29.06%	546.87	396.31	1.49	2306.32	70.94%	1034.23	1261.48	10.61
1992	3557.87	1144.49	32.17%	659.50	483.96	1.03	2413.38	67.83%	1058.01	1346.42	8.95
1993	3610.30	1270.21	35.18%	784.72	484.46	1.03	2340.09	64.82%	948.70	1381.76	9.62
1994	3676.98	1274.82	34.67%	778.83	495.13	0.86	2402.16	65.33%	1021.92	1370.49	9.75
1995	3494.23	1280.04	36.63%	767.85	511.43	0.76	2214.18	63.37%	930.59	1274.10	9.50
1996	3595.50	1209.39	33.64%	669.85	538.79	0.75	2386.10	66.36%	1051.23	1327.89	6.98
1997	3805.90	1288.15	33.85%	737.07	550.38	0.70	2517.75	66.15%	1052.43	1462.43	2.88
1998	3971.25	1351.10	34.02%	725.15	625.26	0.69	2620.15	65.98%	1065.40	1546.76	7.98
1999	4273.44	1413.98	33.09%	699.05	714.23	0.70	2859.46	66.91%	1153.26	1698.85	7.35
2000	4813.93	1539.65	31.98%	701.49	837.44	0.72	3274.28	68.02%	1210.68	2057.12	6.48
2001	5108.65	1589.71	31.12%	666.65	922.44	0.61	3518.94	68.88%	1214.87	2295.41	8.66
2002	5459.38	1603.56	29.37%	623.43	979.60	0.53	3855.82	70.63%	1211.23	2635.89	8.70
2003	6029.95	1675.43	27.79%	604.94	1069.91	0.57	4354.52	72.21%	1256.05	3091.67	6.80
2004	6901.30	1580.19	22.90%	554.80	1024.86	0.53	5321.11	77.10%	1244.95	4070.37	5.79
2005	7129.13	1565.70	21.96%	503.16	1062.09	0.45	5563.43	78.04%	1084.48	4476.02	2.93
2006	6950.44	1675.11	24.10%	478.17	1196.42	0.52	5275.34	75.90%	988.34	4282.51	4.49
2007	6820.42	1783.92	26.16%	454.10	1329.24	0.58	5036.50	73.84%	948.20	4083.99	4.30
Trend 1990-2007	*149.38%*	*90.44%*	*NA*	*-16.31%*	*238.51%*	*-60.60%*	*180.09%*	*NA*	*17.62%*	*315.92%*	*-57.32%*
Share 1990	*NA*	*34.25%*	*NA*	*57.92%*	*41.92%*	*0.16%*	*65.75%*	*NA*	*44.83%*	*54.61%*	*0.56%*
Share 2007	*NA*	*26.16%*	*NA*	*25.46%*	*74.51%*	*0.03%*	*73.84%*	*NA*	*18.83%*	*81.09%*	*0.09%*

Source: Environment Agency

Table 3-39 and Figure 3-7 detail the quantities of blended fuel sold to the domestic fleet and the amount of fuel exported.

Table 3-39 – Total fuel sold for road transport – inland consumption and road fuel export: 1990-2007

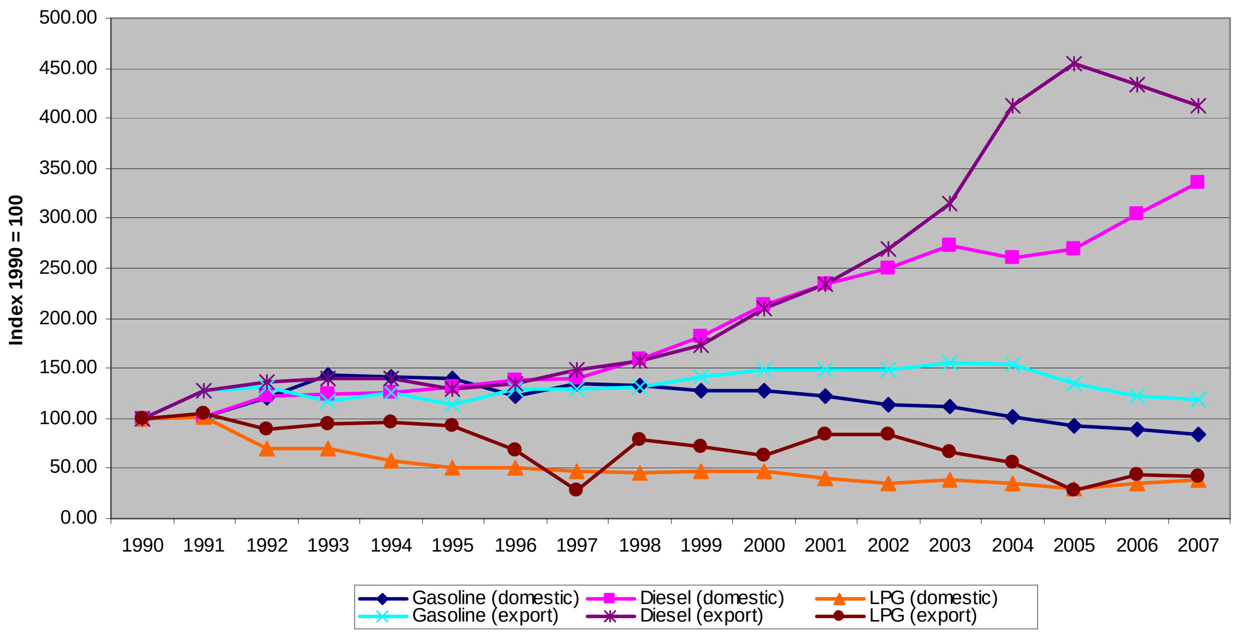
1A3b - Road Transportation

Blended Fuel sales (t)

Year	National Total	domestic road fuel sales					road fuel export sales				
		Total	share (%)	*Blended Gasoline*	*Blended Diesel*	*LPG*	Total	share (%)	*Blended Gasoline*	*Blended Diesel*	*LPG*
1990	846 187.2	289 196.1	34.18%	165 813.8	122 897.1	485.3	556 991.1	65.82%	246 368.2	307 318.2	3 304.7
1991	1 005 989.4	291 644.3	28.99%	167 120.2	124 035.0	489.1	714 345.1	71.01%	316 051.8	394 814.5	3 478.9
1992	1 098 751.1	352 489.1	32.08%	200 699.3	151 453.4	336.4	746 262.0	67.92%	321 973.7	421 358.7	2 929.6
1993	1 112 873.3	389 777.0	35.02%	237 829.5	151 610.1	337.4	723 096.3	64.98%	287 529.5	432 418.2	3 148.6
1994	1 132 304.0	390 925.0	34.52%	235 665.7	154 978.1	281.3	741 379.0	65.48%	309 222.3	428 973.9	3 182.7
1995	1 075 398.2	392 310.5	36.48%	231 942.0	160 119.8	248.7	683 087.7	63.52%	281 098.8	398 899.5	3 089.3
1996	1 106 251.6	371 038.6	33.54%	202 073.2	168 722.7	242.6	735 213.1	66.46%	317 123.0	415 827.7	2 262.4
1997	1 171 369.0	394 976.7	33.72%	222 442.1	172 309.1	225.6	776 392.3	66.28%	317 616.0	457 843.9	932.4
1998	1 223 790.3	415 058.6	33.92%	219 061.1	195 773.5	224.0	808 731.7	66.08%	321 849.6	484 304.2	2 578.0
1999	1 318 540.5	435 351.1	33.02%	211 513.5	223 612.3	225.3	883 189.4	66.98%	348 942.1	531 878.6	2 368.7
2000	1 487 183.9	474 708.6	31.92%	212 338.4	262 139.0	231.2	1 012 475.3	68.08%	366 466.6	643 924.9	2 083.8
2001	1 580 053.0	490 844.1	31.07%	201 936.0	288 711.9	196.1	1 089 208.9	68.93%	367 996.7	718 431.3	2 780.9
2002	1 690 944.5	495 846.3	29.32%	189 117.8	306 558.3	170.1	1 195 098.2	70.68%	367 427.2	824 884.2	2 786.9
2003	1 868 937.4	518 567.3	27.75%	184 128.9	334 255.3	183.1	1 350 370.2	72.25%	382 308.3	965 879.0	2 182.9
2004	2 141 029.3	489 239.7	22.85%	169 286.8	319 783.5	169.5	1 651 789.6	77.15%	379 877.1	1 270 059.0	1 853.5
2005	2 212 515.8	484 992.7	21.92%	153 832.7	331 015.9	144.1	1 727 523.1	78.08%	331 561.5	1 395 023.7	937.9
2006	2 158 116.5	519 473.4	24.07%	146 527.1	372 780.3	166.0	1 638 643.1	75.93%	302 863.1	1 334 339.1	1 441.0
2007	2 117 750.3	553 637.1	26.14%	139 895.6	413 553.9	187.5	1 564 113.1	73.86%	292 116.3	1 270 613.3	1 383.5
Trend 1990-2007	*150.27%*	*91.44%*	NA	-15.63%	236.50%	-61.35%	*180.81%*	NA	18.57%	313.45%	-58.14%
Share 1990	NA	*34.18%*	NA	57.34%	42.50%	0.17%	*65.82%*	NA	44.23%	55.17%	0.59%
Share 2007	NA	*26.14%*	NA	25.27%	74.70%	0.03%	*73.86%*	NA	18.68%	81.24%	0.09%

Source: Environment Agency

Figure 3-7 – Domestic and exported fuel sold trends - indexes - for 1A3b – Road Transportation by fuel type: 1990-2007



3.2.7.2.1 Key source

With 51.7% of the total GHG emissions from Luxembourg, road transportation is the major key source. With regard to CO_2, it has been a key source for both diesel oil and gasoline without interruption since 1990. For N_2O, the picture is a bit different: diesel oil is a key source since 2005 and gasoline has been identified as a key source between 1996 and 2002: see Table 3-6 in Section 3.2.2.

3.2.7.2.2 Activity data

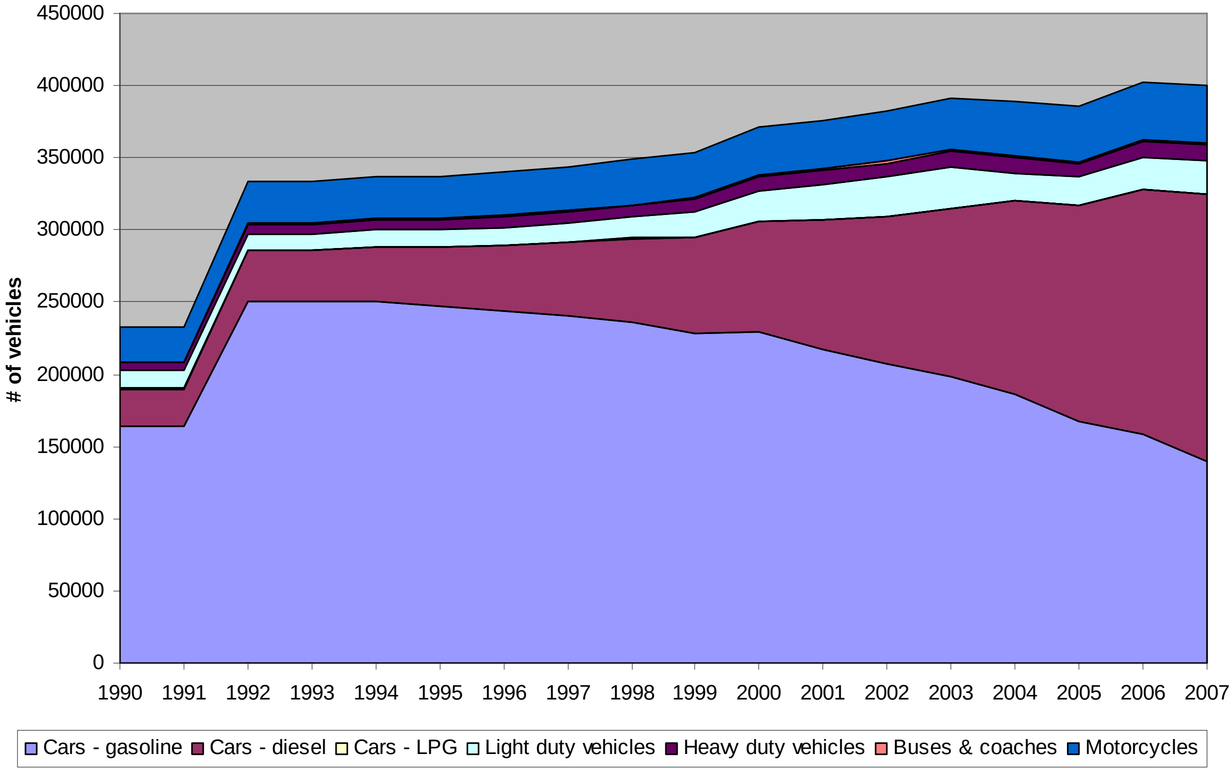
Parameters and sources needed to feed the COPERT emission calculation model are listed in Table 3-40:

Table 3-40 – Parameters for COPERT IV

Type	Parameter	Source
Country info	Min and Max Temp. per month	National Statistics (STATEC)
	Average trip length [km]	AEV – expert judgement
	Average trip time [min]	AEV – expert judgement
Fuel info	Annual fuel consumption per fuel type	National Statistics (STATEC)
	Fuel specifications	Fuel Quality System
Circulation data	Average speed (urban, rural, highway) for each sub-sector and technology class	AEV – expert judgement
	Driving share (urban, rural, highway) in % of transport volume	AEV – expert judgement
Evaporation data	Fuel tank size [lt] and canister size	AEV – expert judgement
Fleet Data	Data on vehicle stock (population/vehicle stock and mileage km/year for each subsector and technology class)	National Vehicle Inspection Company (SNCT)

The evolution of vehicle types registered in Luxembourg is shown in Figure 3-8.

Figure 3-8 – National vehicle fleet: 1990-2007



Source: SNCT

3.2.7.2.3 Methodological issues

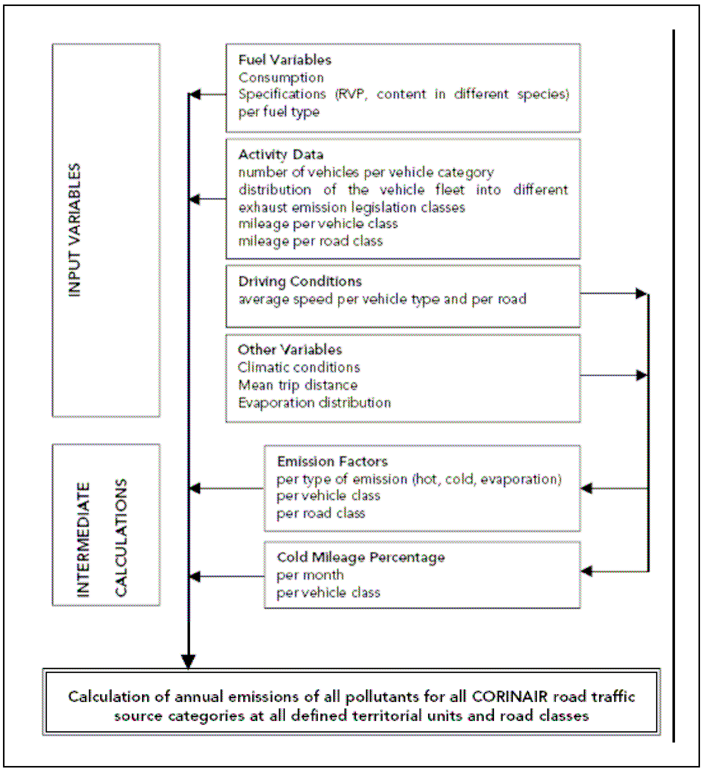
Road traffic emissions have been calculated using the COPERT model, which is referred to, in the 2006 IPCC Guidelines, as a Tier 3 method.

Input data were based on car fleet statistics of registered vehicles in Luxembourg (SNCT). Emission factors are defaults from COPERT IV. With this information it is thus possible to estimate annual fuel consumptions for the domestic vehicle fleet. However, this fuel consumption estimate is much lower than the total road fuel sales in Luxembourg, the difference being road fuel exports. (see Table 3-39). Lacking data on the vehicles commuting or transiting to or through Luxembourg, it is quite difficult to use the COPERT model to estimate emissions on the basis of fuel sold.

Therefore, Luxembourg uses a five steps calculation procedure to calculate road transportation GHG emissions, assuming that the domestic fleet resembles the vehicle fleet of commuter and transit vehicles:

1) Fuel consumption and GHG emissions of the domestic vehicle fleet are estimated for each fossil fuel type using COPERT IVv6.1. (see also Figure 3-9)
2) Implied emission factors are calculated from the above mentioned data, by dividing the emissions relative to each gas and fuel type by the corresponding calculated fuel consumption.
3) Biofuel quantities were subtracted from the quantities of fuel sold, to differentiate between fossil and biogenic emissions.
4) National emissions per fuel type were calculated by multiplying the implied emissions factors with the corresponding quantities of fuel calculated in step 3.
5) National emissions per GHG are obtained by adding the corresponding national emissions per fuel type.

Figure 3-9 – Flow chart of the application of the baseline methodology in COPERT IV



3.2.7.2.4 Emission Factors

For gasoline, diesel oil and LPG, default GHG emission factors from the COPERT IV model were used.

For biogasoline (ethanol, ETBE) and biodiesel (FAME, HVH, HVP) European CO_2 implied emission factors[95] for gasoline and diesel oil, respectively, were used as emission factors. For CH_4 and N_2O, national implied emission factors of gasoline and diesel were used.

For an overview of the implied emission factors, please refer to Table 3-41.

Table 3-41 – Implied emission factors per fuel type for IPCC Sub-category 1A3b – Road Transport: 1990-2007

1A3b - Road Transportation
Implied Emission Factors (kg/TJ)

Year	Gasoline			Diesel			LPG			Biomass		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1990	70 529	56.28	4.56	73 709	7.99	1.38	63 922	27.94	NO	NO	NO	NO
1991	70 529	56.37	4.55	73 709	7.99	1.38	63 922	27.94	NO	NO	NO	NO
1992	70 547	50.93	5.85	73 709	7.88	1.41	63 922	28.03	0.34	NO	NO	NO
1993	70 566	45.23	7.15	73 709	7.89	1.41	63 922	28.05	0.34	NO	NO	NO
1994	70 575	42.40	7.69	73 709	7.78	1.37	63 922	28.16	0.78	NO	NO	NO
1995	70 584	39.54	8.27	73 709	7.65	1.32	63 922	28.35	1.49	NO	NO	NO
1996	70 582	40.47	8.53	73 709	7.50	1.28	63 922	28.61	2.38	NO	NO	NO
1997	70 601	34.86	8.75	73 709	6.84	1.39	63 922	27.93	2.69	NO	NO	NO
1998	70 609	32.84	8.62	73 709	6.45	1.39	63 922	27.10	3.07	NO	NO	NO
1999	70 616	31.28	8.33	73 709	5.87	1.45	63 922	26.02	3.70	NO	NO	NO
2000	70 623	29.63	8.32	73 709	5.46	1.52	63 922	25.04	4.17	NO	NO	NO
2001	70 629	28.27	8.22	73 709	5.07	1.57	63 922	24.24	4.49	NO	NO	NO
2002	70 634	26.61	7.98	73 709	4.73	1.63	63 922	23.93	5.00	NO	NO	NO
2003	70 639	25.00	7.27	73 709	3.92	2.09	63 922	22.71	4.83	NO	NO	NO
2004	70 642	23.73	6.76	73 709	3.42	2.42	63 922	22.27	5.17	73 450	3.42	2.42
2005	70 646	22.52	6.36	73 709	3.00	2.73	63 922	21.70	5.28	73 450	3.00	2.73
2006	70 647	21.85	5.86	73 709	2.63	2.82	63 922	20.42	4.78	73 450	2.63	2.82
2007	70 652	20.67	4.68	73 709	1.65	3.24	63 922	19.94	4.59	73 387	2.19	3.28
Trend 1990-2007	0.17%	-63.27%	2.62%	0.00%	-79.39%	134.55%	0.00%	-28.64%	NA	NA	NA	NA

Source: Environment Agency

3.2.7.3 Railways (1A3c)

In 2007, railways fuel consumption was responsible for 0.02% of GHG emissions from fuel combustion activities (0.26% in 1990) and represented 0.01% of the total GHG emissions in CO_2e, excluding LULUCF (0.21% in 1990).

Railways related GHG emissions are quite low in Luxembourg. The reason stems from the fact that Luxembourg's national railway company, *CFL (Chemins de Fer Luxembourgeois*), uses, almost exclusively, locomotives powered by electricity. A clear downwards trend of the GHG emissions in recent years is shown in Table 3-42.

95 UNFCCC SAI Report 2008, FCCC/WEB/SAI/2008, Table 1.30, p.66

Table 3-42 – Activity data, emissions and emission factors for IPCC Sub-category 1A3c – Railways: 1990-2007

1A3c - Railways *Diesel Oil*													
Year	**Activity (GJ)**	**Emissions (Gg)**				**Emission Factors (kg/TJ)**							
		Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	CO_2	type	CH_4	type	N_2O	type	source
1990	338 735	28.13	*25.10*	*0.0014*	*0.0097*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
1991	338 735	28.13	*25.10*	*0.0014*	*0.0097*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
1992	338 735	28.13	*25.10*	*0.0014*	*0.0097*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
1993	338 735	28.13	*25.10*	*0.0014*	*0.0097*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
1994	328 822	27.31	*24.37*	*0.0014*	*0.0094*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
1995	266 248	22.11	*19.73*	*0.0011*	*0.0076*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
1996	297 535	24.71	*22.05*	*0.0012*	*0.0085*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
1997	292 492	24.29	*21.67*	*0.0012*	*0.0084*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
1998	292 492	24.29	*21.67*	*0.0012*	*0.0084*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
1999	292 492	24.29	*21.67*	*0.0012*	*0.0084*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
2000	287 725	23.90	*21.32*	*0.0012*	*0.0082*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
2001	310 049	25.75	*22.97*	*0.0013*	*0.0089*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
2002	273 989	22.76	*20.30*	*0.0011*	*0.0078*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
2003	238 874	19.84	*17.70*	*0.0010*	*0.0068*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
2004	189 893	15.77	*14.07*	*0.0008*	*0.0054*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
2005	120 573	10.01	*8.93*	*0.0005*	*0.0034*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
2006	89 907	7.47	*6.66*	*0.0004*	*0.0026*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
2007	21 640	1.80	*1.60*	*0.0001*	*0.0006*	*74 100*	*D*	*4.00*	*D*	*28.60*	*D*	*2006 IPCC GL*
Trend 1990-2007	*-93.61%*	*-93.61%*	*-93.61%*	*-93.61%*	*-93.61%*	*0.00%*	*NA*	*0.00%*	*NA*	*0.00%*	*NA*	*NA*

Source: Environment Agency

3.2.7.3.1 Key source

GHG emissions from railways are not a key source.

3.2.7.3.2 Activity data

Diesel oil consumption is obtained directly from *CFL* and converted into energy units using the default NCV from the 2006 IPCC Guidelines: 43.0 GJ/t fuel.

Activity data are listed in Table 3-42.

3.2.7.3.3 Methodology

The 2006 IPCC Guidelines Tier 1 approach has been applied.

3.2.7.3.4 Emission factors

The 2006 IPCC Guidelines default GHG EFs for diesel oil have been applied: see Table 3-42.

3.2.7.4 Navigation (1A3d)

In 2007, fuel consumption in navigation was responsible for 0.004% of GHG emissions from fuel combustion activities (0.002% in 1990) and represented 0.004% of the total GHG emissions in CO_2e, excluding LULUCF (0.002% in 1990). From 1990 to 2007, the emissions have nearly doubled, due to the increase of tourism activities in the Moselle region: see Table 3-43.

As Luxembourg has no direct access to the sea, there are no maritime activities taking place. Similarly, Luxembourg has only one river where shipping activities are allowed, the Moselle, a border river with Germany. Shipping activities are mainly passenger (leisure and tourism) and freight activities.

Table 3-43 – Activity data, emissions and emission factors for IPCC Sub-category 1A3d – Navigation: 1990-2007

1A3d - Navigation *Gas Oil*												
Year	Activity (GJ)	Emissions (Gg)				Emission Factors (kg/TJ)						
		Total $CO_{2 eq}$	CO_2	CH_4	N_2O	CO_2	type	CH_4	type	N_2O	type	source
1990	3 305	0.25	0.24	0.000023	0.000007	74 100	D	7.00	D	2.00	D	2006 IPCC GL
1991	3 388	0.25	0.25	0.000024	0.000007	74 100	D	7.00	D	2.00	D	2006 IPCC GL
1992	3 276	0.25	0.24	0.000023	0.000007	74 100	D	7.00	D	2.00	D	2006 IPCC GL
1993	4 880	0.37	0.36	0.000034	0.000010	74 100	D	7.00	D	2.00	D	2006 IPCC GL
1994	4 444	0.33	0.33	0.000031	0.000009	74 100	D	7.00	D	2.00	D	2006 IPCC GL
1995	4 478	0.34	0.33	0.000031	0.000009	74 100	D	7.00	D	2.00	D	2006 IPCC GL
1996	4 202	0.31	0.31	0.000029	0.000008	74 100	D	7.00	D	2.00	D	2006 IPCC GL
1997	5 038	0.38	0.37	0.000035	0.000010	74 100	D	7.00	D	2.00	D	2006 IPCC GL
1998	4 882	0.37	0.36	0.000034	0.000010	74 100	D	7.00	D	2.00	D	2006 IPCC GL
1999	5 730	0.43	0.42	0.000040	0.000011	74 100	D	7.00	D	2.00	D	2006 IPCC GL
2000	5 928	0.44	0.44	0.000041	0.000012	74 100	D	7.00	D	2.00	D	2006 IPCC GL
2001	5 940	0.44	0.44	0.000042	0.000012	74 100	D	7.00	D	2.00	D	2006 IPCC GL
2002	5 876	0.44	0.44	0.000041	0.000012	74 100	D	7.00	D	2.00	D	2006 IPCC GL
2003	5 990	0.45	0.44	0.000042	0.000012	74 100	D	7.00	D	2.00	D	2006 IPCC GL
2004	6 174	0.46	0.46	0.000043	0.000012	74 100	D	7.00	D	2.00	D	2006 IPCC GL
2005	7 306	0.55	0.54	0.000051	0.000015	74 100	D	7.00	D	2.00	D	2006 IPCC GL
2006	6 867	0.51	0.51	0.000048	0.000014	74 100	D	7.00	D	2.00	D	2006 IPCC GL
2007	6 437	0.48	0.48	0.000045	0.000013	74 100	D	7.00	D	2.00	D	2006 IPCC GL
Trend 1990-2007	94.78%	94.78%	94.78%	94.78%	94.78%	0.00%	NA	0.00%	NA	0.00%	NA	NA

Source: Environment Agency

3.2.7.4.1 Key source

Navigation related GHG emissions are not a key source.

3.2.7.4.2 Activity data

Fuel consumption data (gas oil) is obtained from the two national operators as no data is available from the official statistics. Indeed, no consumption is reported in the IEA Joint Questionnaire on oil products, probably due to the fact that the consumption is below 0.5 kt and that no digits are allowed in the questionnaire. Fuel consumption data is converted to energy units using the default NCV from the 2006 IPCC Guidelines: 43.0 Gj/t gas oil. This activity data are listed in Table 3-43.

Concerning the fuel consumption of leisure boats (yachts, jet-skis, etc), no data is available at this stage. However, only one (very) small marina exists on Luxembourg's side of the Moselle River: Schwebsange. This marina is equipped with a gasoline filling station. The amount of fuel sold at this station is not known for the moment, but the sales are included in *IPCC sub-category 1A3b – Road Transportation* as this filling station is supplied by the same mineral oil companies supplying road transportation filling stations.[96]

3.2.7.4.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied.

Due to the particular geographical situation of the Moselle River, freight shipping activities, which are executed on barges, which do not refuel in Luxembourg's sole commercial port (Mertert), are not accounted for in Luxembourg's GHG inventory. These activities are exclusively international, i.e. destination is always abroad. For passenger shipping activities, the situation is different. There are two companies executing passenger shipping on the Moselle River. As communicated by these companies, about 80% of there journeys are to be considered domestic (from Luxembourg to Luxembourg), and the remaining 20% to be considered international (from Luxembourg to an international destination, or vice versa). Thus, the emissions reported under IPCC sub-category *1A3d -*

Navigation cover the 80% of domestic journeys. The emissions relating to the remaining 20% international journeys are reported under international bunkers – marine.[96]

3.2.7.4.4 Emission factors

The 2006 IPCC Guidelines default GHG EFs for gas oil have been applied: see Table 3-43.

3.2.7.5 Other Transportation (1A3e)

No activities have been identified for Luxembourg, hence notation key NA.[97]

Whereas the IPCC 2006 Guidelines recommend to report emissions from vehicles and mobile machinery used within the agriculture, forestry, industry (including construction and maintenance), residential, and sectors, such as airport ground support equipment, agricultural tractors, chain saws, forklifts, snowmobiles in IPCC sub-category *1A3e – Other Transportation*, Luxembourg reports these emissions in the relevant IPCC sub-categories as follows:

- 1A2a, c, e, f .... Industry
- 1A4a............................. Commercial/institutional: Other mobile machinery
- 1A4b............................. Residential: Household and gardening
- 1A4c .... Agriculture: Tractors, Harvesters, etc
- 1A5b............................. Mobile: Other mobile equipment

Pipeline compressors, reported under *1A3e – Other Transportation*, do not exist in Luxembourg.

3.2.7.6 Recalculations

Table 3-44 presents the main revisions and recalculations done since submission 2008v1.2 and the ICR of October 2008 relevant to IPCC sub-category *1A3 - Transport*.

Table 3-44 – Recalculations done since submission 2008v1.2

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
1A3a-d	Revision of the energy balance using IEA Joint Questionnaires provided by the Energy Directorate of the Ministry of Economic Affairs	updated AD inclusion of biomass
1A3b	Emission calculations based on COPERT IV v6.1 model.[98]	updated model version
1A3b	information on the biofuel content in diesel and gasoline was gathered from the Ministry of Economic Affairs and the Customs and Excise Administration	inclusion of biofuels
1A3d	information on fuel consumption and fraction of national vs international shipping activities was gathered directly from the shipping companies operating on the Moselle River. About	updated AD CS spilt na-

96 ARR 2008, § 50

97 ARR 2008, § 37

98 ARR 2008, § 56

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
	20% of the fuel consumption is allocated to international bunkers – marine.	tional/international

3.2.7.7 Category specific QA/QC procedures

Activity data obtained directly from the operators was cross checked with official statistics, if available, for plausibility.

Consistency and completeness checks have been performed using the tools embedded in CRF Reporter.

3.2.7.8 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 3-45 will be explored.

Table 3-45 – Planned improvements for IPCC Sub-category 1A3 – Transport

GHG source & sink category	Planned improvement
1A3a – Civil Aviation	refine the share between domestic and international flights (90/10) for aviation gasoline that is based, for the moment, on expert judgement
1A3b – Road Transport	investigate whether it would be feasible to obtain country specific NCV and EF for gasoline and diesel oil[99]
1A3b – Road Transportation	update some of the country specific parameters used in the COPERT IV model, especially concerning the vehicle split for heavy duty vehicles.[98]
1A3b – Road Transportation	lubricants: 50% of carbon that is not stored will be allocated in this sub-category[100]
1A3d – Navigation	reallocate gasoline emissions produced by leisure shipping activities from 1A3b.[96]

3.2.8 Other Sectors (1A4)

This section describes GHG emissions resulting from fuel combustion activities in the "other sectors" sub-category. *1A4 - Other sectors* covers combustion activities from stationary combustion and mobile combustion in sub-categories:

- *1A4a – Commercial/Institutional*
- *1A4b – Residential*
- *1A4c - Agriculture/Forestry/Fisheries*

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99 ARR 2008, § 42

100 ARR 2008, § 52

In 2007, IPCC Sub-category 1A4 was responsible for 12.5% of GHG emissions from fuel combustion activities (this share was 13.0% in 1990) and represented around 11.0% of the total GHG emissions in CO_2e, excluding LULUCF (10.5% was recorded for the year 1990).

Table 3-46 summarizes GHG emissions for IPCC Sub-category 1A4.

3.2.8.1 Commercial/Institutional (1A4a)

In 2007, fuel combustion from the commercial and institutional sectors was responsible for 6.1% of GHG emissions from fuel combustion activities (this share was 6.4% in 1990). With regard to total GHG emissions in CO_2e, excluding LULUCF and excluding CO_2 emissions from biomass, percentages were 5.3% in 2007 and 5.2% in 1990.

3.2.8.1.1 Key source

Commercial and institutional fuel combustion is a key source with regard to CO_2 emissions. It has been a key source for both liquid and gaseous fuels without interruption since 1990: see Table 3-6 in Section 3.2.2.

3.2.8.1.2 Activity data

Under *1A4a – Commercial/Institutional*, the following activities have been classified:

Non-industrial commercial and institutional combustion plants <50 MW (SNAP: 020103)

This source category covers numerous smaller combustion units, mainly for building heating. No specific bottom-up data could be obtained, so that emission estimations solely rely on top-down data from official statistics. The consumption of coke, hard coal (other bituminous coal), lignite briquettes (brown coal briquettes), patent fuels, wood, gas oil, LPG and natural gas was obtained from official statistics (STATEC, IEA Joint Questionnaires). However, the consumptions reported under the so-called "*domestic sector*" in STATEC's Statistical Yearbook cover consumptions both from commercial and institutional as well as from residential combustion. Consequently, data was distributed arbitrarily, i.e. 50% did go under 1A4a - Commercial/Institutional and 50% under 1A4b - Residential.

Fuel consumption data was converted into energy units using default NCV values from the 2006 IPCC Guidelines or from the IEA Handbook on Energy except for natural gas where a country specific NCV was applied.

Other mobile sources and machinery (SNAP: 080800)

Diesel oil consumption was obtained from official statistics (STATEC, IEA Joint Questionnaires).

Activity data from both stationary and mobile sources, as described above, are listed in Table 3-47.

Table 3-46 – GHG emission trends in CO_2e for IPCC Sub-category 1A4 – Other Sectors: 1990-2007

1A4 - Other Sectors

GHG emissions by source & sink Category excluding CO2 emissions from biomass (Gg)

Year	1A4a - Commercial/Institutional				1A4b - Residential				1A4c - Agriculture/Forestry/Fisheries				1A4 - Other Sectors			
	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*	Total $CO_{2\,eq}$	CO_2 *(excl. biomass)*	CH_4 *(incl. biomass)*	N_2O *(incl. biomass)*
1990	680.66	*675.22*	*0.18*	*0.01*	680.66	*675.22*	*0.18*	*0.01*	16.30	*15.98*	*0.002*	*0.001*	**1 377.61**	*1 366.41*	*0.36*	*0.01*
1991	816.73	*810.63*	*0.19*	*0.01*	816.73	*810.63*	*0.19*	*0.01*	19.54	*19.15*	*0.002*	*0.001*	**1 652.99**	*1 640.41*	*0.39*	*0.01*
1992	753.65	*747.90*	*0.19*	*0.01*	753.65	*747.90*	*0.19*	*0.01*	19.50	*19.11*	*0.002*	*0.001*	**1 526.80**	*1 514.92*	*0.37*	*0.01*
1993	748.07	*742.39*	*0.18*	*0.01*	748.07	*742.39*	*0.18*	*0.01*	16.25	*15.93*	*0.002*	*0.001*	**1 512.39**	*1 500.71*	*0.37*	*0.01*
1994	717.93	*712.39*	*0.18*	*0.01*	717.93	*712.39*	*0.18*	*0.01*	19.50	*19.12*	*0.002*	*0.001*	**1 455.36**	*1 443.91*	*0.36*	*0.01*
1995	727.37	*721.84*	*0.18*	*0.01*	727.37	*721.84*	*0.18*	*0.01*	16.25	*15.93*	*0.002*	*0.001*	**1 470.99**	*1 459.62*	*0.36*	*0.01*
1996	807.02	*801.19*	*0.19*	*0.01*	807.02	*801.19*	*0.19*	*0.01*	19.45	*19.07*	*0.002*	*0.001*	**1 633.49**	*1 621.46*	*0.38*	*0.01*
1997	781.22	*775.45*	*0.19*	*0.01*	781.22	*775.45*	*0.19*	*0.01*	22.76	*22.31*	*0.003*	*0.001*	**1 585.19**	*1 573.21*	*0.38*	*0.01*
1998	816.09	*810.20*	*0.19*	*0.01*	822.64	*816.40*	*0.21*	*0.01*	22.76	*22.31*	*0.003*	*0.001*	**1 661.49**	*1 648.91*	*0.40*	*0.01*
1999	781.80	*776.07*	*0.19*	*0.01*	785.08	*779.17*	*0.20*	*0.01*	29.22	*28.70*	*0.004*	*0.001*	**1 596.10**	*1 583.93*	*0.39*	*0.01*
2000	752.78	*747.10*	*0.19*	*0.01*	756.06	*750.20*	*0.20*	*0.01*	22.79	*22.31*	*0.003*	*0.001*	**1 531.63**	*1 519.60*	*0.39*	*0.01*
2001	841.25	*835.17*	*0.20*	*0.01*	841.25	*835.17*	*0.20*	*0.01*	22.43	*22.31*	*0.003*	*0.000*	**1 704.93**	*1 692.66*	*0.40*	*0.01*
2002	761.56	*755.98*	*0.18*	*0.01*	761.56	*755.98*	*0.18*	*0.01*	19.21	*19.11*	*0.003*	*0.000*	**1 542.34**	*1 531.06*	*0.37*	*0.01*
2003	761.17	*755.61*	*0.18*	*0.01*	761.17	*755.61*	*0.18*	*0.01*	19.08	*18.97*	*0.003*	*0.000*	**1 541.41**	*1 530.20*	*0.37*	*0.01*
2004	846.85	*837.19*	*0.19*	*0.02*	810.43	*804.70*	*0.19*	*0.01*	44.72	*42.24*	*0.004*	*0.008*	**1 702.00**	*1 684.13*	*0.38*	*0.03*
2005	729.11	*723.74*	*0.18*	*0.01*	729.11	*723.74*	*0.18*	*0.01*	51.70	*47.77*	*0.004*	*0.012*	**1 509.92**	*1 495.25*	*0.36*	*0.02*
2006	717.60	*711.59*	*0.18*	*0.01*	710.44	*705.20*	*0.18*	*0.00*	52.25	*47.94*	*0.004*	*0.014*	**1 480.29**	*1 464.73*	*0.36*	*0.03*
2007	688.54	*681.53*	*0.17*	*0.01*	670.67	*665.59*	*0.17*	*0.00*	56.08	*51.02*	*0.004*	*0.016*	**1 415.28**	*1 398.13*	*0.35*	*0.03*
Trend 1990-2007	*1.16%*	*0.93%*	*-2.22%*	*96.30%*	*-1.47%*	*-1.43%*	*-2.73%*	*-14.99%*	*244.05%*	*219.27%*	*80.96%*	*1693.98%*	*2.73%*	*2.32%*	*-2.01%*	*164.58%*

Source: Environment Agency

Notes:

CO_2 emissions does not include CO2 emissions from biomass which are reported under Memo Items.

CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

N_2O emissions are converted in CO_2e by multiplying the emissions by 310, i.e. the global warming potential (*GWP*) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

Table 3-47 – Activity data for IPCC Sub-category 1A4a – Commercial/Institutional

1A4a - Commercial/Institutional *Activity Data by fuel type (GJ)*						
		Solid	Liquid	Gaseous	Biomass	Other
Year	Activity Total (excl. biomass)	*Coke Oven Coke, Brown Coal Briquettes, Other Bituminous Coal, Patent Fuels*	*Gas Oil, Diesel Oil, LPG*	*Natural Gas*	*Wood and similar wood wastes*	
1990	9 835 879	*122 941*	*6 440 938*	*3 272 000*	*322 500*	*NO*
1991	11 744 045	*143 415*	*7 921 130*	*3 679 500*	*322 500*	*NO*
1992	10 911 737	*115 254*	*7 073 983*	*3 722 500*	*322 500*	*NO*
1993	10 878 395	*125 013*	*6 793 882*	*3 959 500*	*322 500*	*NO*
1994	10 469 521	*82 132*	*6 487 890*	*3 899 500*	*322 500*	*NO*
1995	10 662 385	*101 399*	*6 302 486*	*4 258 500*	*322 500*	*NO*
1996	11 941 339	*60 878*	*6 880 461*	*5 000 000*	*322 500*	*NO*
1997	11 529 043	*56 174*	*6 801 369*	*4 671 500*	*322 500*	*NO*
1998	12 111 352	*40 958*	*7 040 894*	*5 029 500*	*322 500*	*NO*
1999	11 654 743	*38 115*	*6 662 128*	*4 954 500*	*322 500*	*NO*
2000	11 271 671	*26 723*	*6 352 948*	*4 892 000*	*334 000*	*NO*
2001	12 575 650	*25 608*	*7 170 042*	*5 380 000*	*334 000*	*NO*
2002	11 471 351	*15 728*	*6 154 622*	*5 301 000*	*322 500*	*NO*
2003	11 495 673	*14 844*	*5 998 829*	*5 482 000*	*322 500*	*NO*
2004	12 684 221	*17 507*	*6 782 714*	*5 884 000*	*321 500*	*NO*
2005	11 043 777	*13 980*	*5 557 298*	*5 472 500*	*322 500*	*NO*
2006	10 938 441	*6 352*	*5 176 589*	*5 755 500*	*325 000*	*NO*
2007	10 485 782	*5 015*	*4 974 350*	*5 506 417*	*325 000*	*NO*
Trend 1990-2007	*6.61%*	*-95.92%*	*-22.77%*	*68.29%*	*0.78%*	*NA*

Source: Environment Agency

3.2.8.1.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied, except for natural gas where a Tier 2 methodology was used.

3.2.8.1.4 Emission factors

Default CO_2, CH_4, N_2O, emission factors have been applied, except for natural gas, where a country specific CO_2 emission factor was used: see Table 3-48.

Table 3-48 – Emission factors for IPCC Sub-category 1A4a – Commercial/Institutional

1A4a - Commercial/Institutional *Emission Factors for 2007 (kg/TJ)*								
Fuel	Fuel Type	*CO_2*		*CH_4*		*N_2O*		*Source*
		EF	*type*	*EF*	*type*	*EF*	*type*	
Coke Oven Coke	solid	*107 000*	*D*	*10.00*	*D*	*1.50*	*D*	*2006 IPCC GL*
Brown Coal Briquettes	solid	*97 500*	*D*	*10.00*	*D*	*1.50*	*D*	*2005 IPCC GL*
Other Bituminous Coal	solid	*94 600*	*D*	*10.00*	*D*	*1.50*	*D*	*2006 IPCC GL*
Patent Fuels	solid	*97 500*	*D*	*10.00*	*D*	*1.50*	*D*	*2006 IPCC GL*
LPG	liquid	*63 100*	*D*	*5.00*	*D*	*0.10*	*D*	*2006 IPCC GL*
Gas Oil	liquid	*74 100*	*D*	*10.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Diesel Oil	liquid	*74 100*	*D*	*4.15*	*D*	*28.60*	*D*	*2006 IPCC GL*
Natural Gas	gaseous	*56 793*	*CS*	*5.00*	*D*	*0.10*	*D*	*AEV 2006 IPCC GL*
Wood and similar wood wastes	biomass	*112 000*	*D*	*300.00*	*D*	*4.00*	*D*	*2006 IPCC GL*

Source: Environment Agency

Table 3-49 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3-49 – Implied emission factors for IPCC Sub-category 1A4a – Commercial/Institutional

1A4a - Commercial/Institutional *Implied Emission Factors (kg/TJ)*									
Year	Solid			Liquid			Gaseous		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1990	97 440	10.00	1.50	73 633	9.79	0.58	57 755	5.00	0.10
1991	97 580	10.00	1.50	73 748	9.84	0.58	57 743	5.00	0.10
1992	97 503	10.00	1.50	73 696	9.82	0.58	57 848	5.00	0.10
1993	98 508	10.00	1.50	73 719	9.83	0.58	57 894	5.00	0.10
1994	97 510	10.00	1.50	73 745	9.84	0.58	57 940	5.00	0.10
1995	101 492	10.00	1.50	73 759	9.85	0.58	57 929	5.00	0.10
1996	97 319	10.00	1.50	73 765	9.85	0.58	57 546	5.00	0.10
1997	97 339	10.00	1.50	73 918	9.92	0.59	57 205	5.00	0.10
1998	97 338	10.00	1.50	73 885	9.90	0.59	56 863	5.00	0.10
1999	97 263	10.00	1.50	73 899	9.91	0.59	56 522	5.00	0.10
2000	97 462	10.00	1.50	73 897	9.91	0.59	56 221	5.00	0.10
2001	97 424	10.00	1.50	73 920	9.92	0.59	56 258	5.00	0.10
2002	97 500	10.00	1.50	74 008	9.96	0.60	56 396	5.00	0.10
2003	97 500	10.00	1.50	74 056	9.98	0.60	56 533	5.00	0.10
2004	97 500	10.00	1.50	74 016	9.58	2.41	56 671	5.00	0.10
2005	97 500	10.00	1.50	73 946	9.93	0.59	56 910	5.00	0.10
2006	97 500	10.00	1.50	73 960	9.84	1.06	57 008	5.00	0.10
2007	97 500	10.00	1.50	74 043	9.72	1.81	56 793	5.00	0.10

Source: Environment Agency

3.2.8.2 Residential (1A4b)

In 2007, fuel combustion from the residential sector was responsible for 5.9% of GHG emissions from fuel combustion activities (this share was 6.4% in 1990). With regard to total GHG emissions in CO_2e, excluding LULUCF and excluding CO_2 emissions from biomass, percentages were 5.2% in 2007 and 5.2% in 1990.

3.2.8.2.1 Key source

Residential fuel combustion is a key source with regard to CO_2 emissions. It has been a key source for both liquid and gaseous fuels without interruption since 1990: see Table 3-6 in Section 3.2.2.

3.2.8.2.2 Activity data

Under *1A4b – Residential*, the following activities have been classified:

Non-industrial residential combustion plants < 50 MW (SNAP: 020202)

This source category covers numerous smaller combustion units, mainly for building heating. No specific bottom-up data could be obtained, so that emission estimations solely rely on top-down data from official statistics. The consumption of coke, hard coal (other bituminous coal), lignite briquettes (brown coal briquettes), patent fuels, wood, gas oil, LPG and natural gas was obtained from official statistics (STATEC, IEA Joint Questionnaires). However, the consumptions reported under the so-called "*domestic sector*" in STATEC's Statistical Yearbook cover consumptions both from commercial and institutional as well as from residential combustion. Consequently, data was distributed arbitrarily, i.e. 50% did go under 1A4a - Commercial/Institutional and 50% under 1A4b - Residential.

Fuel consumption data was converted into energy units using default NCV values from the 2006 IPCC Guidelines or from the IEA Handbook on Energy except for natural gas where a country specific NCV was applied.

<u>*Household and gardening (SNAP: 080900)*</u>

Gasoline consumption was obtained from official statistics (STATEC, IEA Joint Questionnaires).

Activity data from both stationary and mobile sources, as described above, are listed in Table 3-50.

Table 3-50 – Activity data for IPCC Sub-category 1A4b – Residential

1A4b - Residential *Fuel consumption by fuel type (GJ)*						
		Solid	Liquid	Gaseous	Biomass	Other
Year	Activity Total (excl. biomass)	*Coke Oven Coke, Brown Coal Briquettes, Other Bituminous Coal*	*Gas Oil, LPG, Gasoline*	*Natural Gas*	*Wood and similar wood wastes*	
1990	9 835 879	122 941	6 440 938	3 272 000	322 500	NO
1991	11 744 045	143 415	7 921 130	3 679 500	322 500	NO
1992	10 911 737	115 254	7 073 983	3 722 500	322 500	NO
1993	10 878 395	125 013	6 793 882	3 959 500	322 500	NO
1994	10 469 521	82 132	6 487 890	3 899 500	322 500	NO
1995	10 662 385	101 399	6 302 486	4 258 500	322 500	NO
1996	11 941 339	60 878	6 880 461	5 000 000	322 500	NO
1997	11 529 043	56 174	6 801 369	4 671 500	322 500	NO
1998	12 200 837	40 958	7 130 379	5 029 500	322 500	NO
1999	11 699 529	38 115	6 706 915	4 954 500	322 500	NO
2000	11 316 406	26 723	6 397 683	4 892 000	334 000	NO
2001	12 575 650	25 608	7 170 042	5 380 000	334 000	NO
2002	11 471 351	15 728	6 154 622	5 301 000	322 500	NO
2003	11 495 673	14 844	5 998 829	5 482 000	322 500	NO
2004	12 245 714	17 507	6 344 207	5 884 000	321 500	NO
2005	11 043 777	13 980	5 557 298	5 472 500	322 500	NO
2006	10 852 182	6 352	5 090 331	5 755 500	325 000	NO
2007	10 270 633	5 015	4 759 201	5 506 417	325 000	NO
Trend 1990-2007	4.42%	-95.92%	-26.11%	68.29%	0.78%	NA

<u>Source:</u> Environment Agency

3.2.8.2.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied, except for natural gas where a Tier 2 methodology was used.

3.2.8.2.4 Emission factors

Default CO_2, CH_4, N_2O, emission factors have been applied, except for natural gas, where a country specific CO_2 emission factor was used: see Table 3-51.

Table 3-51 – Emission factors for IPCC Sub-category 1A4b – Residential

1A4b - Residential								
Emission Factors for 2007 (kg/TJ)								
Fuel	Fuel Type	CO_2		CH_4		N_2O		Source
		EF	type	EF	type	EF	type	
Coke Oven Coke	solid	107 000	D	10.00	D	1.50	D	2006 IPCC GL
Brown Coal Briquettes	solid	97 500	D	10.00	D	1.50	D	2005 IPCC GL
Other Bituminous Coal	solid	94 600	D	10.00	D	1.50	D	2006 IPCC GL
Patent Fuels	solid	97 500	D	10.00	D	1.50	D	2006 IPCC GL
LPG	liquid	63 100	D	5.00	D	0.10	D	2006 IPCC GL
Gas Oil	liquid	74 100	D	10.00	D	0.60	D	2006 IPCC GL
Gasoline	liquid	69 300	D	180.00	D	0.40	D	2006 IPCC GL
Natural Gas	gaseous	56 793	CS	5.00	D	0.10	D	AEV 2006 IPCC GL
Wood and similar wood wastes	biomass	112 000	D	300.00	D	4.00	D	2006 IPCC GL

Source: Environment Agency

Table 3-52 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3-52 – Implied emission factors for IPCC Sub-category 1A4b – Residential

1A4b - Residential									
Implied Emission Factors (kg/TJ)									
Year	Solid			Liquid			Gaseous		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1990	97 440	10.00	1.50	73 633	9.79	0.58	57 755	5.00	0.10
1991	97 580	10.00	1.50	73 748	9.84	0.58	57 743	5.00	0.10
1992	97 503	10.00	1.50	73 696	9.82	0.58	57 848	5.00	0.10
1993	98 508	10.00	1.50	73 719	9.83	0.58	57 894	5.00	0.10
1994	97 510	10.00	1.50	73 745	9.84	0.58	57 940	5.00	0.10
1995	101 492	10.00	1.50	73 759	9.85	0.58	57 929	5.00	0.10
1996	97 319	10.00	1.50	73 765	9.85	0.58	57 546	5.00	0.10
1997	97 339	10.00	1.50	73 918	9.92	0.59	57 205	5.00	0.10
1998	97 338	10.00	1.50	73 827	12.04	0.59	56 863	5.00	0.10
1999	97 263	10.00	1.50	73 868	11.04	0.59	56 522	5.00	0.10
2000	97 462	10.00	1.50	73 864	11.10	0.59	56 221	5.00	0.10
2001	97 424	10.00	1.50	73 920	9.92	0.59	56 258	5.00	0.10
2002	97 500	10.00	1.50	74 008	9.96	0.60	56 396	5.00	0.10
2003	97 500	10.00	1.50	74 056	9.98	0.60	56 533	5.00	0.10
2004	97 500	10.00	1.50	74 010	9.96	0.60	56 671	5.00	0.10
2005	97 500	10.00	1.50	73 946	9.93	0.59	56 910	5.00	0.10
2006	97 500	10.00	1.50	73 958	9.94	0.59	57 008	5.00	0.10
2007	97 500	10.00	1.50	74 040	9.97	0.60	56 793	5.00	0.10

Source: Environment Agency

3.2.8.3 Agriculture/Forestry/Fisheries (1A4c)

In 2007, fuel combustion in agriculture, as well as in forestry and fisheries activities, was responsible for 0.50% of GHG emissions from fuel combustion activities (this share was 0.16% in 1990). With regard to total GHG emissions in CO_2e, excluding LULUCF and excluding CO_2 emissions from biomass, percentages were 0.44% in 2007 and 0.13% in 1990.

3.2.8.3.1 Key source

Fuel combustion related to agriculture/forestry/fisheries is not a key source .

3.2.8.3.2 Activity data

Under *1A4c – Agriculture/Forestry/Fisheries*, the following activities have been classified:

Non-industrial combustion plants in agriculture, forestry and aquaculture (SNAP: 020302)

The consumption data of this activity group is derived from official statistics (STATEC, IEA Joint Questionnaires). However, only the consumption of gas oil is reported in official statistics, i.e. other fuels might be included elsewhere by official statistics.

Tractors and harvesters used in agriculture (SNAP: 080600)

Diesel oil consumption, as reported by official statistics (STATEC, IEA Joint Questionnaires), was attributed to mobile machinery in agriculture, i.e. tractors, harvesters, etc.

Activity data from both stationary and mobile sources, as described above, are listed in Table 3-53.

Table 3-53 – Activity data and implied emission factors for IPCC Sub-category 1A4c – Agriculture/Forestry

1A4c - Agriculture/Forestry/Fisheries

Activity Data and Implied Emission Factors (kg/TJ)

Year	Activity (GJ)	Liquid		
		CO_2	CH_4	N_2O
1990	215 641	74 100	9.26	4.16
1991	258 461	74 100	9.26	4.16
1992	257 953	74 100	9.26	4.16
1993	215 042	74 100	9.26	4.16
1994	258 017	74 100	9.26	4.16
1995	215 039	74 100	9.26	4.16
1996	257 400	74 100	9.26	4.16
1997	301 117	74 100	9.26	4.16
1998	301 079	74 100	9.26	4.16
1999	387 252	74 100	9.35	3.71
2000	301 021	74 100	9.16	4.60
2001	301 043	74 100	10.00	0.60
2002	257 873	74 100	10.00	0.60
2003	256 057	74 100	10.00	0.60
2004	570 059	74 100	7.30	13.52
2005	644 641	74 100	6.10	19.27
2006	646 940	74 100	5.71	21.13
2007	688 477	74 100	5.25	23.35

Source: Environment Agency

3.2.8.3.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied.

3.2.8.3.4 Emission factors

2006 IPCC Guidelines default emission factors have been applied: see Table 3-54.

Table 3-54 – Emission factors for IPCC Sub-category 1A4c – Agriculture/Forestry/Fisheries

1A4c - Agriculture/Forestry/Fisheries

Emission Factors for 2007 (kg/TJ)

Fuel	Fuel Type	CO_2		CH_4		N_2O		Source
		EF	type	EF	type	EF	type	
Gas Oil	liquid	74 100	D	10.00	D	0.60	D	2006 IPCC GL
Diesel Oil	liquid	74 100	D	4.15	D	28.60	D	2006 IPCC GL

Source: Environment Agency

An overview of the evolution of the implied emission factors per fuel type is given in Table 3-53.

3.2.8.4 Recalculations

Table 3-55 presents the main revisions and recalculations done since submission 2008v1.2 and the ICR of October 2008 relevant to IPCC sub-category *1A4 – Other Sectors*.

Table 3-55 – Recalculations done since submission 2008v1.2

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
1A4	Revision of the energy balance using IEA Joint Questionnaires provided by the Energy Directorate of the Ministry of Economic Affairs[101]	updated AD inclusion of biomass
1A4	Natural gas : NCV and EF were changed to country specific values over the entire time series[102]	updated EF
1A4	Complete revision and documentation of AD and EF to increase transparency[103]	updated documentation
1A4	Emissions from mobile sources and machinery are reported in the relevant sub-categories.[104]	updated source allocation

3.2.8.5 Category specific QA/QC procedures

Standard QA/QC procedures were executed according to the QA/QC policy.

Consistency and completeness checks have been performed using the tools embedded in CRF Reporter.

3.2.8.6 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 3-56 will be explored.

Table 3-56 – Planned improvements for IPCC Sub-category 1A4 – Other Sectors

GHG source & sink category	Planned improvement
1A4 – Other Sectors	collect information helping to refine the fuel consumption split between the commercial/institutional sector, the residential sector and the agriculture/forestry/fisheries sector.[105]
1A4 – Other Sectors	investigate whether it would be possible to move away from default EFs to country specific ones, at least for gas oil, diesel oil and gasoline.

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101 ARR 2008, § 38, 45

102 ARR 2008, § 39

103 ARR 2008, § 46

104 ARR 2008, § 37

105 ARR 2008, § 57

3.2.9 Other (1A5)

This section describes GHG emissions resulting from fuel combustion activities in sub-category *1A5 – Other*. It covers combustion activities from stationary combustion and mobile combustion in sub-categories:

- *1A5a – Stationary*: Building and Plant Site Fuel Powered Machinery
- *1A5b – Mobile*: Off-road Vehicles and Other Machinery, Airport and Military Vehicles

In 2007, IPCC Sub-category 1A5 was responsible for 0.12% of GHG emissions from fuel combustion activities (this share was 0.53% in 1990) and represented around 0.10% of the total GHG emissions in CO_2e, excluding LULUCF (0.43% was recorded for the year 1990).

In previous submissions, no emissions were reported in this sub-category. These were reported as included among other IPCC categories, hence the notation key IE in previous submissions. However, due to the revision of the energy balance the consequent use of official statistics, in particular the IEA Joint Questionnaires, which report fuel consumptions in this category, it was now possible to reallocate the corresponding emissions to this sub-category.

Table 3-57 summarizes GHG emissions for IPCC sub-category 1A5.

3.2.9.1 Stationary (1A5a)

In 2007, fuel combustion *1A5a - Stationary* was responsible for 0.06% of GHG emissions from fuel combustion activities (this share was 0.03% in 1990). With regard to total GHG emissions in CO_2e, excluding LULUCF and excluding CO_2 emissions from biomass, percentages were 0.05% in 2007 and 0.02% in 1990.

3.2.9.1.1 Key source

1A5a - Stationary related GHG emissions are not a key source.

3.2.9.1.2 Activity data

Fuel consumption data (gas oil, LPG) is obtained from official statistics (STATEC, IEA Joint Questionnaires) and was attributed to this sub-category based on expert judgement.

Activity data is listed in Table 3-58.

3.2.9.1.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied.

Table 3-57 – GHG emission trends in CO_2e for IPCC Sub-category 1A4 – Other Sectors: 1990-2007

1A5 - Other

GHG emissions by source & sink category (Gg)

Year	1A5a - Stationary				1A5b - Mobile				1A5 - Other			
	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O
1990	2.97	*2.97*	*0.000235*	*0.000005*	53.56	*47.79*	*0.0027*	*0.0184*	**56.53**	*50.75*	*0.0029*	*0.0184*
1991	2.97	*2.97*	*0.000235*	*0.000005*	53.56	*47.79*	*0.0027*	*0.0184*	**56.53**	*50.75*	*0.0029*	*0.0184*
1992	2.97	*2.97*	*0.000235*	*0.000005*	53.56	*47.79*	*0.0027*	*0.0184*	**56.53**	*50.75*	*0.0029*	*0.0184*
1993	2.97	*2.97*	*0.000235*	*0.000005*	46.44	*41.43*	*0.0023*	*0.0160*	**49.41**	*44.40*	*0.0026*	*0.0160*
1994	2.97	*2.97*	*0.000235*	*0.000005*	42.86	*38.24*	*0.0021*	*0.0148*	**45.83**	*41.21*	*0.0024*	*0.0148*
1995	2.75	*2.74*	*0.000217*	*0.000004*	17.86	*15.93*	*0.0009*	*0.0062*	**20.61**	*18.67*	*0.0011*	*0.0062*
1996	2.65	*2.64*	*0.000210*	*0.000004*	35.63	*31.79*	*0.0018*	*0.0123*	**38.28**	*34.43*	*0.0020*	*0.0123*
1997	7.10	*7.08*	*0.000561*	*0.000011*	35.73	*31.88*	*0.0018*	*0.0123*	**42.83**	*38.96*	*0.0023*	*0.0123*
1998	8.70	*8.68*	*0.000688*	*0.000014*	57.16	*50.99*	*0.0029*	*0.0197*	**65.86**	*59.68*	*0.0035*	*0.0197*
1999	12.33	*12.30*	*0.000975*	*0.000020*	35.74	*31.88*	*0.0018*	*0.0123*	**48.07**	*44.19*	*0.0028*	*0.0123*
2000	11.89	*11.86*	*0.000940*	*0.000019*	46.43	*41.42*	*0.0023*	*0.0160*	**58.32**	*53.29*	*0.0033*	*0.0160*
2001	23.68	*23.63*	*0.001873*	*0.000037*	46.43	*41.43*	*0.0023*	*0.0160*	**70.12**	*65.06*	*0.0042*	*0.0160*
2002	13.06	*13.03*	*0.001033*	*0.000021*	7.14	*6.37*	*0.0004*	*0.0025*	**20.20**	*19.40*	*0.0014*	*0.0025*
2003	3.06	*3.05*	*0.000242*	*0.000005*	7.09	*6.32*	*0.0004*	*0.0024*	**10.15**	*9.37*	*0.0006*	*0.0024*
2004	NO	*NO*	*NO*	*NO*	14.57	*13.00*	*0.0007*	*0.0050*	**14.57**	*13.00*	*0.0007*	*0.0050*
2005	NO	*NO*	*NO*	*NO*	17.85	*15.92*	*0.0009*	*0.0061*	**17.85**	*15.92*	*0.0009*	*0.0061*
2006	NO	*NO*	*NO*	*NO*	10.75	*9.59*	*0.0005*	*0.0037*	**10.75**	*9.59*	*0.0005*	*0.0037*
2007	6.41	*6.38*	*0.000861*	*0.000052*	7.15	*6.38*	*0.0004*	*0.0025*	**13.56**	*12.75*	*0.0012*	*0.0025*
Trend 1990-2007	*115.62%*	*114.93%*	*266.05%*	*998.16%*	*-86.66%*	*-86.66%*	*-86.66%*	*-86.66%*	*-76.02%*	*-74.87%*	*-58.17%*	*-86.38%*

Source: Environment Agency

Notes:

CO_2 emissions does not include CO2 emissions from biomass which are reported under Memo Items.

CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

N_2O emissions are converted in CO_2e by multiplying the emissions by 310, i.e. the global warming potential (*GWP*) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

Table 3-58 – Activity data and implied emission factors for IPCC Sub-categories 1A5 – Other

1A5 - Other *Activity Data and Implied Emission Factors (kg/TJ)*								
Year	1A5a - Stationary - Liquid (LPG, Gas Oil)				1A5b - Mobile - Liquid (Diesel Oil)			
	Activity (GJ)	CO_2	CH_4	N_2O	Activity (GJ)	CO_2	CH_4	N_2O
1990	47 020	*63 100*	*5.00*	*0.10*	644 883	*74 100*	*4.15*	*28.60*
1991	47 020	*63 100*	*5.00*	*0.10*	644 883	*74 100*	*4.15*	*28.60*
1992	47 020	*63 100*	*5.00*	*0.10*	644 883	*74 100*	*4.15*	*28.60*
1993	47 020	*63 100*	*5.00*	*0.10*	559 109	*74 100*	*4.15*	*28.60*
1994	47 020	*63 100*	*5.00*	*0.10*	516 033	*74 100*	*4.15*	*28.60*
1995	43 417	*63 100*	*5.00*	*0.10*	215 039	*74 100*	*4.15*	*28.60*
1996	41 904	*63 100*	*5.00*	*0.10*	428 999	*74 100*	*4.15*	*28.60*
1997	112 262	*63 100*	*5.00*	*0.10*	430 168	*74 100*	*4.15*	*28.60*
1998	137 591	*63 100*	*5.00*	*0.10*	688 180	*74 100*	*4.15*	*28.60*
1999	195 005	*63 100*	*5.00*	*0.10*	430 280	*74 100*	*4.15*	*28.60*
2000	188 013	*63 100*	*5.00*	*0.10*	559 039	*74 100*	*4.15*	*28.60*
2001	374 525	*63 100*	*5.00*	*0.10*	559 080	*74 100*	*4.15*	*28.60*
2002	206 518	*63 100*	*5.00*	*0.10*	85 958	*74 100*	*4.15*	*28.60*
2003	48 333	*63 100*	*5.00*	*0.10*	85 352	*74 100*	*4.15*	*28.60*
2004	NO	*NO*	*NO*	*NO*	175 403	*74 100*	*4.15*	*28.60*
2005	NO	*NO*	*NO*	*NO*	214 880	*74 100*	*4.15*	*28.60*
2006	NO	*NO*	*NO*	*NO*	129 388	*74 100*	*4.15*	*28.60*
2007	86 060	*74 100*	*10.00*	*0.60*	86 060	*74 100*	*4.15*	*28.60*

Source: Environment Agency

3.2.9.1.4 Emission factors

2006 IPCC Guidelines default emission factors have been applied: see Table 3-59.

Table 3-59 – Emission factors for IPCC Sub-category 1A5 – Other

1A5 - Other *Emission Factors for 2007 (kg/TJ)*								
Fuel	Fuel Type	CO_2		CH_4		N_2O		*Source*
		EF	*type*	*EF*	*type*	*EF*	*type*	
LPG	liquid	*63 100*	*D*	*5.00*	*D*	*0.10*	*D*	*2006 IPCC GL*
Gas Oil	liquid	*74 100*	*D*	*10.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Diesel Oil	liquid	*74 100*	*D*	*4.15*	*D*	*28.60*	*D*	*2006 IPCC GL*

Source: Environment Agency

An overview of the evolution of the implied emission factors per fuel type is given in Table 3-58.

3.2.9.2 Mobile (1A5b)

In 2007, fuel combustion from *1A5b - Mobile* was responsible for 0.06% of GHG emissions from fuel combustion activities (this share was 0.05% in 1990). With regard to total GHG emissions in CO_2e, excluding LULUCF and excluding CO_2 emissions from biomass, percentages were 0.05% in 2007 and 0.41% in 1990.

3.2.9.2.1 Key source

1A5b - Mobile related GHG emissions are not a key source.

3.2.9.2.2 Activity data

Fuel consumption data (diesel oil) is obtained from official statistics (STATEC, IEA Joint Questionnaires) and was attributed to this sub-category based on expert judgement.

Activity data is listed in Table 3-58.

3.2.9.2.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied.

3.2.9.2.4 Emission factors

Default emission factors have been applied: see Table 3-59.

3.2.9.3 Recalculations

Table 3-60 presents the main revisions and recalculations done since submission 2008v1.2 and the ICR of October 2008 relevant to IPCC sub-category *1A5 – Other*.

Table 3-60 – Recalculations done since submission 2008v1.2

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
1A5	Emissions reported as included elsewhere are now reported in the corresponding sub-categories using fuel consumption data from the IEA Joint Questionnaires provided by the Energy Directorate of the Ministry of Economic Affairs[106]	updated source allocation
1A5	Complete revision and documentation of AD and EF to increase transparency	updated documentation

3.2.9.4 Category specific QA/QC procedures

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed using the tools embedded in CRF Reporter.

3.2.9.5 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 3-61 will be explored.

Table 3-61 – Planned improvements for IPCC Sub-category 1A5 – Other

GHG source & sink category	Planned improvement
1A5 – Other	investigate whether the consumption data reported by the official statistics has been correctly understood, and correctly allocated.
1A5 – Other	investigate whether it would be possible to move away from default EFs to country specific ones, at least for gas oil and diesel oil.

106 ARR 2008, § 38

3.3 Comparison of the Sectoral Approach with the Reference Approach

This section provides a comparative analysis of the reference approach and the sectoral approach, and gives explanations for the differences between the two approaches.[107] Table 3-62 presents CO_2 emissions of the sectoral and the reference approaches, whereas, Table 3-63 (on the next page) presents the difference of CO_2 emissions in percent between the reference and sectoral approaches.

Table 3-62 – CO_2 emissions of sectoral and reference approach

CO_2 emissions of sectoral and reference approach [Gg CO_2]									
Year	Reference Approach				Sectoral Approach				
	Solid	*Liquid*	*Gaseous*	Total	*Solid*	*Liquid*	*Gaseous*	*Other*	Total
1990	*4 980*	*4 512*	*1 004*	10 496	*5 327*	*4 011*	*1 155*	*33*	10 526
1991	*4 691*	*5 098*	*1 044*	10 833	*5 023*	*4 824*	*1 198*	*34*	11 079
1992	*4 397*	*5 573*	*1 089*	11 058	*4 608*	*5 005*	*1 250*	*35*	10 898
1993	*4 527*	*5 307*	*1 131*	10 964	*4 727*	*4 985*	*1 300*	*33*	11 045
1994	*3 916*	*5 323*	*1 141*	10 380	*3 949*	*4 993*	*1 311*	*32*	10 285
1995	*2 218*	*4 582*	*1 302*	8 101	*2 201*	*4 668*	*1 497*	*31*	8 397
1996	*2 076*	*4 992*	*1 428*	8 497	*1 975*	*4 869*	*1 629*	*24*	8 497
1997	*1 331*	*4 945*	*1 463*	7 739	*1 235*	*5 055*	*1 663*	*28*	7 981
1998	*476*	*5 345*	*1 479*	7 300	*289*	*5 281*	*1 668*	*70*	7 308
1999	*476*	*5 127*	*1 533*	7 136	*311*	*5 552*	*1 725*	*77*	7 664
2000	*536*	*6 192*	*1 567*	8 295	*308*	*6 027*	*1 754*	*84*	8 172
2001	*478*	*6 085*	*1 623*	8 186	*228*	*6 413*	*1 818*	*111*	8 570
2002	*408*	*6 454*	*2 461*	9 323	*226*	*6 505*	*2 763*	*121*	9 615
2003	*358*	*6 934*	*2 487*	9 779	*197*	*7 032*	*2 798*	*117*	10 144
2004	*433*	*7 570*	*2 803*	10 806	*213*	*8 033*	*3 162*	*126*	11 534
2005	*380*	*7 922*	*2 768*	11 070	*226*	*8 198*	*3 120*	*124*	11 668
2006	*496*	*7 934*	*2 898*	11 328	*194*	*7 935*	*3 271*	*131*	11 531
2007	*378*	*7 270*	*2 825*	10 473	*215*	*7 630*	*3 177*	*115*	11 138

Source: Environment Agency

The following reasons provide explanations to the differences recorded between the Sectoral and the Reference Approaches (CRF table 1.A(b) and 1.A(c)):

- data for the Reference Approach (RA) are coming from Eurostat databases on energy. The data have been extracted from Eurostat's web site on 29 January 2009;
- data precision (of the data used for the RA) is limited in the questionnaires (no digit), hence some variables reported as NO (since they correspond, for example, to 0 kt, ktep in the database) are perhaps not 'real' zero values but rather values smaller than 0.5;
- Eurostat's default net calorific values are used in the RA vs. country specific, plant specific, IEA or IPCC default NCVs for the Sectoral Approach (SA);
- 2006 IPCC Guidelines default carbon contents were used for the RA vs. country specific, plant specific, 2006 IPCC default EFs for the Sectoral Approach (SA);

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[107] ARR 2008, § 48

- the unit for the fraction of carbon oxidized is the default one too;
- jet kerosene: is included in the RA, whereas this fuel is not included in the SA and the apparent energy consumption;
- diesel & gasoline: blended diesel and gasoline are used in Luxembourg since 2007. In the RA, CO_2 emissions from these fuels are fully accounted as fossil emissions, while in the SA the share of mixed biofuels is accounted as biogenic;
- solid fuels: The RA includes process emissions from the iron & steel production which are included in category *2C – Metal Production* in the SA;
- solid fuels: quantities, used in the RA and reported in Eurostat/IEA Joint questionnaire on coal by the Ministry of Economic Affairs, are import figures, whereas, quantities used in the SA are bottom-up collected actual consumption data. Hence, stocks are considered in the RA as being completely consumed in the relative year, i.e. import = consumption;
- municipal solid waste (garbage): in order to have accurate comparisons in table 1.A(c), this energy source has to be recorded under one of the three main fuels of the Reference Approach (i.e. Liquid, Solid and Gaseous). If not, the total for the RA would not include municipal waste incineration on the contrary of the SA, hence leading to incomplete comparisons. The source "Other Solid Fossil Fuels" has been selected for recording municipal waste incineration data. Nevertheless, RA data for waste incineration covers both biogenic and non-biogenic fractions incinerated, whereas the SA only considers the non-biogenic fraction.

Table 3-63 – Difference of CO_2 emissions by type of fuel in percent

Difference of CO_2 emissions between sectoral and reference approach [%]				
Year	*Solid*	*Liquid*	*Gaseous*	Total
1990	- 6.51	12.50	- 13.07	- 0.28
1991	- 6.61	5.68	- 12.80	- 2.22
1992	- 4.58	11.34	- 12.94	1.47
1993	- 4.25	6.46	- 13.01	- 0.73
1994	- 0.83	6.60	- 12.94	0.92
1995	0.78	- 1.86	- 13.04	- 3.52
1996	5.14	2.53	- 12.35	- 0.01
1997	7.75	- 2.17	- 11.99	- 3.03
1998	64.45	1.22	- 11.36	- 0.11
1999	53.30	- 7.66	- 11.12	- 6.89
2000	73.99	2.75	- 10.64	1.51
2001	109.57	- 5.12	- 10.70	- 4.48
2002	80.31	- 0.79	- 10.92	- 3.04
2003	81.88	- 1.39	- 11.14	- 3.60
2004	102.97	- 5.76	- 11.35	- 6.31
2005	68.17	- 3.36	- 11.28	- 5.13
2006	155.21	- 0.01	- 11.39	- 1.75
2007	75.68	- 4.72	- 11.10	- 5.98

Source: Environment Agency

3.4 Feedstocks

Non-energy use of fuels is considered in the national energy balance. For the data recorded, please refer to the delivery available on the Central Data Repository of the EIONET of the EEA: http://cdr.eionet.europa.eu/lu/eu/ghgmm/envsg0iva.

3.5 Fugitive Emissions from Fuels (1B)

3.5.1 Solid Fuels (1B1)

This source category does not exist in Luxembourg.

3.5.2 Oil and Natural Gas (1B2)

This section describes GHG fugitive emissions from oil and natural gas in distribution and transmission. In Luxembourg, fugitive emissions could only occur from oil distribution (IPCC Subcategory 1B2a.v) and from natural gas transmission, distribution and leakages (IPCC Subcategories 1B2b.iii/iv and v). Other fugitive emissions – because they are closely linked to production, processing or exploration – are not occurring in Luxembourg.

Fugitive emissions from the distribution of oil products have not yet been estimated, hence the NE notation key reported in the CRF tables.

As regards to natural gas, methane emissions from distribution are due to leaks or to accidental events. There is, however, no distinction being made between transmission and distribution and leakages. Hence, IPCC sub-category *1B2b3 – Transmission* includes emissions from IPCC subcategories *1B2b4 – Distribution* and *1B2b5 – Other Leakage*.

In 2007, IPCC sub-category *1B2b3 – Transmission* was responsible for 0.45% of GHG emissions from the energy sector (0.17% in 1990) and represented 0.39% of the total GHG emissions in CO_2e, excluding LULUCF (0.14% in 1990).

Table 3-64 summarizes GHG emissions for IPCC Sub-category 1B2.

3.5.2.1 Key source

Fugitive emissions from oil and natural gas distribution and transmission are not a key source.

3.5.2.2 Activity data

Activity data are listed in Table 3-65

Table 3-64 – GHG emission trends in CO_2e for IPCC Sub-category 1B2 – Oil and Natural Gas: 1990-2007

GHG emissions by source & sink Category 1B2 - Oil and Natural Gas

CO_2e emissions (Gg)

Year	1B2a - Oil				1B2b - Natural Gas				1B2c - Venting & Flaring				1B2d - Other				1B2 - Oil & Natural Gas			
	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O
1990	NE,NO	*NE,NO*	*NE,NO*	*NO*	18.36	*0.03*	*18.33*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**18.36**	*0.03*	*18.33*	*NA,NO*
1991	NE,NO	*NE,NO*	*NE,NO*	*NO*	19.15	*0.03*	*19.12*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**19.15**	*0.03*	*19.12*	*NA,NO*
1992	NE,NO	*NE,NO*	*NE,NO*	*NO*	19.95	*0.03*	*19.92*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**19.95**	*0.03*	*19.92*	*NA,NO*
1993	NE,NO	*NE,NO*	*NE,NO*	*NO*	20.64	*0.03*	*20.60*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**20.64**	*0.03*	*20.60*	*NA,NO*
1994	NE,NO	*NE,NO*	*NE,NO*	*NO*	20.88	*0.03*	*20.85*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**20.88**	*0.03*	*20.85*	*NA,NO*
1995	NE,NO	*NE,NO*	*NE,NO*	*NO*	23.56	*0.04*	*23.52*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**23.56**	*0.04*	*23.52*	*NA,NO*
1996	NE,NO	*NE,NO*	*NE,NO*	*NO*	26.14	*0.04*	*26.10*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**26.14**	*0.04*	*26.10*	*NA,NO*
1997	NE,NO	*NE,NO*	*NE,NO*	*NO*	26.83	*0.04*	*26.79*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**26.83**	*0.04*	*26.79*	*NA,NO*
1998	NE,NO	*NE,NO*	*NE,NO*	*NO*	27.08	*0.04*	*27.04*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**27.08**	*0.04*	*27.04*	*NA,NO*
1999	NE,NO	*NE,NO*	*NE,NO*	*NO*	28.05	*0.04*	*28.01*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**28.05**	*0.04*	*28.01*	*NA,NO*
2000	NE,NO	*NE,NO*	*NE,NO*	*NO*	28.83	*0.05*	*28.78*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**28.83**	*0.05*	*28.78*	*NA,NO*
2001	NE,NO	*NE,NO*	*NE,NO*	*NO*	29.84	*0.05*	*29.80*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**29.84**	*0.05*	*29.80*	*NA,NO*
2002	NE,NO	*NE,NO*	*NE,NO*	*NO*	43.92	*0.07*	*43.85*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**43.92**	*0.07*	*43.85*	*NA,NO*
2003	NE,NO	*NE,NO*	*NE,NO*	*NO*	44.49	*0.07*	*44.42*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**44.49**	*0.07*	*44.42*	*NA,NO*
2004	NE,NO	*NE,NO*	*NE,NO*	*NO*	50.22	*0.08*	*50.14*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**50.22**	*0.08*	*50.14*	*NA,NO*
2005	NE,NO	*NE,NO*	*NE,NO*	*NO*	49.32	*0.08*	*49.24*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**49.32**	*0.08*	*49.24*	*NA,NO*
2006	NE,NO	*NE,NO*	*NE,NO*	*NO*	51.76	*0.08*	*51.68*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**51.76**	*0.08*	*51.68*	*NA,NO*
2007	NE,NO	*NE,NO*	*NE,NO*	*NO*	50.58	*0.08*	*50.50*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**50.58**	*0.08*	*50.50*	*NA,NO*
Trend 1990-2007	*NA*	*NA*	*NA*	*NA*	*175.55%*	*175.55%*	*175.55%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*175.55%*	*NA*	*175.55%*	*NA*

Source: Environment Agency

Notes:

CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

Table 3-65 – Activity data trend for IPCC Sub-category 1B2 – Oil and Natural Gas: 1990-2007

Natural Gas Consumption (GJ)									
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
19'885'000	20'743'000	21'615'000	22'354'000	22'621'000	25'519'000	28'314'000	29'069'000	29'333'000	30'389'000
2000	2001	2002	2003	2004	2005	2006	2007		
31'228'000	32'331'000	48'986'000	49'498'000	55'794'000	54'829'000	57'377'000	55'948'000		

Source: STATEC

3.5.2.3 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied.

3.5.2.4 Emission factors

2006 IPCC Guidelines default emission factors have been applied:

- Natural Gas Transmission - CO_2: $8.8*10^{-7}$ $Gg/10^6$ m^3
- Natural Gas Distribution - CO_2: $5.1*10^{-5}$ $Gg/10^6$ m^3
- Natural Gas Transmission - CH_4: $4.8*10^{-4}$ $Gg/10^6$ m^3
- Natural Gas Distribution - CH_4: $1.1*10^{-3}$ $Gg/10^6$ m^3

3.5.3 Recalculations

Table 3-66 presents the main revisions and recalculations done since submission 2008v1.2 and the ICR of October 2008 relevant to IPCC sub-category *1B2b3 – Natural Gas – Transmission*.

Table 3-66 – Recalculations done since submission 2008v1.2

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
1B2b3	Complete revision and documentation of AD and EFs to increase transparency	updated AD updated EFs updated documentation

3.5.4 Category specific QA/QC procedures

Standard QA/QC procedures were followed.

Consistency and completeness checks have been performed using the tools embedded in CRF Reporter.

3.5.5 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 3-67 will be explored.

Table 3-67 – Planned improvements for IPCC Sub-category 1B2 – Oil and Natural Gas

GHG source & sink category	Planned improvement
1.B.2.v Distribution of oil products	Only refined oil products are distributed in Luxembourg. Activity data on these has been collected; however, no EFs are available in the IPCC guidelines. Therefore, EFs from neighbouring countries might be chosen instead. Further investigations are needed.[108]

3.6 Memo Items

Under Memo Items, Parties should report GHG emissions from international bunkers (aviation and marine), from multilateral operations and from CO_2 emitted from biomass.

3.6.1 International bunkers

In 2007, GHG emissions from International Bunkers amounted to 1 840 Gg CO_2 eq (see Table 3-68), an increase of approximately 230% compared to 1990.

Table 3-68 – Activity data and GHG emissions for International Bunkers

International Bunkers - Aviation & Marine

Activity Data (GJ) and GHG emissions by source & sink category (Gg)

Year	Aviation (Kerosene & Aviation Gasoline)					Marine (Gas Oil)					Total Activity	Total $CO_{2\,eq}$
	Activity (GJ)	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O	Activity (GJ)	Total $CO_{2\,eq}$	CO_2	CH_4	N_2O		
1990	5 622 101	405.52	*401.98*	*0.003*	*0.011*	932	0.070	*0.069*	*0.000007*	*0.000002*	**5 623 033**	**406**
1991	5 841 878	421.38	*417.69*	*0.003*	*0.012*	1 012	0.076	*0.075*	*0.000007*	*0.000002*	**5 842 890**	**421**
1992	5 666 411	408.72	*405.15*	*0.003*	*0.011*	924	0.069	*0.068*	*0.000006*	*0.000002*	**5 667 335**	**409**
1993	5 622 706	405.57	*402.02*	*0.003*	*0.011*	1 297	0.097	*0.096*	*0.000009*	*0.000003*	**5 624 003**	**406**
1994	7 116 159	513.29	*508.80*	*0.004*	*0.014*	1 111	0.083	*0.082*	*0.000008*	*0.000002*	**7 117 270**	**513**
1995	8 082 485	582.99	*577.90*	*0.004*	*0.016*	1 119	0.084	*0.083*	*0.000008*	*0.000002*	**8 083 604**	**583**
1996	8 785 286	633.68	*628.15*	*0.004*	*0.018*	1 051	0.079	*0.078*	*0.000007*	*0.000002*	**8 786 337**	**634**
1997	10 717 789	773.08	*766.32*	*0.005*	*0.021*	1 032	0.077	*0.076*	*0.000007*	*0.000002*	**10 718 821**	**773**
1998	12 079 127	871.27	*863.66*	*0.006*	*0.024*	1 145	0.086	*0.085*	*0.000008*	*0.000002*	**12 080 273**	**871**
1999	14 187 311	1 023.34	*1 014.39*	*0.007*	*0.028*	1 258	0.094	*0.093*	*0.000009*	*0.000003*	**14 188 569**	**1 023**
2000	13 704 139	988.48	*979.84*	*0.007*	*0.027*	1 391	0.104	*0.103*	*0.000010*	*0.000003*	**13 705 529**	**989**
2001	14 802 131	1 067.68	*1 058.35*	*0.007*	*0.030*	1 393	0.104	*0.103*	*0.000010*	*0.000003*	**14 803 524**	**1 068**
2002	16 031 812	1 156.38	*1 146.27*	*0.008*	*0.032*	1 469	0.110	*0.109*	*0.000010*	*0.000003*	**16 033 281**	**1 156**
2003	16 690 777	1 203.91	*1 193.39*	*0.008*	*0.033*	1 498	0.112	*0.111*	*0.000010*	*0.000003*	**16 692 274**	**1 204**
2004	18 183 912	1 311.61	*1 300.15*	*0.009*	*0.036*	1 448	0.108	*0.107*	*0.000010*	*0.000003*	**18 185 360**	**1 312**
2005	18 447 421	1 330.62	*1 318.99*	*0.009*	*0.037*	1 942	0.145	*0.144*	*0.000014*	*0.000004*	**18 449 363**	**1 331**
2006	17 305 348	1 248.24	*1 237.33*	*0.009*	*0.035*	2 051	0.154	*0.152*	*0.000014*	*0.000004*	**17 307 399**	**1 248**
2007	18 579 028	1 340.11	*1 328.40*	*0.009*	*0.037*	1 708	0.128	*0.127*	*0.000012*	*0.000003*	**18 580 735**	**1 340**
Trend 1990-2007	*230.46%*	*230.46%*	*230.46%*	*230.46%*	*230.46%*	*83.18%*	*83.18%*	*83.18%*	*83.18%*	*83.18%*	*230.44%*	*230.44%*

Source: Environment Agency

3.6.1.1 Aviation Bunkers

As indicated in IPCC sub-category *1A3a – Civil Aviation* (Section 3.2.7.1.2), there is only one airport for commercial aviation in Luxembourg (Findel). Therefore all flights, either coming to Luxembourg or going out from Luxembourg, are international flights. Domestic flights are mainly leisure or urgency (medical, police) flights made with small-sized propellers planes or helicopters using aviation gasoline. However, based on expert judgement, 10% of these flights are considered as international. Consequently, all kerosene sales and 10% of the aviation gasoline sales and their related emissions are allocated to international bunkers.[109]

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108 ARR 2008, § 36

109 ARR 2008, § 49

3.6.1.1.1 Activity data

Fuel consumptions of kerosene and aviation gasoline are obtained from national statistics (STATEC, IEA Joint Questionnaires) (see Table 3-68). Data on the number of Landings and Take-Offs (LTO) has been obtained from national statistics (STATEC, Yearbook 2008)

3.6.1.1.2 Methodological issues

The 2006 IPCC Guidelines Tier 2 approach has been applied for jet flights combusting kerosene.[110] This methodology is based on five steps:

1. Estimate the domestic and international fuel consumption totals for aviation.
2. Estimate LTO fuel consumption for domestic and international operations.
3. Estimate the cruise fuel consumption for domestic and international aviation.
4. Estimate emissions from LTO and cruise phases for domestic and international aviation.
5. Calculate Total Emissions = LTO Emissions + Cruise Emissions.

The 2006 IPCC Guidelines Tier 1 approach has been applied for leisure planes combusting aviation gasoline.

3.6.1.1.3 Emission factors

The emissions factors, used for calculating emissions from International Bunkers – Aviation, are listed in Table 3-69.

Table 3-69 – Emission factors for International Bunkers - Aviation

International Bunkers - Aviation *Emission Factors for 2007*								
Fuel	Flight Phase	CO_2 EF	CO_2 (unit) type	CH_4 EF	CH_4 (unit) type	N_2O EF	N_2O (unit) type	Source
Jet Kerosene	LTO	5.094	(t/LTO) D	0.00	(t/LTO) D	0.0002	(t/LTO) D	EMEP-Corinair GB 2007
	cruise	3.15	(t/t fuel) D	0.00	(t/t fuel) D	0.0001	(t/t fuel) D	
Aviation gasoline	all	69 300	(kg/TJ) D	0.50	(kg/TJ) D	2.00	(kg/TJ) D	2006 IPCC GL

Source: Environment Agency

A NCV of 43.92 GJ/t kerosene (IEA Energy Statistic's Manual) and 45.03 GJ/t aviation gasoline (IEA Energy Statistic's Manual) has been applied for converting activity data.

3.6.1.2 Marine Bunkers

As indicated in IPCC sub-category *1A3d – Navigation* (Section 3.2.7.4.3), navigation only occurs on the Moselle River. About 20% of the total GHG emissions from shipping are considered as international and are, thus, reported under International Bunkers – Marine.

Activity data and emissions are listed in Table 3-68.

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110 ARR 2008, § 50

For more details on activity data sources, methodological issues and emission factors used, please refer to Section 3.2.7.4.

3.6.2 Multilateral Operations

It is supposed that related emissions are appearing under other CRF Sector 1 source categories, hence the IE notation keys in the CRF tables.

3.6.3 CO_2 Emissions from Biomass

This category is automatically filled in CRF tables by gathering CO_2 emissions – and only carbon dioxide emissions – estimated for biomass used as a fuel.

3.6.4 Recalculations

Table 3-70 presents the main revisions and recalculations done since submission 2008v1.2 and the ICR of October 2008 relevant to *Memo Items*.

Table 3-70 – Recalculations for International Bunkers

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
Memo Items – International Bunkers - Aviation	revised emissions taking into account LTO (2006 IPCC Guidelines Tier 2 methodology).	updated methodology
Memo Items – International Bunkers - Marine	20% of shipping emissions are considered international and are therefore reported under International Bunkers - Marine.	allocation issue
Memo Items – CO_2 Emissions from Biomass	Biomass and bio fuels in particular, are now being considered in the respective source categories as obtained from national statistics (STATEC, IEA Joint Questionnaires).	reallocation issues revised AD revised EFs

3.6.5 Category specific QA/QC procedures

Standard QA/QC procedures were followed.

3.6.6 Planned Improvements

No planned improvements are being considered at this stage.

3.7 Selected references

ARBED (1990 – 1998): Annual communications from the operator to the Environment Agency Luxembourg. Luxembourg.

EMEP/CORINAIR Emission Inventory Guidebook, 4th edition (2007). European Environment Agency (EEA), Copenhagen.

ETS Emission Trading Scheme Guidelines 2004 – Commission Decision of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

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

Kouridis, C.; Ntziachristos, L. & Samaras, Z. (2000): COPERT III – Computer programme to calculate emissions from road transport – User Manual (Version 2.1). Technical report No 50, European Environment Agency (EEA). Copenhagen.

Ministère de l'Economie et du Commerce Extérieur, Direction de l'Energie (1990 – 2008): Rapports d'Activité. Luxembourg.

Ministère de l'Environnement, L'Environnement en Chiffres 2002-2003 (2003).

Ntziachristos, L. & Samaras, Z. (2000): COPERT III – Computer programme to calculate emissions from road transport – Methodology and Emission Factors (Version 2.1). Technical report No 49, European Environment Agency (EEA). Copenhagen.

Société Nationale de Contrôle Technique (SNCT) (1990-2007) : Stock of passenger cars, light duty vehicle, heavy duty vehicle, busses, motor cycles. Sandweiler, Luxembourg.

STATEC 1990 – 2008. Annuaires statistiques. Luxembourg.

TÜV Rheinland (1990): Emissionskataster für das Großherzogtum Luxemburg. Köln.

TÜV Rheinland (1992-1993) Impaktstudien für die ARBED-Werke Esch/Belval, Differdange und Esch-Schifflange für das Jahr 1990.

4 Industrial Processes (CRF sector 2)

4.1 Sector Overview

Chapter 4 includes information on and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under CRF Sector 2 – *Industrial Processes* for the period 1990 to 2007.

Emissions from this sector comprise emissions from the following categories: mineral products (2A), metal production (2C) and consumption of halocarbons and SF_6 (2F). For more details on categories where emissions are not occurring and categories that are not estimated or included elsewhere, see Tables 4-2 and 4-3.

Only process related emissions are considered in this sector. Emissions due to fuel combustion in manufacturing industries are allocated to IPCC Sub-category *1A2 – Fuel Combustion Activities – Manufacturing Industries and Construction* (see Chapter 3).

Other required information, as suggested in Annex I of document FCCC/SBSTA/2006/9, will be presented under each source category review (methodology, AD, EFs, etc.).

4.1.1 Emission Trends

This section briefly describes the emission trends from 1990 to 2007 for each of the IPCC Categories under CRF Sector 2 for which GHG emissions are reported – i.e. categories *2A – Mineral Products*, *2C – Metal Production* and *2F - Consumption of Halocarbons and* SF_6.

Industrial process emissions include emissions from industrial installations and from consumption of halocarbons and SF_6 (the fluorinated gases or F-gases).[111] The most important emitting activities are clinker, flat glass and iron and steel productions. With regard to F-gases, increasing emissions are mainly due to a growing use of air conditioning.

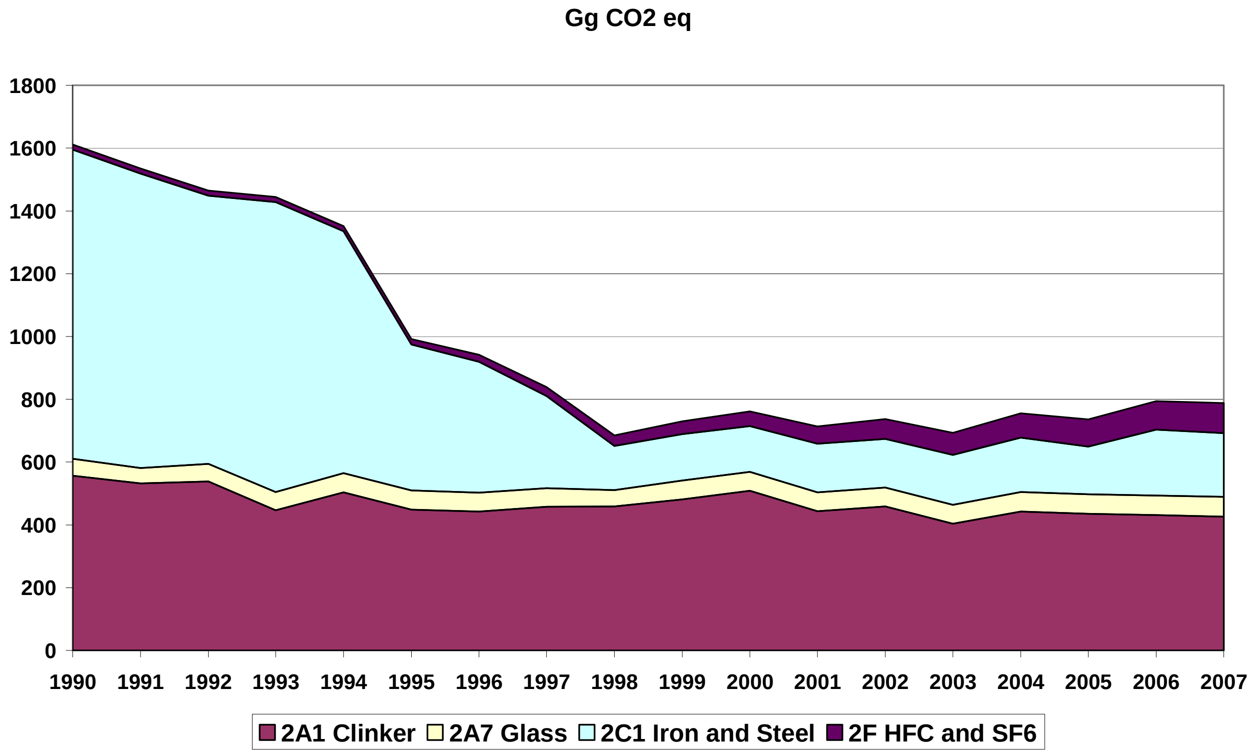
As shown in Table 4-1 and Figure 4-1, emissions of GHG due to industrial processes have decreased by about 51.1% between 1990 and 2007 (-56.6% for carbon dioxide but +479% for F-gases). It is for IPCC Category 2C – *Metal Production* that CO_2 emissions have decreased the most over the period: -79.3%. For IPCC Category 2A – Mineral Products the decline is limited to -19.9% for CO_2 emissions. In fact, only 3 companies and their various production installations are part of CRF Sector 2 (excluding F-gases):

- IPCC sub-category 2A: one cement works unit and one flat glass manufacturing company;

111 No PFC application and emissions have been identified in Luxembourg so far (see Section 4.7).

- IPCC sub-category 2C: the iron and steel manufacturing company Arcelor-Mittal, as already mentioned in previous chapters.

Figure 4-1 – GHG emission trends for CRF Sector 2 – Industrial Processes: 1990-2007



The trend observed for the iron and steel production units is, of course, linked to the dramatic change that occurred in the 1990s with regard to the production process: move from blast furnaces to electrical arc furnaces. This technological change has already been developed in previous chapters (see, e.g., Section 2.2.1) and will not be detailed once again here.

The striking increase of F-gas emissions is the consequence of supposedly growing use in the country, but also of the hypothesis made for their estimation: see Section 4.7.

Figure 4-2 and Figure 4-3 provide a quick overview on industrial processes related emission trends between 1990 and 2007. More explanations are presented in the subsequent sections detailing each of the sector source sub-categories.

Table 4-1 – GHG emission trends in CO_2e for CRF Sector 2 – Industrial Processes: 1990-2007

2 - Industrial Processes

GHG emissions by source & sink category (Gg CO_2 eq)

Year	2A - Mineral Products				2C - Metal Production				2F - Consumption Halocarbons & SF_6				2 - Industrial Processes				
	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	HFCs	PFCs	SF_6	Total	CO_2	CH_4	N_2O	F-gases
1990	610.65	610.65	NO	NO	984.91	984.91	NO	NO	16.53	13.62	NO	2.91	1 612.09	1 595.57	NO	NO	16.53
1991	580.73	580.73	NO	NO	937.74	937.74	NO	NO	16.53	13.62	NO	2.91	1 535.00	1 518.48	NO	NO	16.53
1992	595.20	595.20	NO	NO	853.29	853.29	NO	NO	16.53	13.62	NO	2.91	1 465.02	1 448.49	NO	NO	16.53
1993	505.28	505.28	NO	NO	923.19	923.19	NO	NO	16.53	13.62	NO	2.91	1 445.00	1 428.47	NO	NO	16.53
1994	564.56	564.56	NO	NO	770.83	770.83	NO	NO	16.53	13.62	NO	2.91	1 351.92	1 335.39	NO	NO	16.53
1995	509.66	509.66	NO	NO	465.38	465.38	NO	NO	16.53	13.62	NO	2.91	991.57	975.05	NO	NO	16.53
1996	502.87	502.87	NO	NO	416.60	416.60	NO	NO	22.54	19.51	NO	3.03	942.00	919.47	NO	NO	22.54
1997	516.48	516.48	NO	NO	294.10	294.10	NO	NO	28.55	25.40	NO	3.15	839.12	810.58	NO	NO	28.55
1998	510.84	510.84	NO	NO	140.69	140.69	NO	NO	34.56	31.28	NO	3.28	686.08	651.52	NO	NO	34.56
1999	541.49	541.49	NO	NO	147.70	147.70	NO	NO	40.57	37.17	NO	3.40	729.76	689.19	NO	NO	40.57
2000	569.40	569.40	NO	NO	146.05	146.05	NO	NO	46.58	43.06	NO	3.52	762.03	715.45	NO	NO	46.58
2001	504.27	504.27	NO	NO	154.76	154.76	NO	NO	54.55	50.98	NO	3.57	713.58	659.03	NO	NO	54.55
2002	519.34	519.34	NO	NO	155.40	155.40	NO	NO	62.52	58.89	NO	3.62	737.26	674.75	NO	NO	62.52
2003	463.92	463.92	NO	NO	158.94	158.94	NO	NO	70.48	66.81	NO	3.68	693.35	622.86	NO	NO	70.48
2004	505.04	505.04	NO	NO	172.45	172.45	NO	NO	78.45	74.73	NO	3.73	755.94	677.49	NO	NO	78.45
2005	496.98	496.98	NO	NO	152.92	152.92	NO	NO	86.42	82.64	NO	3.78	736.32	649.90	NO	NO	86.42
2006	493.08	493.08	NO	NO	209.79	209.79	NO	NO	91.07	87.21	NO	3.86	793.94	702.87	NO	NO	91.07
2007	489.19	489.19	NO	NO	203.49	203.49	NO	NO	95.72	91.78	NO	3.94	788.39	692.67	NO	NO	95.72
Trend 2006-2007	-0.79%	-0.79%	NA	NA	-3.01%	-3.01%	NA	NA	5.11%	5.24%	NA	2.08%	-0.70%	-1.45%	NA	NA	5.11%
Trend 1990-2007	-19.89%	-19.89%	NA	NA	-79.34%	-79.34%	NA	NA	479.20%	573.96%	NA	35.45%	-51.10%	-56.59%	NA	NA	479.20%

Source: Environment Agency

Notes:

CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

N_2O emissions are converted in CO_2e by multiplying the emissions by 310, i.e. the global warming potential (*GWP*) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

The F-gases are those not covered by the Montreal Protocol, i.e. HFCs, PFCs and SF_6 expressed in CO_2e using the global warming potential (GWP) values based on the effects of GHG over a 100-year time horizon.

Figure 4-2 – GHG emission trends – indexes – for CRF Sector 2 – Industrial Processes: 1990-2007

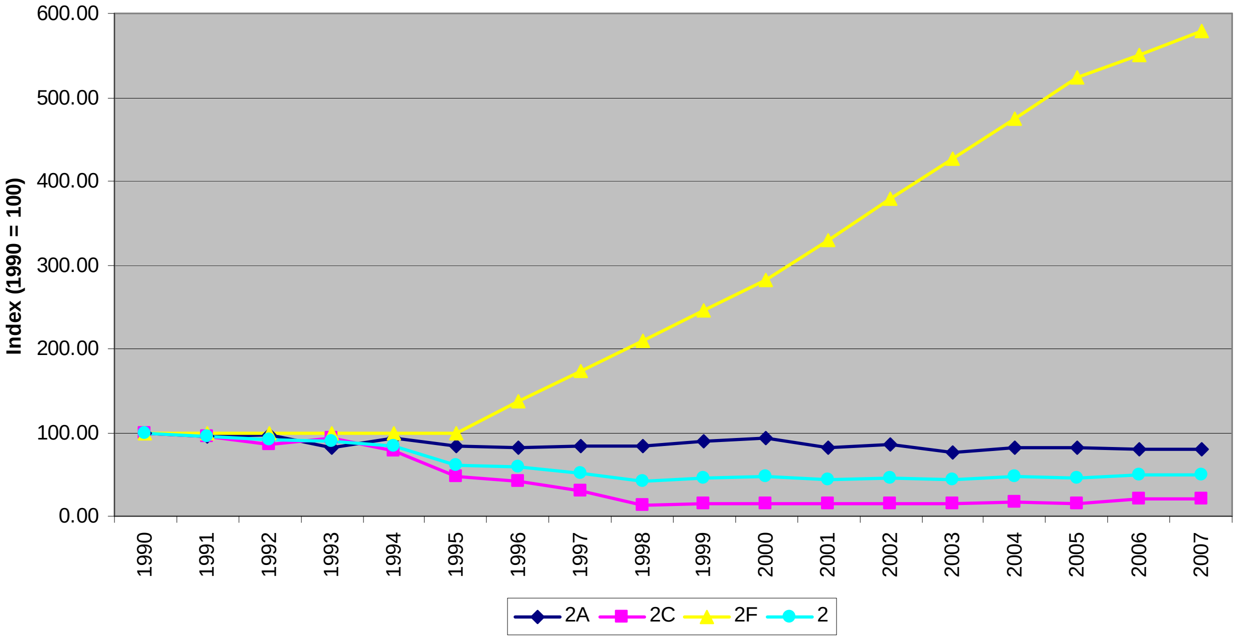
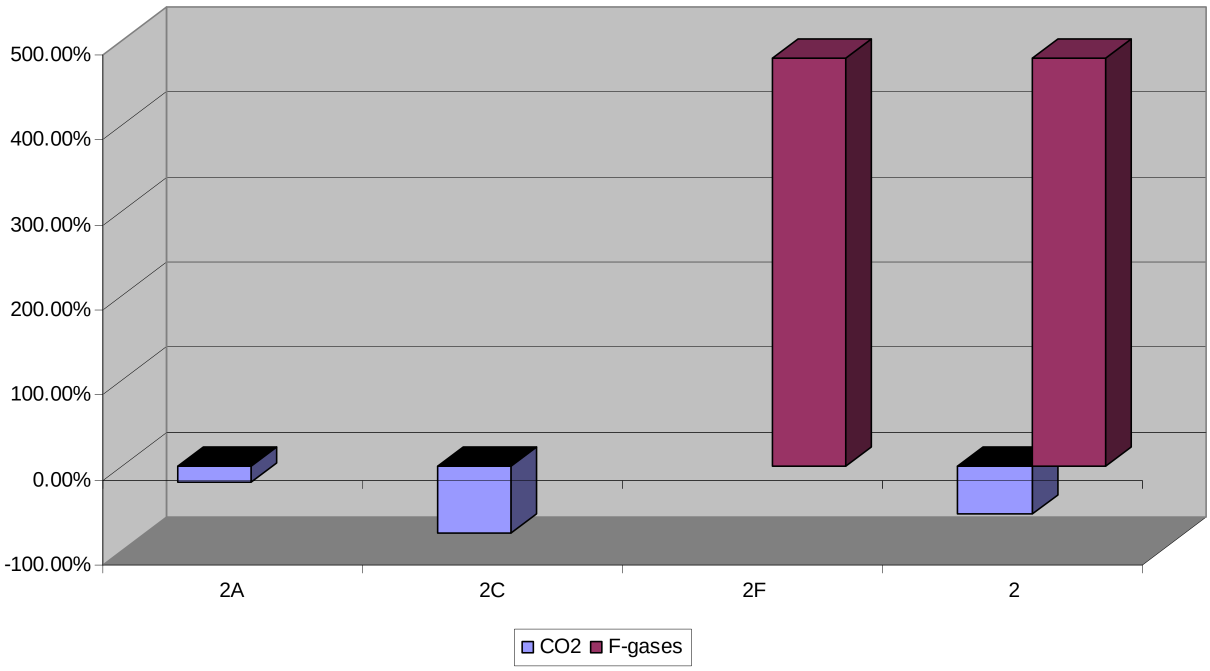


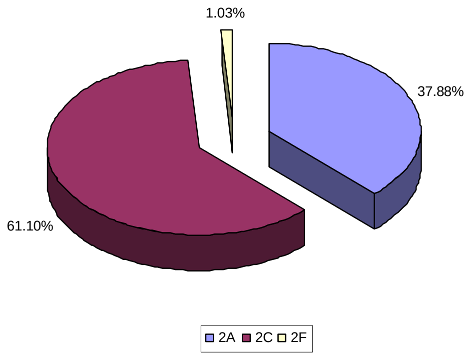
Figure 4-3 – GHG emission trends in % for CRF Sector 2 – Industrial Processes: 1990-2006



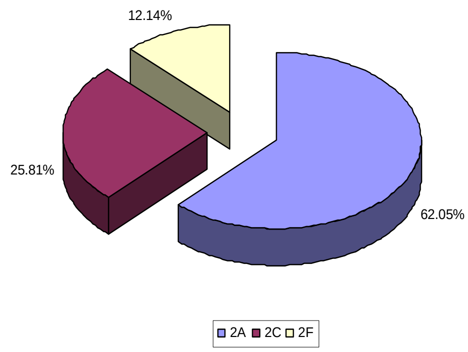
The emission trends briefly described above led to a significant change in the composition of industrial processes' GHG emissions, as shown in Figure 4-4.

Figure 4-4 – IPCC Categories weights in GHG emissions for CRF Sector 2 – Industrial Processes: 1990 and 2007

1990



2007



4.1.2 Key Sources

The methodology and results of the key source analysis are presented in Chapter 1. Table 4-2 presents the key source categories of IPCC Category 2 Industrial processes.

Table 4-2 – Key sources of IPCC Category 2 - Industrial processes

2 - Industrial Processes *Key sources*						
IPCC Category	Category Name	GHG	LA excl. LULUCF	LA incl. LULUCF	TA excl. LULUCF	TA incl. LULUCF
2A1	Cement Production	CO2	95-07	90-07	X	X
2A7	Other - Glass Production	CO2	90, 92-01, 02-04, 07	90		
2C1	Iron & Steel Production	CO2	90-07	90-98, 06-07	X	X
2F	Consumption of Halocarbons & SF6	F-gases	99-07		X	X

Source: Environment Agency

Notes: LA = Level Assessement including respectively exluding LULUCF

TA = Trend Assessement 2007 including respectively excluding LULUCF

4.1.3 Completeness

Table 4-3 and Table 4-4 give an overview of the IPCC categories included under CRF Sector 2 and provide information on the status of emission estimates of all sub-categories.

Table 4-3 – Overview of sub-categories of CRF Sector 2 – Industrial Processes: status of emission estimates for CO_2, CH_4 and N_2O

GHG source & sink category	Description	Status		
		CO_2	CH_4	N_2O
2A1	mineral products - cement production	X		
2A2	mineral products - lime production	NO		
2A3	mineral products - limestone and dolomite use	IE		
2A4	mineral products - soda ash production and use	IE		
2A5	mineral products - asphalt roofing	NO		
2A6	mineral products - road paving with asphalt	NO		
2A7	mineral products - other: glass production	X	NO	NO
2B1	chemical industry - ammonia production	NO	NO	NO
2B2	chemical industry - nitric acid production			NO
2B3	chemical industry - adipic acid production	NO		NO
2B4	chemical industry - carbide production	NO	NO	
2B5	chemical industry - other	NO	NO	NO
2C1	metal production - iron and steel production	X	NO	
2C2	metal production - ferroalloys production	NO	NO	
2C3	metal production - aluminium production	NO	NO	
2C4	metal production - SF_6 used in aluminium and magnesium foundries			
2C5	metal production - other	NA	NA	NA
2D1	other production - pulp and paper			
2D2	other production - food and drink	NO		
2G	other	NA	NA	NA

Note: a **X** indicates that emissions from this sub-category have been estimated, the grey shaded cells are those also shaded in the CRF tables.

Table 4-4 – Overview of subcategories of CRF Sector 2 – Industrial Processes: status of emission estimates for halocarbons and SF_6

GHG source & sink category	Description	Status		
		HFCs - actual	PFCs - actual	SF_6 - actual
2E1	production of halocarbons and SF_6 - by-products emissions	NO	NA	NA
2E2	production of halocarbons and SF_6 - fugitive emissions	NO	NO	NO
2E3	production of halocarbons and SF_6 - other	NA	NA	NA
2F1	consumption of halocarbons and SF_6 - refrigeration and air conditioning equipment	X	NO	NO
2F2	consumption of halocarbons and SF_6 - foam blowing	X	NO	NO
2F3	consumption of halocarbons and SF_6 - fire extinguishers	NE	NO	NO
2F4	consumption of halocarbons and SF_6 - aerosols/metered dose inhalers	X	NO	NO
2F5	consumption of halocarbons and SF_6 - solvents	NE	NO	NO
2F6	consumption of halocarbons and SF_6 - other applications using ODS substitutes	NE	NO	NO
2F7	consumption of halocarbons and SF_6 - semiconductor manufacture	NE	NO	NO
2F8	consumption of halocarbons and SF_6 - electrical equipment	NA	NO	X
2F9	consumption of halocarbons and SF_6 - other: noise reduction window	NO	NO	X
G	other	NA	NA	NA

Note: a **X** indicates that emissions from this sub-category have been estimated, the grey shaded cells are those also shaded in the CRF tables.

4.2 Mineral Products (2A)

This section describes the estimation of carbon dioxide emissions resulting from industrial processes used in cement works and flat glass installations. In 2007, this source category was responsible for 70.6% of CO_2 emissions from industrial processes – but only 38.3% in 1990 – and for 4.3% of the total CO_2 emissions estimated for Luxembourg. It represented 3.8% of the total GHG emissions in CO_2e (excluding LULUCF).

4.2.1 Cement Production (2A1)

In 2007, cement production was responsible for 61.5% of CO_2 emissions from industrial processes – but only 35.0% in 1990 – and for 4.51% of the total CO_2 emissions estimated for Luxembourg. It represented 3.30% of the total GHG emissions in CO_2e (excluding LULUCF).

4.2.1.1 Key source

2A1 - Cement Production is a key source with regard to CO_2 emissions. It has been a key source without interruption since 1990: see Table 4-2 in Section 4.1.2.

4.2.1.2 Activity data

In Luxembourg, one clinker production plant is operating. During the production of clinker, limestone, which is mainly calcium carbonate ($CaCO_3$), is calcined to produce lime (CaO) and CO_2 as a by-product.

Activity data, i.e. clinker production, is obtained annually from the plant operator (Table 4-5).

4.2.1.3 Methodological issues

For the estimation of CO_2 emissions, the Tier 2 method of 2000 IPCC-GPG using clinker production data is applied:

$$CO_2\ Emissions = EF_{clinker} \bullet Clinker\ Production \bullet CKD\ Correction\ Factor$$

According to the operator of the plant, there is no calcined Cement Kiln Dust (*CKD*) to be lost from the system. Hence, the CKD Correction Factor equals 1.00.

Estimates from the Tier 2 method, as well as activity data and IEFs, are summarized in Table 4-5.

Table 4-5 – CO_2 emissions trend, activity data and IEFs for IPCC Sub-category 2A1 – Cement Production: 1990-2007

2A1 - Cement Production *Activity data, emissions and implied emission factors*			
Year	AD t	CO_2 *Gg*	IEF *kg CO_2 / t clinker*
1990	1048 000	*557.09*	*531.57*
1991	1001 637	*532.06*	*531.19*
1992	1013 452	*537.93*	*530.79*
1993	842 855	*447.03*	*530.38*
1994	950 854	*503.92*	*529.97*
1995	848 455	*449.31*	*529.56*
1996	837 518	*443.12*	*529.09*
1997	865 659	*457.60*	*528.62*
1998	870 053	*459.52*	*528.15*
1999	913 265	*481.91*	*527.68*
2000	965 369	*508.95*	*527.21*
2001	843 608	*443.87*	*526.15*
2002	874 577	*459.24*	*525.10*
2003	769 754	*403.39*	*524.05*
2004	847 389	*443.18*	*523.00*
2005	833 798	*435.20*	*521.95*
2006	826 131	*431.20*	*521.95*
2007	816 688	*426.27*	*521.95*
Trend 2006-2007	*-1.14%*	*-1.14%*	*0.00%*
Trend 1990-2007	*-22.07%*	*-23.48%*	*-1.81%*

Sources: AD: plant operator ; CO2 and IEF: Environment Agency

4.2.1.4 Emission factors

According to 2000 IPCC-GPG Tier 2 method, the emission factor is based on the CaO content of the clinker:

$$EF_{clinker} = 0.785 \bullet CaO\ Content\ (Weight\ Fraction)\ in\ Clinker$$

It is assumed that all the CaO is from carbonate source (e.g. $CaCO_3$ in limestone). Plant-specific CaO contents are available on a five-yearly basis (chemical analysis done by the plant operator). These contents are provided in Table 4-6.

Table 4-6 – CaO contents in %

Year	CaO Content *weight %*
1990	67.72%
1995	67.46%
2000	67.16%
2005	66.49%

Source: plant operator

The CaO contents for the years for which no CaO contents are available, are estimated by a linear interpolation. The CaO content for the year 2007 is set equal to the CaO content of the year 2007: see Table 4-7.

Table 4-7 – Effective and interpolated CaO content in % and EFs: 1990-2007

2A1 - Cement Production *CaO content & emission factors*			
Year	CaO (%) operator	CaO (%) *interpolation*	EF *kg CO_2 / t clinker*
1990	67.72	*67.72*	*531.57*
1991		*67.67*	*531.19*
1992		*67.62*	*530.79*
1993		*67.56*	*530.38*
1994		*67.51*	*529.97*
1995	67.46	*67.46*	*529.56*
1996		*67.40*	*529.09*
1997		*67.34*	*528.62*
1998		*67.28*	*528.15*
1999		*67.22*	*527.68*
2000	67.16	*67.16*	*527.21*
2001		*67.03*	*526.15*
2002		*66.89*	*525.10*
2003		*66.76*	*524.05*
2004		*66.62*	*523.00*
2005	66.49	*66.49*	*521.95*
2006		*66.49*	*521.95*
2007		*66.49*	*521.95*

Sources: plant operator and Environment Agency

The calculated plant-specific EFs are consistent with the 2004 ETS Tier 1 Guidelines default EF of 525 kg CO_2/t clinker.

4.2.1.5 Uncertainties

Table 4-8 gives the error values which are assumed on the various calculation parameters for the uncertainty assessment.

Table 4-8 – Error values (%) for uncertainty assessment

Step	Error (%) IPCC GPG 2000 Table 3.1 (Tier 2)	Error (%) Plant-specific estimation
1) Production data	1-2	1.5
2) Assume 100% carbonate source from $CaCO_3$	1-3	2
3) CaO chemical analysis	1-2	1.5

Combined resulting errors (uncertain quantities are to be combined by multiplication):

- Activity data uncertainty .... 1.5 %
- Emission factor uncertainty .... 2.5 %
- Emissions uncertainty .... 2.9 %

4.2.1.6 Category specific QA/QC procedures

The calculated plant-specific emission factors are consistent with the 2004 ETS Tier 1 Guidelines default emission factor of 525 kg CO_2/t clinker.

4.2.2 Lime Production (2A2)

This source category does not exist in Luxembourg.

4.2.3 Limestone and Dolomite Use (2A3)

The use of limestone and dolomite is accounted for in IPCC Sub-categories *2A1 – Cement Production* and *2A7 – Other – Glass Production*.

4.2.4 Soda Ash Production and Use (2A4)

The use of soda ash is accounted for in IPCC Sub-category *2A7 – Other – Glass Production*.

4.2.5 Asphalt Roofing (2A5)

This source category does not exist in Luxembourg.

4.2.6 Road Paving with Asphalt (2A6)

This source category does not exist in Luxembourg.

4.2.7 Other (2A7) – Glass Production

In 2007, glass production was responsible for 9.1% of CO_2 emissions from industrial processes – but only 3.4% in 1990 – and for 0.55% of the total CO_2 emissions estimated for Luxembourg. It represented 0.49% of the total GHG emissions in CO_2e (excluding LULUCF).

4.2.7.1 Key source

2A7 - Glass Production is a key source with regard to CO_2 emissions. It has been a key source in 1990, between 1992 and 2001, from 2003 to 2004 and in 2007: see Table 4-2 in Section 4.1.2.

4.2.7.2 Activity data

In Luxembourg, one company runs two flat glass production plants. CO_2 is released during melting in the kiln, from carbonates contained in mineral input materials (limestone, dolomite and soda ash).

Activity data, i.e. flat glass production, is obtained annually from the plant operators (Table 4-9).

4.2.7.3 Methodological issues

A country specific methodology is applied:

$$CO_2\ emissions = EF_{glass} \bullet Glass\ Production$$

Estimates from the CS method, as well as activity data and IEFs, are summarized in Table 4-9.

Table 4-9 – CO_2 emission trend, activity data and IEFs for IPCC Sub-category 2A7 – Other – Glass Production: 1990-2007

2A7 - Other - Glass Production *Activity data, emissions and implied emission factors*			
Year	AD t	CO_2 *Gg*	IEF *kg CO_2 / t glass*
1990	377 240	*53.57*	*142.00*
1991	342 745	*48.67*	*142.00*
1992	403 328	*57.27*	*142.00*
1993	410 176	*58.24*	*142.00*
1994	426 991	*60.63*	*142.00*
1995	425 026	*60.35*	*142.00*
1996	420 750	*59.75*	*142.00*
1997	414 616	*58.88*	*142.00*
1998	361 401	*51.32*	*142.00*
1999	419 579	*59.58*	*142.00*
2000	425 751	*60.46*	*142.00*
2001	425 391	*60.41*	*142.00*
2002	423 240	*60.10*	*142.00*
2003	426 299	*60.53*	*142.00*
2004	435 595	*61.85*	*142.00*
2005	435 073	*61.78*	*142.00*
2006	435 806	*61.88*	*142.00*
2007	443 094	*62.92*	*142.00*
Trend 2006-2007	*1.67%*	*1.67%*	*0.00%*
Trend 1990-2007	*17.46%*	*17.46%*	*0.00%*

Sources: AD: plant operator ; CO2 and IEF: Environment Agency

4.2.7.4 Emission factors

The emission factor is based on the loss of ignition of the batch composition. The background data and the calculation of the emission factor are provided by the operator. There is no indication of any change in product quality or batch composition over time and hence the emission factor is kept constant the whole time.

$$EF_{glass} = 142\ kg\ CO_2/\ t\ glass$$

The calculated plant-specific EF is consistent with the calculated value for 2005 according to the 2004 ETS Guidelines carbonates method. For 2005, an EF of 140 kg CO_2/t glass was determined based on the carbonates contents in the raw materials and the activity data.

4.2.7.5 Uncertainties

Estimation of uncertainties based on expert judgement:

- Activity data uncertainty .... 2.0 %
- Emission factor uncertainty .... 5.0 %
- Cumulative emission uncertainty .... 5.4 %

4.2.7.6 Category specific QA/QC procedures

The calculated CO_2 emission is consistent with the calculated value according to the 2004 ETS Guidelines' carbonates method.

4.2.8 Recalculations

No revisions and recalculations have been done since the submission 2008v1.2 to IPCC subcategory 2A.

4.2.9 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 4-10 will be explored.

Table 4-10 – Planned improvements for IPCC Category 2A – Mineral Products

GHG source & sink category	Planned improvement
2A1 – Cement Production	streamlining with the new 2006 IPCC Guidelines and the new 2007 ETS Guidelines.
2A5 – Asphalt Roofing	investigate further whether this category is effectively NA or NO in Luxembourg.
2A6 – Road Paving with Asphalt	investigate further whether this category is effectively NA or NO in Luxembourg.
2A7 – Other – Glass Production	streamlining with the new 2006 IPCC Guidelines and the new 2007 ETS Guidelines.

4.3 Chemical Industry (2B)

There are no emissions to be reported for the chemical industry for Luxembourg. Emissions from solvent use are reported in IPCC Category *3 – Solvent and Other Product Use*.

4.4 *Metal Production (2C)*

This section describes the estimation of carbon dioxide emissions resulting from industrial processes relating to iron and steel production (IPCC Sub-category 2C1). As a matter of fact, steel production combines process and energy related emissions. For pragmatic reasons (and to be as close as reasonable to the real situation), gaseous fuels have been considered causing energy related emissions[112] (this includes blast furnace gas derived from solid fuels), and solid fuels (coke, anthracite, residue oil and – for electric arc furnaces – carbon electrodes) process related emissions.

No other IPCC Sub-categories under IPCC Category 2C are reporting GHG emissions, hence IPCC Category *2C* = IPCC Sub-category *2C1 – Iron and Steel Production*.

4.4.1 Iron and Steel Production (2C1)

In 2007, iron and steel production was responsible for 29.4% of CO_2 emissions from industrial processes – but 61.7% in 1990 – and for 1.8% of the total CO_2 emissions estimated for Luxembourg. It represented 1.6% of the total GHG emissions in CO_2e (excluding LULUCF).

An overview of the iron and steel related CO_2 emissions is provided in Table 4-11.

Table 4-11 – CO_2 emissions trend, activity data and IEFs for IPCC Sub-category 2C1 – Iron and Steel Production: 1990-2007

2C1 - Iron & Steel Production *Emissions, AD, IEFs*				
Year	CO_2 Iron & Steel (Gg)	CO_2 Steel only (Gg)	Steel prod. BOF & EAF (t)	IEF kg CO_2/t steel
1990	984.91	404.48	3 506 230	115.36
1991	937.74	389.85	3 379 440	115.36
1992	853.29	353.98	3 068 463	115.36
1993	923.19	379.64	3 292 942	115.29
1994	770.83	328.42	3 073 268	106.86
1995	465.38	231.02	2 613 137	88.41
1996	416.60	210.51	2 501 828	84.14
1997	294.10	181.56	2 580 219	70.37
1998	140.69	140.69	2 476 909	56.80
1999	147.70	147.70	2 600 324	56.80
2000	146.05	146.05	2 571 243	56.80
2001	154.76	154.76	2 724 679	56.80
2002	155.40	155.40	2 736 000	56.80
2003	151.94	151.94	2 675 000	56.80
2004	152.45	152.45	2 684 000	56.80
2005	119.13	119.13	2 194 485	54.29
2006	170.49	170.49	2 802 049	60.85
2007	162.22	162.22	2 845 872	57.00

Sources: AD: plant operator ; Statec

112 Accounted for under IPCC Category 1A – Fuel Combustion Activities. See also Section 4.4.1.3 below.

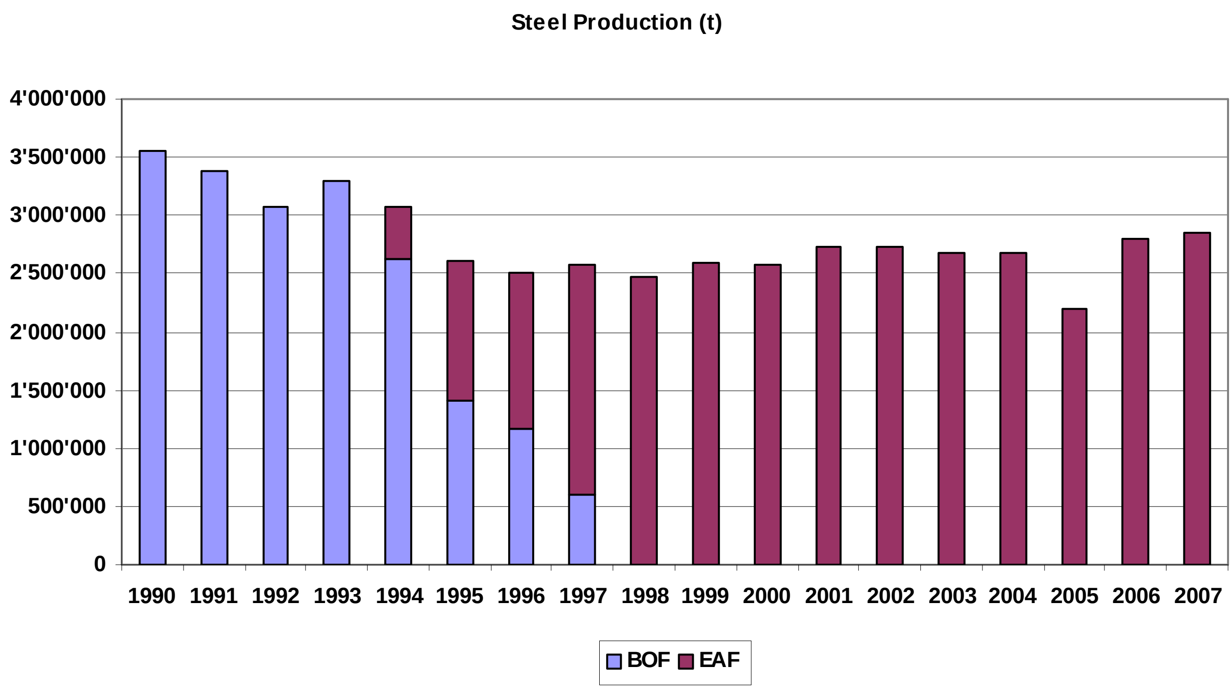
4.4.1.1 Key source

2C1 – Iron and Steel Production is a key source with regard to CO_2 emissions. It has been a key source since 1990: see Table 4-2 in Section 4.1.2.

4.4.1.2 Activity data

One sinter plant, two blast furnaces and three basic oxygen furnace steel plants (*BOF*) were operated in Luxembourg in 1990. In 2007, three electric arc furnaces (*EAF*) and one advanced multiple-heath furnace followed by a specially designed electric arc furnace (PRIMUS) remained. The shift from BOF steel production to the EAF steel production occurs between 1993 and 1997. The PRIMUS process was started in 2003. (see Figure 4-5).

Figure 4-5 – Steel production according to BOF and EAF: 1990-2007



Several plants are considered:

<u>*Sinter Plant (SP)*</u>
In the sinter plant iron ore and other iron-containing materials are agglomerated prior to the introduction into the blast furnace. Process emissions occur from the oxidation of the carbonates in the iron ore.

<u>*Blast furnace (BF)*</u>
Mainly sinter (iron oxides), coke and other fuels are supplied to the blast furnace. CO_2 process emissions are associated with the use of carbon to convert iron oxide to pig iron. Coke and other

fuels serve not only as reducing agent but also to produce blast furnace gas as energy source which is recovered and used as fuel within the plant and in other steel industry processes and in a power station.

An energy balance serves to exclude double-counting of carbon from the consumption as reducing agent if this is already accounted for as fuel consumption in IPCC category *1A – Fuel Combustion Activities*.

Basic oxygen furnace steel production (BOF)
In the basic oxygen furnace, pig iron (4% C) is transformed to steel (0.13% C). During the process, the reduced carbon is released as CO_2.

Electric arc furnace steel production (EAF)
In the electric arc furnaces anthracite and carbon, including the consumption of the electrodes, are used as reducing agent with the result of CO_2 process emissions. The consumption of natural gas in the EAF is accounted for as energy consumption and, consequently, reported under IPCC Sub-category *1A2a – Iron and Steel*.

PRIMUS® process (PRIMUS)
The PRIMUS process consists of a combination of an advanced multiple-heath furnace and a specially designed electric arc furnace. Steelmaking dust is transformed into iron. Process emissions occur from raw material (steelmaking dust) and reducing agents (anthracite, carbon and the consumption of the electrodes).

Activity data for iron production (*BF*) and steel production (*BOF & EAF*) are collected from STATEC's Statistical Yearbook. They have been supplemented by information received directly from the operator. This is the case for sinter production (*SP*) and for the steel production breakdown between BOF & EAF between 1993 and 1997.

The activity data for the PRIMUS® process is based on the introduced filter dust.

The production data for the steel production in 1990 (*BOF*) was corrected based on detailed information from the TÜV Rheinland 1992-1993 study. It is assumed that the 1990 value of 3 560 290 tonnes for BOF in STATEC's Statistical Yearbook is a typing error.

Table 4-12 summarizes iron and steel production by process.

Table 4-12 – Iron and steel production by process: 1990-2007

2C1 - Iron & Steel Production *Steel Production (t)*					
Year	SP	BF	BOF	EAF	Primus
1990	4 804 000	*2 645 200*	*3 506 230*	*NO*	*NO*
1991	4 567 000	*2 463 000*	*3 379 440*	*NO*	*NO*
1992	4 152 000	*2 255 200*	*3 068 463*	*NO*	*NO*
1993	4 561 000	*2 412 000*	*3 288 847*	*4 095*	*NO*
1994	3 747 000	*1 926 890*	*2 627 278*	*445 990*	*NO*
1995	1 977 700	*1 028 230*	*1 410 469*	*1 202 668*	*NO*
1996	1 810 970	*829 010*	*1 168 070*	*1 333 758*	*NO*
1997	1 002 815	*438 030*	*597 814*	*1 982 405*	*NO*
1998	NO	*NO*	*NO*	*2 476 909*	*NO*
1999	NO	*NO*	*NO*	*2 600 324*	*NO*
2000	NO	*NO*	*NO*	*2 571 243*	*NO*
2001	NO	*NO*	*NO*	*2 724 679*	*NO*
2002	NO	*NO*	*NO*	*2 736 000*	*NO*
2003	NO	*NO*	*NO*	*2 675 000*	*NO*
2004	NO	*NO*	*NO*	*2 684 000*	*NO*
2005	NO	*NO*	*NO*	*2 194 485*	*29 263*
2006	NO	*NO*	*NO*	*2 802 049*	*38 942*
2007	NO	*NO*	*NO*	*2 845 872*	*46 446*

Sources: AD: plant operator ; Statec

Note: STATEC's 1990 value for BOF replaced by TÜV Rheinland 1992-1993 study reported value.

4.4.1.3 Methodological issue

Sinter Plant (SP)

The emissions in 1990 are calculated from the mass of carbon in the ore. It is therefore a country specific methodology. The data were collected directly from the operator.

Table 4-13 – Background data for the calculation of CO_2 emissions – Sinter Plant

Raw material	Tonnes (dry)	% C	Gg CO_2
Minettes calcaires	2 043 408	4.38	328.16
Minettes silicieuses	908 957	1.57	52.27
Total	2 952 365	NA	380.43

A country specific methodology has been applied for the years 1991 to 1997 based on the emission factor determined for the year 1990:

$$CO_2\ Emissions_{SP} = EF_{SP} \bullet Sinter\ Production$$

Blast furnace (BF) and basic oxygen furnace steel production (BOF)

The 2000 IPCC-GPG Tier 2 methodology is applied for calculating the emissions in 1990.

The emissions from iron production in BF and from steel production in BOF are calculated separately based on a carbon balance over the production processes.

$$Emissions_{BF} = E_{Iron} = (C_{Reducing\ Agent} + C_{Ore} - C_{Iron}) \bullet 44/12$$

$$Emissions_{BOF} = E_{Steel} = (C_{Iron} + C_{Scrap} + C_{AddBOF} - C_{Steel}) \bullet 44/12$$

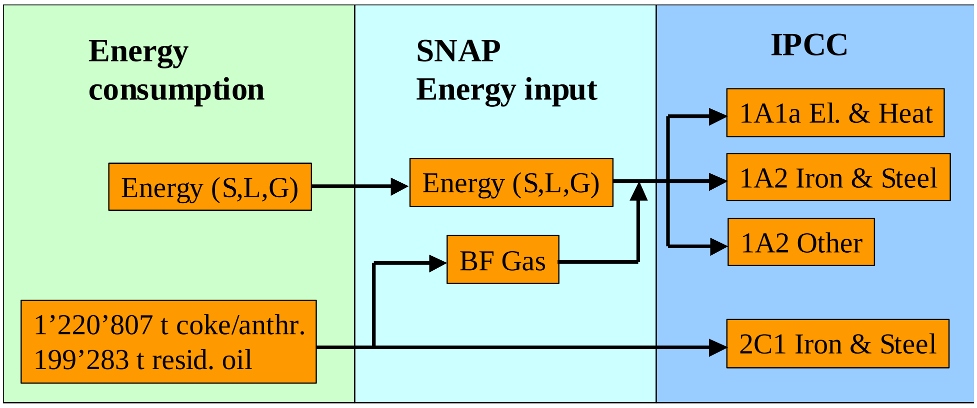
With:

$C_{Reducing\ Agent}$	= carbon serving as reducing agent: calculated from the energy balance over the iron and steel production, see below
C_{Ore}	= additional C-input from Iron ore and Iron scrap into the BF: 3 841 t iron ore (1.57% C, plant specific) + 6 222 t iron scrap (4% C, IPCC default)
C_{Iron}	= 2 645 200 t Iron (4% C, IPCC default)
C_{Scrap}	= 1 296 470 t Steel Scrap (0.4%, ETS default)
C_{AddBOF}	= Additional C-input in BOF: 19 532 t Ferromangan (4% C, plant specific), 1 688 t Carbon 95 (95% C, plant specific), 2 671 t Carbon 98 (98% C, plant specific)
C_{Steel}	= 5 506 230 t Steel (0.13% C, plant specific)

Activity data, as indicated above, were collected from the operator [TÜV Rheinland, 1992-1993].

The carbon accounted for reducing agent ($C_{Reducing\ Agent}$) in the blast furnace is determined from the energy balance over the iron and steel industry.

Figure 4-6 – Energy balance iron and steel industry – flow chart



In 1990, the overall energy consumption in the iron and steel industry was compared with the energy input into the different SNAP Categories reported in the CORINAIR inventory. 1 180 646 t coke, 40 027 t anthracite and 199 283 t residual oil are accounted to be transformed partly into blast furnace gas which is then fed with the remaining solid, liquid and gaseous fuels into the CORINAIR SNAP Categories and further on into the different IPCC Energy Sub-categories 1A1a, 1A2a and 1A2f. The remaining part of the blast furnace gas carbon serves as reducing agent that is reported under IPCC Sub-category 2C1:

$$C_{Reducing\ Agent} = C_{2C1} = C_{(1\ 220\ 807\ t\ coke/anthracite\ +\ 199\ 283\ t\ residual\ oil)} - C_{BFGas}$$

From the 1990 energy balance (Table 4-14), 160.05 Gg carbon (C) serves as reducing agent in the blast furnace.

Table 4-14 – Energy balance iron and steel industry: 1990

Energy	tonnes	% C		Gg C
Coke	1 180 646	90.33		1066.48
Anthracite	40 027	95.00		38.03
Oil	199 283	85.75		170.88
Energy	**GJ**	**kg CO_2/ GJ**	**kg C/ GJ**	**Gg C**
BFGas	15 851 000	258.00	70.36	1115.33
				Gg C
C Reducing Agent				160.05

Therefore, the resulting carbon dioxide emissions for the iron and steel production in 1990 equal:

$$CO_2\ Emissions_{BF} = 200.00\ Gg\ CO_2$$

$$CO_2\ Emissions_{BOF} = 404.48\ Gg\ CO_2$$

For the subsequent years (1991 to 1997), a country specific methodology has been applied based on the emission factor determined for the year 1990:

$$CO_2\ Emissions_{BF} = EF_{BF} \bullet Pig\ Iron\ Production$$

$$CO_2\ Emissions_{BOF} = EF_{BOF} \bullet Steel\ Production$$

Electric arc furnace steel production (EAF)

The 2004 ETS guidelines are applied for calculating the emissions in 2007.

The emissions are calculated based on a carbon balance over the production process.

$$E_{Steel} = (C_{Scrap} + C_{Electrodes} + C_{Carbon} + C_{Anthracite} - C_{Steel}) \bullet 44/12$$

It is assumed that C_{Scrap} equals C_{Steel}.

The activity data are collected from the individual EAF (consumption of electrodes, carbon and anthracite with their respective carbon contents).

The resulting emissions for the steel production in 2007 are:

$$2007 - CO_2\ Emissions_{EAF} = 162.22\ Gg\ CO_2$$

$$2006 - CO_2\ Emissions_{EAF} = 170.49\ Gg\ CO_2$$

$$2005 - CO_2\ Emissions_{EAF} = 119.13\ Gg\ CO_2$$

$$2004 - CO_2\ Emissions_{EAF} = 152.45\ Gg\ CO_2$$

For the previous years (1993 to 2003), a country specific methodology has been applied based on the emission factor determined for the years 2004 to 2006:

$$CO_2\ Emissions_{EAF} = EF_{EAF} \bullet Steel\ Production$$

PRIMUS® process (PRIMUS)

The ETS 2004 guidelines are applied for calculating the emissions in 2007.

$$E_{Primus} = (C_{Raw\ materials} + C_{Electrodes} + C_{Carbon} + C_{Anthracite} - C_{Products})\ x\ 44/12$$

It is assumed that $C_{Products}$ equals zero (Source: ETS declaration).

The activity data are collected from the operator (consumption of electrodes, carbon and anthracite with their respective carbon contents).

The resulting emissions in 2007 are:

$$Emissions_{PRIMUS} = 41.27\ Gg\ CO_2$$

The same methodology is applied for the years 2005 and 2006.

The emissions for the years 2003 and 2004 are estimated based on the relative carbon consumption (Table 4-15, Source: plant operator) and the average ratio of the CO_2 emissions per carbon consumption for the years 2005-2007.

Table 4-15 – Carbon consumption of the Primus process

Year	Carbon consumption (t)
2003	2'376
2004	6'592
2005	11'781
2006	12'850
2007	13'302

4.4.1.4 Emission factors

For **SP, BF and BOF**, EFs are calculated from the determined CO_2 emissions and the production data in 1990. The EF is kept constant for the subsequent years 1991 to 1997: see Table 4-16.

Table 4-16 – EFs for SP, BF and BOF

Production (1990)	Emissions (1990)	EF
4 804 000 t sinter	380.44 Gg CO_2	EF_{SP} = 79.19 kg CO_2 / t sinter
2 645 200 t iron	200.00 Gg CO_2	EF_{BF} = 75.61 kg CO_2 / t iron
3 506 230 t steel	404.48 Gg CO_2	EF_{BOF} = 115.36 kg CO_2 / t steel

For **EAF**, the EF_{EAF} is calculated from the determined CO_2 emissions and the production data.

For the period from 1993 to 2004, the EF is equal to the one determined for the year 2004. For the years 2005 and 2006, EFs are recalculated for each year: see Table 4-17.

Table 4-17 – EFs for EAF

Production (2004)	Emissions (2004)	EF
2 684 000 t steel	152.45 Gg CO_2	EF_{EAF} = 56.80 kg CO_2 / t steel
Production	**Emissions**	**EF_{EAF} *(kg CO_2 / t steel)***
2005 – 2 194 485 t steel	2005 – 119.13 Gg CO_2	54.29
2006 – 2 802 049 t steel	2006 – 170.49 Gg CO_2	60.85
2007 – 2 45 872 t steel	2007 – 162.22 Gg CO_2	57.00

The calculated plant-specific emission factor for steel production in 2004 (EF_{EAF} = 56.80 kg CO_2 / t steel) is consistent with the calculated emission factors according to the 2004 ETS Guidelines for the three EAF for the years 2005 (EF_{EAF} = 54.29 kg CO_2 / t steel) and 2006 (60.85 kg CO_2 / t steel).

For the PRIMUS® process, the implied emission factors $EF_{PRIMUS,}$ for the years 2005-2007, are calculated from the determined CO_2 emissions and the introduced filter dust (Table 4-18).

Table 4-18 – AD, emissions and IEF for Primus

Year	Filter dust (t)	Emissions (Gg CO_2)	EF_{PRIMUS} (Mg CO_2 / t dust)
2005	36'211	33.79	1.15
2006	44'296	39.30	1.01
2007	49'174	41.27	0.89

4.4.1.5 Uncertainties

Table 4-19 gives the error values which are assumed on the various calculation parameters for the uncertainty assessment.

Table 4-19 – Error values (%) for uncertainty assessment

Step	Error (%) IPCC GPG 2000 Chapter 3.1.3.1	Error (%) Plant-specific estimation
1) Amount of reducing agent for iron production	5	5
2) Pig iron activity data / Steel activity data	a few	2
3) Carbon content of pig iron and iron ore (plant-specific data are available)	5	5
4) emission factors uncertainties	5	5

Combined resulting errors (uncertain quantities are to be combined by multiplication):

- Emissions uncertainty (1990: 1), 2), 3), 4)) .... 8.9 %

- Emissions uncertainty (2004: 2), 4).................... 5.4 %

4.4.1.6 Category specific QA/QC procedures

Activity and energy data for 1990 have been cross-checked with the activity data available in STATEC's Statistical Yearbook as well as with those provided by the operator directly or through the TÜV Rheinland 1992-1993 study. The iron and steel IPCC Sub-categories 1A2a (fuel combustion) and 2C1 (process emissions) have been cross-checked to avoid double counting.

The calculated plant-specific emission factor for steel production in 2004 (EF_{EAF} = 56.80 kg CO_2 / t steel) is consistent with the calculated emission factors for the 3 EAF for the years 2005 (EF_{EAF} = 54.29 kg CO_2 / t steel)and 2006 according to the ETS guidelines 2004 (60.85 kg CO_2 / t steel).

4.4.2 Ferroalloys Production (2C2)

There are no dedicated plants for producing ferroalloys in Luxembourg.

4.4.3 Aluminium Production (2C3)

Aluminium production in Luxembourg is made out of aluminium scraps. There is, therefore, no primary aluminium production. The production from aluminium scraps is generating only fuel combustion emissions – hence, no process emissions – and is, therefore, reported under IPCC Sub-category *1A2b – Non-Ferrous Metals*.

4.4.4 Recalculations

Table 4-20 presents the main revisions and recalculations done since the submission 2008v1.2 relevant to IPCC subcategory 2C.

Table 4-20 – Changes in GHG inventories since submissions 2008v1.2

GHG source & sink category	Revisions 2008v1.2 → 2009v1.4	Type of revision
2C1	PRIMUS process added	activity added

4.4.5 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 4-21 will be explored.

Table 4-21 – Planned improvements for IPCC Category 2C – Metal Production

GHG source & sink category	Planned improvement
2C1 – Iron and Steel Production	application of the mass balance approach according to the ETS guidelines.

4.5 Other Production (2D)

There are no emissions to be reported for the food and drink industry for Luxembourg.

4.6 Production of Halocarbons and SF_6 (2E)

This source category does not exist in Luxembourg.

4.7 Consumption of Halocarbons and SF_6 (2F)

This section describes the estimation of F-gases emissions resulting from industrial processes (production, consumption). In 2007, F-gases represented 0.7% of the total GHG emissions in CO_2e (excluding LULUCF). This percentage was only 0.13% in 1990. As shown by Figure 4-2 in Section 4.1.1, F-gases related emissions experienced a major increase between 1990 and 2007.

4.7.1 Key source

2F – Production of Halocarbons &SF_6 is a key source with regard to F-gas emissions since 1999: see Table 4-2 in Section 4.1.2.

4.7.2 Activity data

A first estimation of the emissions of fluorinated GHG types (HFCs, PFCs and SF_6) has been undertaken end 1999 by the Environment Agency and Luxembourg's *Centre de Ressources des Technologies pour l'Environnement* (*CRTE*). The study tried to establish F-gas emissions for the years 1995, 2000, 2005 and 2010. F-gas emission estimates presented in Table 4-22 are the result of that work.

The following sources have been identified:

- 2(I) F Consumption of Halocarbons and SF_6;
- 2(I) F1 Refrigeration and Air Conditioning Equipment;
- 2(I) F 2 Foam Blowing;
- 2(I) F 4 Aerosols/Metered Dose Inhalers;
- 2(I) F 7 Electrical Equipment;
- 2(I) F 8 Other (windows containing SF_6).

Neither PFC applications nor PFC emission sources have been identified in Luxembourg so far.

Finally, Luxembourg has chosen 1995 as the base year for HFCs, PFCs and SF_6.

Table 4-22 – Estimated emissions of HFCs and SF_6: 1995-2010

Application	IPCC Category	1995	2000	2005	2010
		Mg CO_2e			
Stationary cooling installations	2(I) F1	2 088	12 670	33 720	46 810
Mobile cooling installations		4 160	21 388	39 006	48 762
High voltage electrical equipments	2(I) F8	576	956	956	1 076
Vaporizers (medical applications)	2(I) F4	4	2 737	3 650	3 650
Filling of car tires		0	0	0	0
Noise reduction windows	2(I) F9	2 332	2 565	2 822	3 104
Foam blowing	2(I) F2	7 366	6 266	6 266	6 266
Sum	**2(I) F**	**16 526**	**46 582**	**86 420**	**109 668**

Source: Environment Agency and CRTE analysis.

4.7.3 Methodological issues

Emission estimates for the years 1996 to 1999, 2001 to 2004 and 2006 have been calculated with the respective trends 1995-2000, 2000-2005 and 2005-2010. The emissions from 1990 to 1994 are assumed to be equal to 1995 emissions since trend calculations are not possible for those years (it would actually lead to negative values).

A re-evaluation of the emission sources and the emissions of HFCs, PFCs and SF_6, taking into account the 2000 IPCC-GPG Guidelines as well as country specific considerations, is ongoing. In the meantime, the following approaches and hypothesis have been made:

F1 – Refrigeration and Air Conditioning Equipment

The stationary refrigeration and the mobile air conditioning are estimated using reported emissions by Germany expressed per capita with the relative population in Luxembourg.

F2 – Foam Blowing

The PU spray emissions are estimated using reported emissions by Germany expressed per capita with the relative population in Luxembourg.

F4 – Aerosols / Metered Dose Inhalers (MDI)

The MDI emissions are estimated from the reported MDI emissions by Germany per capita with the relative population in Luxembourg. Other aerosols have not been considered. In the new study, the other aerosol emissions account for about 1.5 Gg CO_2e.

F7 – Electrical Equipment

A country specific methodology is applied:

$$Emissions = EF \bullet AR$$

The activity rate (*AR*) is the estimated installed capacity with the total nameplate capacity from the largest operator in Luxembourg.

The yearly emissions are assumed to be 1% of the activity rate, i.e. EF=0.01.

F8 – Noise reduction windows
A country specific methodology is applied:

Emissions= *EF*● *AR*

The activity rate (*AR*) is the calculated SF_6 stock on the basis of the estimated installed noise reduction windows.

The yearly emissions are assumed to be 1% of the activity rate, i.e. EF=0.01.

4.7.4 Recalculations

No revisions and recalculations have been done since the submission 2008v1.2 to IPCC subcategory 2F.

4.7.5 Category specific QA/QC procedures

Preliminary results from the new study confirm that the levels of emissions reported for 1995 are reasonable.

4.7.6 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 4-23 will be explored.

Table 4-23 – Planned improvements for IPCC Category 2F – Consumption of Halocarbons and SF_6

GHG source & sink category	Planned improvement
2F – Consumption of Halocarbons & SF_6	complete re-evaluation including the results of a new study.

4.8 Selected references

ARBED (1990 – 1998): Annual communications from the operator to the Environment Agency Luxembourg. Luxembourg.

CORINAIR Guidebook (1996): Combustion in Energy & transformation industries - ps010101 Activities 010101 – 010105 - Table 21: Selection of relevant fuels from NAPFUE and lower heating values for boilers, gas turbines and stationary engines.

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ETS Emission Trading Scheme Guidelines 2004 – Commission Decision of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

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TÜV Rheinland (1992-1993) Impaktstudien für die ARBED-Werke Esch/Belval, Differdange und Esch-Schifflange für das Jahr 1990.

5 Solvent and Other Product Use (CRF sector 3)

5.1 Sector Overview

Chapter 5 includes information on and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under CRF Sector 3 – Solvent and Other Product Use for the period 1990 to 2007.

Solvents are chemical compounds, which are used to dissolve substances as paint, glues, ink, rubber, plastic, pesticides or for cleaning purposes (degreasing). Solvents used in products such as coatings, inks, and consumer products generally emit substances classified as VOCs (Volatile Organic Compounds). Because solvents consist mainly of NMVOC, solvent use is a major source for anthropogenic NMVOC emissions in Luxembourg. Once released into the atmosphere NMVOCs react with reactive molecules (mainly HO-radicals) or high energetic light to finally form CO_2.

Estimations for N_2O emissions from other product use (anaesthesia and aerosol cans) are also addressed in this chapter.

For more details on categories where emissions are not occurring and categories that are not estimated or included elsewhere, see section 5.1.2.

Other required information, as suggested in Annex I of document FCCC/SBSTA/2006/9, will be presented under each source category review (methodology, AD, EFs, etc.).

5.1.1 Emission Trends

In the year 2007, 0.15% of total GHG emissions in Luxembourg (18,8 Gg CO_2 equivalents) originated from *Solvent and Other Product Use*. 69% of these emissions were indirect CO_2 emissions, 31% were accounted for by N_2O emissions.

Figure 5-1 and Table 5-1 present the trend in total greenhouse gas emissions by subcategories.

Figure 5-1 - Emissions and trend from 1990 – 2007 by Sub-Categories of 3 - Solvent and Other Product Use.

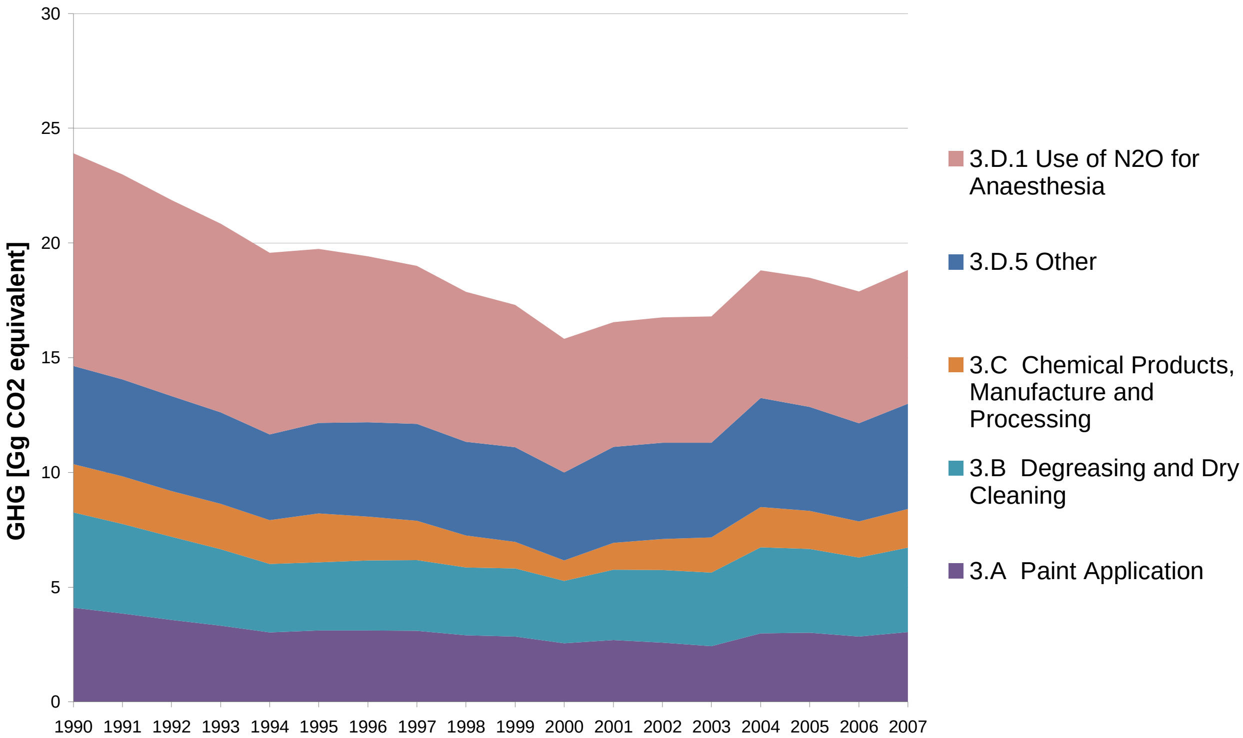

Table 5-1 - Emissions and trend from 1990 – 2007 by Sub-Categories of 3 - Solvent and Other Product Use.

GHG	3	3.A	3.B	3.C	3.D	3.D.1	3.D.2	3.D.3	3.D.4	3.D.5
	TOTAL	Paint Application	Degreasing and Dry Cleaning	Chemical Products, Manufacture and Processing	Total	Use of N_2O for Anaes-thesia	N_2O from Fire Extinguishers[113]	N_2O from Aerosol Cans	Other Use of N_2O	Other
	[Gg CO_2 equivalent]									
1990	23.90	4.09	4.16	2.11	13.54	9.26	NA	NE	NO	4.27
1991	22.98	3.84	3.91	2.07	13.16	8.92	NA	NE	NO	4.24
1992	21.88	3.58	3.62	2.00	12.68	8.56	NA	NE	NO	4.12
1993	20.85	3.32	3.33	1.99	12.21	8.23	NA	NE	NO	3.98
1994	19.57	3.02	2.98	1.92	11.66	7.91	NA	NE	NO	3.75
1995	19.74	3.10	2.98	2.12	11.53	7.58	NA	NE	NO	3.95
1996	19.42	3.12	3.05	1.92	11.34	7.23	NA	NE	NO	4.10
1997	19.00	3.10	3.08	1.72	11.10	6.89	NA	NE	NO	4.21
1998	17.88	2.90	2.95	1.40	10.62	6.55	NA	NE	NO	4.08

113 In Europe, and hence in Luxembourg, N_2O is not used in Fire Extinguishers (expert judgement). In the CRF tables NE is used, this will be revised in the next submission and changed to NA.

GHG	3	3.A	3.B	3.C	3.D	3.D.1	3.D.2	3.D.3	3.D.4	3.D.5
	TOTAL	Paint Application	Degreasing and Dry Cleaning	Chemical Products, Manufacture and Processing	Total	Use of N_2O for Anaesthesia	N_2O from Fire Extinguishers[113]	N_2O from Aerosol Cans	Other Use of N_2O	Other
					[Gg CO_2 equivalent]					
1999	17.30	2.85	2.96	1.17	10.32	6.19	NA	NE	NO	4.13
2000	15.81	2.56	2.72	0.90	9.64	5.82	NA	NE	NO	3.82
2001	16.54	2.69	3.07	1.17	9.61	5.43	NA	NE	NO	4.19
2002	16.76	2.58	3.16	1.36	9.66	5.47	NA	NE	NO	4.18
2003	16.80	2.43	3.20	1.53	9.63	5.51	NA	NE	NO	4.12
2004	18.80	2.98	3.76	1.75	10.31	5.56	NA	NE	NO	4.75
2005	18.47	3.02	3.65	1.66	10.15	5.62	NA	NE	NO	4.54
2006	17.88	2.85	3.44	1.57	10.02	5.74	NA	NE	NO	4.28
2007	18.81	3.04	3.68	1.68	10.41	5.83	NA	NE	NO	4.58
Trend 2006–2007	5%	7%	7%	7%	4%					7%
Trend 1990–2007	-21%	-26%	-12%	-20%	-23%					7%
Share in CRF 3 in 1990		17%	17%	9%	57%	39%				18%
Share in CRF 3 in 2007		16%	20%	9%	55%	31%				24%
Share in National Total 1990	0.18%	0.03%	0.03%	0.02%	0.10%	0.07%				0.03%
Share in National Total 2007	0.15%	0.02%	0.03%	0.01%	0.08%	0.05%				0.04%

Greenhouse gas emissions in this sector decreased by 21% between 1990 and 2007, due to decreasing solvent and N_2O use as well as due to the positive impact of the enforced laws and regulations in Luxembourg:

- Solvent Ordinance: for limitation of emission of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products in order to combat acidification and ground-level ozone[114];
- Ordinance for paint finishing system (surface technology systems): for limitation of emission of volatile organic compounds due to the use of organic solvents by activities such as surface coating, painting or varnishing of different materials and products along the entire chain in the painting process in order to combat acidification and ground-level ozone[115]

114 Règlement grand-ducal du 25 janvier 2006 relatif à la réduction des émissions de composés organiques volatils dues à l'utilisation de solvants organiques dans certains vernis et peintures et dans les produits de retouche de véhicules (implementation of Council Directive 2004/42/CE).

115 Règlement grand-ducal du 20 décembre 1995 relatif à certaines modalités d'application et à la sanction du règlement CE N° 3093/94 du Conseil du 15 décembre 1994 relatif à des substances qui appauvrissent la couche d'ozone.

- Ordinance for industrial facilities and installations applying chlorinated hydrocarbon: for limitation of emission of chlorinated organic solvents from industrial facilities and installations applying chlorinated hydrocarbon;
- Convention on Long-range Transboundary Air Pollution (LRTAP)[116], extended by eight protocols from which the following have relevance:
    - The 1988 Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes;[117]
    - The 1991 Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes;[118]
    - The 1998 Protocol on Persistent Organic Pollutants (POPs);[119]
    - The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone; 21 Parties.[120]
- Ordinance for volatile organic compounds (VOC) due to the use of organic solvents in certain activities and installations;[121]
- Council Directive 1999/13/EC of March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations;
- Council Directive 2004/42/CE of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC;
- Ordinance on the limitation of emission during the use of solvents containing lightly volatile halogenated hydrocarbons in industrial facilities and installations.[122]

But also the N_2O use has significantly decreased due to shorter duration of anaesthesia during operations and due to a mor frequent use of local anaesthetics than general anaesthesia.

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116 Loi du 18 juin 1981 portant approbation de la Convention sur la pollution atmosphérique transfrontière à longue distance, en date à Genève, du 13 novembre 1979. (Convention entered into force 16 March 1983; ratified by Luxembourg 15 July 1982)

117 Loi du 31 juillet 1990 portant approbation du Protocole à la Convention sur la pollution atmosphérique transfrontière à longue distance de 1979, relatif à la lute contre les émissions d'oxydes d'azote ou leurs flux transfrontières, fait à Sofia, le 31 octobre 1988. (Protocol entered into force 14 February 1991; ratified by Luxembourg 4 October 1990)

118 Loi du 29 juillet 1993 portant approbation du Protocole à la Convention sur la pollution atmosphérique transfrontière à longue distance, de 1979, relatif à la lutte contre les émissions de composés organiques volatils ou de leurs flux transfrontières, fait à Genève, le 18 novembre 1991. (Protocol entered into force 29 September 1997; ratified by Luxembourg 11.11.1993)

119 Loi du 24 décembre 1999 portant approbation du Protocole à la Convention sur la pollution atmosphérique transfrontière à longue distance, de 1979, relatif aux polluants organiques persistants, fait à Aarhus (Danemark), le 24 juin 1998. (Protocol entered into force on 23 October 2003; ratified by Luxembourg 01.05.2000)

120 Loi du 14 juin 2001 portant approbation du Protocole à la Convention de 1979 sur la pollution atmosphérique transfrontière à longue distance, relatif à la réduction de l'acidification, de l'eutrophisation et de l'ozone troposphérique, fait à Göteborg, le 30 novembre 1999. (Protocol ntered into force on 17 May 2005; ratified by Luxembourg 07.08.2001)

121 Règlement grand-ducal du 4 juin 2001 portant - application de la directive 1999/13/CE du Conseil du 11 mars 1999 relative à la réduction des émissions de composés organiques volatils dues à l'utili-sation de solvants organiques dans certaines activités et installations; - modification du règlement grand-ducal modifié du 16 juillet 1999 portant nomenclature et classification des établissements classés.

122 Règlement grand-ducal du 12 juillet 1995, relatif aux générateurs d'aérosols.

5.1.2 Completeness

Table 5-2 gives an overview of the IPCC categories included in this chapter and presents the transformation matrix from SNAP categories. It also provides information on the status of emission estimates of all subcategories. A "✓" indicates that emissions from this sub-category have been estimated.

Table 5-2 - Overview of subcategories of IPCC Category 3 - Solvents and Other Product Use: correlance with SNAP codes and status of estimation.

IPCC Category		SNAP		CO_2	N_2O
3.A	Paint application	0601	Paint application	✓	NA
3.B	Degreasing and Dry Cleaning	0602	Degreasing, dry cleaning and electronics	✓	NA
3.C	Chemical Products, Manufacture and Processing	0603	Chemical products manufacturing and processing	✓	NA
3.D	Other	0604	Other use of solvents and related activities	✓	NA
		0605	Use of HFC, N_2O, NH_3, PFC and SF_6	NA	✓

5.2 CO_2 Emissions from Solvent and Other Product Use (3A, 3B, 3C and 3D5)

5.2.1 Methodology Overview

CO_2 emissions from solvent use were calculated from NMVOC emissions of this sector. As a first step the quantity of solvents used and the solvent emissions were calculated. To determine the quantity of solvents used, in Luxembourg, in the various applications, a bottom up and a top down approach were combined. Figure 5-2 to Figure 5-4 present an overview of the methodology.

The top down approach provides total quantities of solvents used in Luxembourg. The share of solvents used for the different applications and the solvent emission factors have been calculated on the basis of the bottom up approach. It was based on the economic structure in Luxembourg, applying solvent use and emission factors from the Austrian survey By linking the results of bottom up and top down approach, quantities of solvents annually used and solvent emissions for the different applications were obtained.

This model has been developed for Austria[123] (WINDSPERGER et al. 2002a, 2004) and was in the meantime applied for different europeen countries within the network "non-energy use of fossils and CO_2 emissions" (WINDSPERGER & STEINLECHNER, 2006). The application for Luxembourg is

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suitable as both countries show similar situation regarding economic and technical structure, and moreover as members of the EU similar legal framework conditions.

Figure 5-2 - Top-down-Approach compared to Bottom-up-Approach.

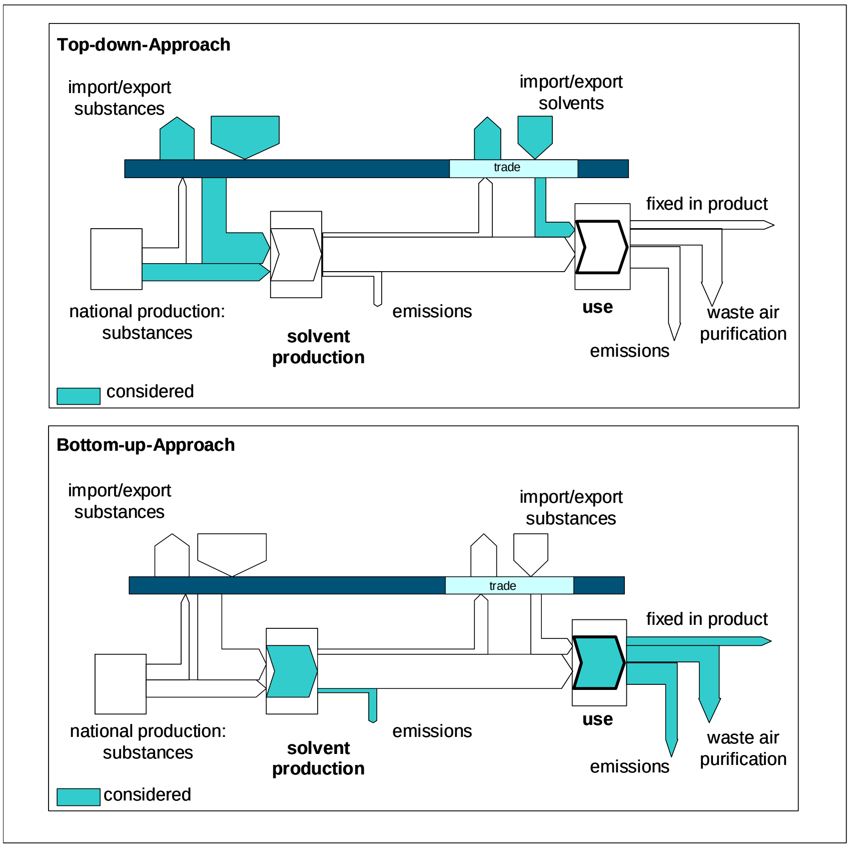

Figure 5-3 - Overview of the methodology for solvent emissions.

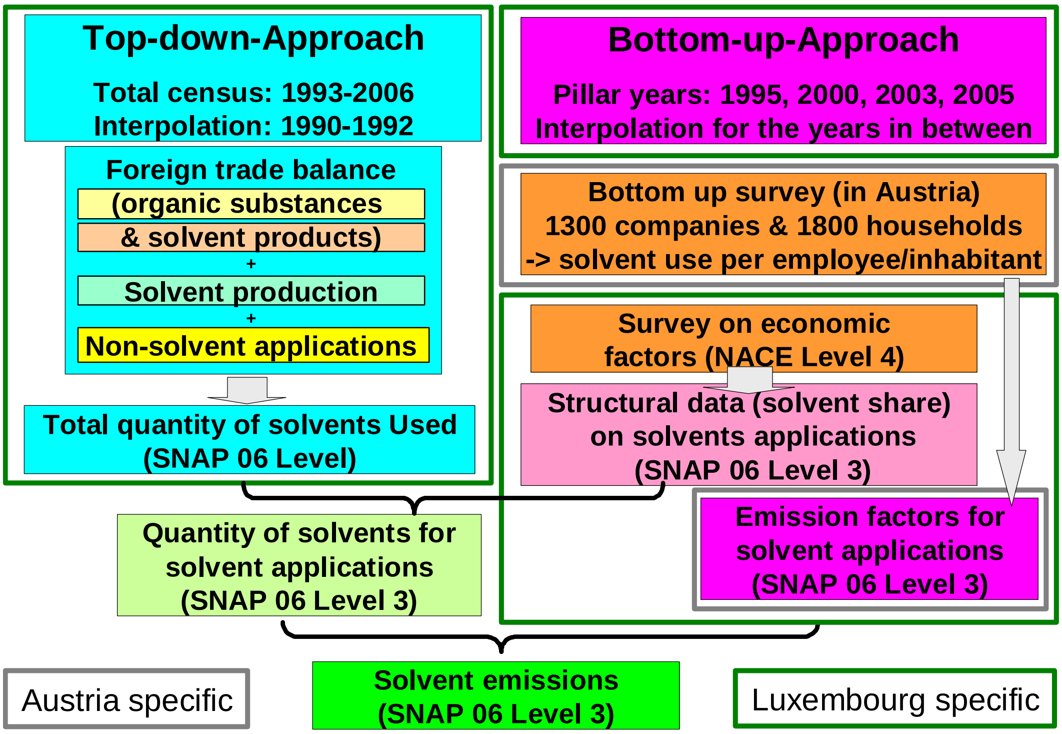

Figure 5-4 - Data of Top-down-Approach and Bottom-up-Approach for 2005.

Top-down – CRF Sector 3

Item	Value
Imp/Exp Solvent products	4
Inland Solvent production	2
Imp/Exp Organic Substances	33
Non-solvent applications	-31
Substances used as solvents	2
Solvents in applications	4
Solvent Activity	8

Bottom-up / Combination Top-down to Bottom-up

CRF Sector 3A-3D	SNAP Level 3		Solvent Share CRF 3	Solvent Share CRF 3A-D	Solvent Share SNAP Lev 3	Solvent Emission Factor CRF 3	Solvent Emission Factor CRF 3A-D	Solvent Emission Factor SNAP Lev 3	Solvent Activity CRF 3	Solvent Activity CRF 3A-D	Solvent Activity SNAP Lev 3	Solvent Emissions CRF 3	Solvent Emissions CRF 3A-D	Solvent Emissions SNAP Lev 3
3 A, Paint application	060101	Manufacture of automobiles	100%	26%	0,3%	**68%**	67%	64%	**7,9**	2,0	0,0	**5,3**	1,4	0,0
	060102	Car repairing			1,0%			86%			0,1			0,1
	060103	Construction and buildings			6,6%			89%			0,5			0,5
	060104	Domestic use			1,3%			89%			0,1			0,1
	060105	Coil coating			2,4%			52%			0,2			0,1
	060107	Wood coating			2,3%			90%			0,2			0,2
	060108	Other industrial paint application			11,9%			50%			0,9			0,5
3 B, Degreasing and Dry Cleaning	060201	Metal degreasing		31%	13,6%		51%	29%		2,4	1,1		1,2	0,3
	060202	Dry cleaning			0,3%			84%			0,0			0,0
	060203	Electronic components manufact.			0,0%			82%			0,0			0,0
	060204	Other industrial cleaning			16,7%			68%			1,3			0,9
3 C, Chemical Products, Manufacture and Processing	060305	Rubber processing		10%	6,3%		83%	93%		0,8	0,5		0,6	0,5
	060306	Pharmaceutical products manufact.			0,7%			26%			0,1			0,0
	060307	Paints manufacturing			0,5%			100%			0,0			0,0
	060308	Inks manufacturing			0,7%			100%			0,1			0,1
	060309	Glues manufacturing			0,0%			100%			0,0			0,0
	060310	Asphalt blowing			0,7%			1%			0,1			0,0
	060311	Adhesive, films & photographs			0,0%			94%			0,0			0,0
	060312	Textile finishing			0,0%			90%			0,0			0,0
	060314	Other manufacturing			0,9%			100%			0,1			0,1
3 D, Other	060403	Printing industry		34%	9,7%		79%	65%		2,7	0,8		2,1	0,5
	060404	Fat and oil extraction			0,3%			20%			0,0			0,0
	060405	Application of glues and adhesives			0,0%			63%			0,0			0,0
	060406	Preservation of wood			0,1%			99%			0,0			0,0
	060407	Treatment & conservation of vehicles			0,3%			85%			0,0			0,0
	060408	Domestic solvent use (other)			17,3%			84%			1,4			1,1
	060411	Domestic use of pharmac. products			4,0%			94%			0,3			0,3
	060412	Other (preservation of seeds,...)			2,1%			78%			0,2			0,1

A study compiled for Austria (WINDSPERGER et al. 2002a) showed huge overestimation of NMVOC emissions when emission estimates are based on a top down approach only because a large amount of substances is used for "non-solvent-applications". "Non-solvent applications" are applications where substances usually are used as feed stock in chemical, pharmaceutical or petrochemical industry (e.g. production of MTBE/ETBE, formaldehyde, polyester, biodiesel, pharmaceuticals etc.) and where therefore no emissions from "solvent use" arise. However, there might be emissions from the use of the produced products, such as MTBE/ETBE which is used as fuel additive and finally combusted; these emissions are considered in the transport sector.

Additionally, the comparison of the top-down and the bottom-up approaches helped to identify several quantitatively important applications like windscreens wiper fluids, antifreeze, moonlighting, hospitals, deicing agents of aeroplanes, tourism, which were not considered in the top-down approach.

5.2.2 Top down Approach

The top-down approach is based on:

1. import-export statistics on solvent substances and solvent containing products (foreign trade balance) (STATEC);
2. production statistics on solvents in Luxembourg;
3. a survey on non-solvent-applications in companies in Austria (Windsperger et al. 2004a);
4. survey on the solvent content in products and preparations at producers and retailers in Austria (Windsperger et al. 2002a).

ad (1) and (2): Total quantity of solvents used in Luxembourg were obtained from import-export statistics and production statistics provided by STATEC.

Nearly a full top down investigation of substances of the import-export statistics from 1993 to 2007 was carried out (data 1990 – 1992 were interpolated). One problem is that the methodology of the import-export statistics changed over the years. In case of severe deviations between some years smoothing the time series with the mean values was used.

In Luxembourg, there are only few facilities producing solvents. The production of solvents considerably decreased, especially in the last years.

ad (3): In a study on the comparison of top down and bottom up approach in Austria (WINDSPERGER et al. 2002a), the amount of solvents used in "non-solvent-applications" was identified. The most important companies in Austria were identified and asked to report the quantities of solvents they used over the considered time period in „non-solvent-applications". In combination with import-export statistic for these solvent substances the percentages of „non-solvent-applications" were calculated.

For Luxembourg, these percentages of "non-solvent-applications" were adapted to the country's specific situation according to information from companies in Luxembourg.

ad (4): Relevant producers and retailers provided data on solvent content in products and preparations in Austria. These data were also adapted to Luxembourg due to the country specific situation.

5.2.3 Bottom up Approach

In a first step, an extensive survey on the use of solvents in the year 2000 was carried out in 1 300 Austrian companies (WINDSPERGER et al. 2002b). In this extensive survey data about the solvent content of paints, cleaning agents etc. and on solvents used (both substances and substance categories) like acetone or alcohols were collected.

Furthermore, information was gathered on:

- type of application of the solvents:"final application", "cleaner" and "product preparation" as well as
- actual type of waste gas treatment: "open application", "waste gas collection" and "waste gas treatment".

For every category of application and waste gas treatment an emission factor was estimated to calculate solvent emissions in the year 2000 (see Table 5-3).

The survey in 1 300 Austrian companies in the year 2000 was carried out at all industrial branches with solvent applications at NACE-level-4. Within these NACE-levels data on solvent use distinguished in substance categories was collected from the companies and a factor of "solvent use per employee" was calculated. For the calculation of the total amounts within the SNAP-digit (level 3) the number of employees in the respective NACE-levels in 2000 was used (WINDSPERGER et al.

2002b). In accordance with statistics in other European countries the structural business statistics (number of employees (NACE Rev.1.1)) were taken from EUROSTAT 2008 [124].

Table 5-3 - Emission factors for NMVOC emissions from Solvent Use.

Category	Factor
final application	1.00
cleaner	0.85
product preparation	0.05
open application	1.00
waste gas collection	0.50
waste gas treatment	0.20

In a second step a survey in 1 800 households was made (WINDSPERGER et al. 2002a) for estimating the domestic solvent use (37 categories in 5 main groups: cosmetic, do-it-yourself, household cleaning, car, fauna and flora). Also, solvent use in the context of moonlighting besides commercial work and do-it-yourself was calculated.

The comparison of top down and bottom up approach helped to identify several additional applications, that make an important contribution to the total amount of solvents used. Thus in a third step the quantities of solvents used in these applications such as windscreens wiper fluids, antifreeze, hospitals, de-icing agents of aeroplanes, tourism were estimated in surveys.

The outcome of these three steps was the total amount of solvents used for each application in the year 2000 (at SNAP level 3) in Austria (WINDSPERGER et al. 2002a).

To adapt the values for Luxembourg coefficients of the solvent consumption per employee (respective inhabitant) were used and applied to the employees of the industry sectors in Luxembourg (resp. Inhabitants). The outcome was the total amount of solvents for every application in the year 2000 in Luxembourg.

To achieve a time series, the development of the economic and technical situation in relation to the year 2000 was considered. It was distinguished between "general aspects" and "specific aspects" (see Table 5-4, Table 5-5 and Table 5-6). The information about these defined aspects were collected for two pillar years (1990 and 1995) and were taken from several studies (SCHMIDT et al. 1998, BARNERT 1998) and expert judgements from associations of industries (chemical industry, printing industry, paper industry) and other stakeholders. On the basis of this information calculation factors were estimated. With these factors and the data for solvent use and emission of 2000 data for

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the two pillar years was estimated. For the years in between, data was linearly interpolated. Since 2000, no new survey has been conducted so that the data remain constant since then.

Table 5-4 - General aspects and their development.

General aspects	1990	1995	2000	2005
efficiency factor solvent cleaning	150%	130%	100%	100%
efficiency factor application	110%	105%	100%	100%
solvent content of water-based paints	12%	10%	8%	8%
solvent content of solvent-based paints	58%	55%	55%	55%
efficiency of waste gas purification	75%	78%	80%	80%

Table 5-5 - Specific aspects and their development: distribution of the used paints (water based-paints – solvent-based paints) and part of waste gas purification (application – purification).

SNAP category	description	year	Distribution of used paints		Part of waste gas treatment	
			Solvent based paints	Water based paints	application	Purification
060101	manufacture of automobiles	2005	73%	27%	10%	0%
		2000	73%	27%	10%	0%
		1995	80%	20%	8%	0%
		1990	90%	10%	5%	0%
060102	car repairing	2005	51%	49%	62%	1%
		2000	51%	49%	62%	1%
		1995	55%	45%	60%	0%
		1990	75%	25%	10%	0%
060107	wood coating	2005	46%	54%	46%	3%
		2000	46%	54%	46%	3%
		1995	60%	40%	45%	2%
		1990	85%	15%	10%	0%
060108	Other industrial paint application	2005	97%	3%	90%	46%
		2000	97%	3%	90%	46%
		1995	99%	1%	87%	45%
		1990	100%	0%	26%	20%
060201	Metal degreasing	2005	92%	8%	75%	0%
		2000	92%	8%	75%	0%
		1995	95%	5%	65%	0%
		1990	100%	0%	10%	0%
060403	Printing industry	2005			44%	17%
		2000			44%	17%
		1995			29%	10%
		1990			10%	5%
060405	Application of glues and adhe-sives	2005			58%	0%
		2000			58%	0%
		1995			53%	0%
		1990			15%	0%
060103	Paint application : construction and buildings	2005	91%	9%	19%	4%
		2000	91%	9%	19%	4%
		1995	93%	7%	15%	2%
		1990	100%	0%	5%	0%

SNAP category	description	year	Distribution of used paints		Part of waste gas treatment	
			Solvent based paints	Water based paints	application	Purification
060105	Paint application : coil coating	2005	100%	0%	63%	0%
		2000	100%	0%	63%	0%
		1995	100%	0%	60%	0%
		1990	100%	0%	25%	0%
060406	Preservation of wood	2005	83%	17%	0%	0%
		2000	83%	17%	0%	0%
		1995	85%	15%	0%	0%
		1990	95%	5%	0%	0%
060412	Other (preserva-tion of seeds,…)	2005	100%	0%	90%	0%
		2000	100%	0%	90%	0%
		1995	100%	0%	80%	0%
		1990	100%	0%	10%	0%

Table 5-6 - Specific aspects and their development: changes in the number of employees compared to the year 2000

SNAP	Description	Changes in the number of employees compared to the year 2000				
		1990	1995	2000	2003	2005
0601	Paint application					
060101	manufacture of automobiles	106%	106%	100%	134%	163%
060102	car repairing	93%	93%	100%	120%	125%
060103	construction and buildings	93%	93%	100%	120%	128%
060104	domestic use			separate analysed		
060105	coil coating	106%	106%	100%	32%	38%
060107	wood coating	93%	93%	100%	117%	126%
060108	industrial paint application	93%	93%	100%	100%	110%
0602	Degreasing, dry cleaning and electronics					
060201	Metal degreasing	117%	117%	100%	100%	88%
060202	Dry cleaning	94%	94%	100%	103%	106%
060203	Electronic components manufacturing	3%	3%	100%	96%	165%
060204	Other industrial cleaning	76%	76%	100%	134%	143%
0603	Chemical products manufacturing and processing					
060305	Rubber processing	190%	190%	100%	199%	198%
060306	Pharmaceutical products manufacturing	88%	88%	100%	194%	134%
060307	Paints manufacturing	133%	133%	100%	111%	111%
060308	Inks manufacturing	89%	89%	100%	94%	93%
060309	Glues manufacturing	NO	NO	NO	NO	NO
060310	Asphalt blowing	218%	218%	100%	103%	104%
060311	Adhesive, magnetic tapes, films and photographs	84%	84%	100%	70%	70%
060312	Textile finishing	119%	119%	100%	6%	7%
060314	Other	88%	88%	100%	87%	132%
0604	Other use of solvents and related activities					
060403	Printing industry	90%	90%	100%	111%	103%
060404	Fat, edible and non edible oil extraction	0%	0%	100%	155%	177%
060405	Application of glues and adhesives	NO	NO	NO	NO	NO
060406	Preservation of wood	91%	91%	100%	245%	125%
060407	Under seal treatment and conservation of vehicles	71%	71%	100%	102%	102%
060408	Domestic solvent use (other than paint application			analysed separately		
060411	Domestic use of pharmaceutical products (k)					

SNAP	Description	Changes in the number of employees compared to the year 2000				
		1990	1995	2000	2003	2005
060412	Other (preservation of seeds,…)	32%	32%	100%	48%	24%

Because of unavailability of data of employees in 1990 in the European database, the number of employees were taken out from 1995.

5.2.4 Combination Top-down – Bottom-up approach and updating

To verify and adjust the data, the solvents given in the top down approach and the results of the bottom up approach were differentiated in the pillar years (1995, 2000, 2003, 2005) (see Table 5-7). The differences between the quantities of solvents from the top down approach and bottom up approach respectively are lower than 10%. Table 5-7 shows the range of the differences in the considered pillar years broken down to the 15 substance categories.

Table 5-7 - Differences between the results of the bottom up and the top down approach for Luxembourg.

Year	Differences [t/a]
2005	-760
2003	0
2000	54
1995	-549

As the data of the top down approach were obtained from national statistics, they are assumed to be more reliable than the data of the bottom up approach. That's why the annual quantities of solvents used were taken from the top down approach while the share of the solvents for the different applications (on SNAP level 3) and the solvent emission factors have been calculated on the basis of the bottom up approach. The following tables (Table 5-8, Table 5-9 and Table 5-10, Table 5-11) present activity data, implied emission factors and NMVOC emissions.

Table 5-8 - Activity data of Category 3 Solvent and other product use [Mg] 1990-2007.

IPCC	3 A							
SNAP	0601	060101	060102	060103	060104	060105	060107	060108
Unit	Mg Solvent							
1990	1 769	14	69	478	85	357	202	564
1991	1 769	14	69	478	85	357	202	564
1992	1 769	14	69	478	85	357	202	564
1993	1 769	14	69	478	85	357	202	564
1994	1 749	14	68	472	84	353	199	558
1995	1 868	15	73	504	90	377	213	596
1996	1 994	16	76	517	97	426	212	650
1997	1 967	16	73	488	96	444	194	655

IPCC	3 A							
SNAP	0601	060101	060102	060103	060104	060105	060107	060108
Unit	Mg Solvent							
1998	1 868	15	68	443	92	444	171	635
1999	1 866	15	66	423	93	466	157	647
2000	1 686	13	58	364	85	440	129	596
2001	1 760	16	66	415	92	371	147	655
2002	1 673	17	69	430	91	259	152	656
2003	1 563	17	70	440	88	144	155	649
2004	1 963	23	83	525	104	181	185	863
2005	2 033	25	81	519	101	187	184	937
2006	1 920	23	77	490	95	177	173	885
2007	2 053	25	82	524	102	189	185	946

IPCC	3 B	3 B	3 B	3 B	3 B
SNAP	0602	060201	060202	060203	060204
Unit	Mg Solvent				
1990	1 817	1 214	21	0	581
1991	1 817	1 214	21	0	581
1992	1 817	1 214	21	0	581
1993	1 817	1 214	21	0	581
1994	1 796	1 200	21	0	575
1995	1 919	1 283	22	0	614
1996	2 083	1 338	24	0	720
1997	2 088	1 289	24	1	774
1998	2 016	1 196	23	1	795
1999	2 045	1 166	24	1	853
2000	1 876	1 029	22	1	824
2001	2 093	1 090	24	2	978
2002	2 131	1 053	23	1	1 053
2003	2 137	1 001	23	1	1 112
2004	2 493	1 137	27	2	1 328
2005	2 407	1 067	26	2	1 312
2006	2 273	1 008	24	2	1 239
2007	2 430	1 078	26	2	1 325

IPCC	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C
SNAP	0603	060305	060306	060307	060308	060309	060310	060311	060312	060314
Unit	Mg Solvent									
1990	1 008	577	30	73	57	0	201	1	6	63
1991	1 008	577	30	73	57	0	201	1	6	63
1992	1 008	577	30	73	57	0	201	1	6	63
1993	1 008	577	30	73	57	0	201	1	6	63
1994	997	570	30	72	57	0	198	1	6	62
1995	1 065	609	32	77	61	0	212	1	6	67
1996	1 018	572	36	74	63	0	191	2	6	75
1997	887	487	37	65	61	0	153	2	5	77
1998	734	390	37	54	57	0	113	2	4	77
1999	625	318	39	46	56	0	81	2	4	80
2000	468	223	37	35	50	0	44	2	3	75

IPCC	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C
SNAP	0603	060305	060306	060307	060308	060309	060310	060311	060312	060314
Unit	Mg Solvent									
2001	587	314	52	37	52	0	48	2	2	80
2002	662	385	63	37	50	0	47	2	1	78
2003	726	449	73	36	47	0	46	1	0	75
2004	818	517	71	42	54	0	53	2	0	79
2005	761	494	56	40	51	0	51	1	0	68
2006	719	466	52	38	48	0	48	1	0	64
2007	768	498	56	40	52	0	52	1	0	68

IPCC	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5
SNAP	0604	060403	060404	060405	060406	060407	060408	060411	060412
Unit	Mg Solvent								
1990	2 173	736	0	0	9	23	975	269	162
1991	2 173	736	0	0	9	23	975	269	162
1992	2 173	736	0	0	9	23	975	269	162
1993	2 173	736	0	0	9	23	975	269	162
1994	2 148	727	0	0	9	23	963	266	160
1995	2 295	777	0	0	9	24	1 029	284	171
1996	2 495	821	3	0	10	26	1 137	306	194
1997	2 505	801	5	0	10	25	1 158	305	202
1998	2 422	753	7	0	9	23	1 135	292	203
1999	2 461	744	9	0	9	23	1 168	294	213
2000	2 261	666	11	0	8	21	1 086	268	202
2001	2 473	739	13	0	12	22	1 193	290	202
2002	2 468	748	15	0	16	22	1 197	287	183
2003	2 428	747	17	0	19	21	1 183	279	162
2004	2 795	831	21	0	17	24	1 395	328	180
2005	2 662	762	21	0	11	23	1 361	318	165
2006	2 514	719	20	0	10	22	1 285	300	156
2007	2 688	769	21	0	11	24	1 375	321	167

Table 5-9 - Implied NMVOC emission factors for Solvent Use 1990–2007

IPCC	3.A	3.A	3.A	3.A	3.A	3.A	3.A
SNAP	060101	060102	060103	060104	060105	060107	060108
Unit	kg/Mg Solvent						
1990	709.45	936.02	890.97	887.69	582.88	959.09	712.19
1991	709.45	936.02	890.97	887.69	582.88	959.09	712.19
1992	709.45	936.02	890.97	887.69	582.88	959.09	712.19
1993	709.45	936.02	890.97	887.69	582.88	959.09	712.19
1994	709.45	936.02	890.97	887.69	582.88	959.09	712.19
1995	709.45	936.02	890.97	887.69	582.88	959.09	712.19
1996	697.65	923.14	888.55	887.69	572.20	946.37	686.31
1997	685.85	910.25	886.13	887.69	561.53	933.65	660.43
1998	674.06	897.36	883.71	887.69	550.85	920.93	634.55
1999	662.26	884.47	881.29	887.69	540.17	908.21	608.67
2000	650.47	871.59	878.87	887.69	529.49	895.49	582.79
2001	635.15	867.68	881.44	887.69	526.00	896.16	569.48

IPCC	3.A	3.A	3.A	3.A	3.A	3.A	3.A
SNAP	060101	060102	060103	060104	060105	060107	060108
Unit	kg/Mg Solvent						
2002	619.84	863.77	884.01	887.69	522.51	896.84	556.17
2003	604.52	859.86	886.58	887.69	519.02	897.51	542.86
2004	623.96	859.73	886.58	887.69	519.02	898.84	522.92
2005	643.39	859.61	886.58	887.69	519.02	900.16	502.99
2006	643.39	859.61	886.58	887.69	519.02	900.16	502.99
2007	643.39	859.61	886.58	887.69	519.02	900.16	502.99

IPCC	3.B	3.B	3.B	3.B
SNAP	060201	060202	060203	060204
Unit	kg/Mg Solvent			
1990	378.17	880.00	957.78	697.42
1991	378.17	880.00	957.78	697.42
1992	378.17	880.00	957.78	697.42
1993	378.17	880.00	957.78	697.42
1994	378.17	880.00	957.78	697.42
1995	378.17	880.00	957.78	697.42
1996	368.17	874.00	935.41	693.82
1997	358.18	868.00	913.05	690.22
1998	348.18	862.00	890.69	686.63
1999	338.19	856.00	868.33	683.03
2000	328.19	850.00	845.97	679.44
2001	317.78	848.01	839.01	678.25
2002	307.37	846.03	832.05	677.05
2003	296.97	844.04	825.09	675.86
2004	294.92	844.04	823.39	675.86
2005	292.87	844.04	821.68	675.86
2006	292.87	844.04	821.68	675.86
2007	292.87	844.04	821.68	675.86

IPCC	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C
SNAP	060305	060306	060307	060308	060309	060310	060311	060312	060314
Unit	kg/Mg Solvent								
1990	963.98	252.84	1 000.00	1 000.00	1 000.00	10.02	918.81	901.43	1 000.00
1991	963.98	252.84	1 000.00	1 000.00	1 000.00	10.02	918.81	901.43	1 000.00
1992	963.98	252.84	1 000.00	1 000.00	1 000.00	10.02	918.81	901.43	1 000.00
1993	963.98	252.84	1 000.00	1 000.00	1 000.00	10.02	918.81	901.43	1 000.00
1994	963.98	252.84	1 000.00	1 000.00	1 000.00	10.02	918.81	901.43	1 000.00
1995	963.98	252.84	1 000.00	1 000.00	1 000.00	10.02	918.81	901.43	1 000.00
1996	958.32	253.86	1 000.00	1 000.00	1 000.00	10.02	922.80	901.43	1 000.00
1997	952.65	254.88	1 000.00	1 000.00	1 000.00	10.02	926.80	901.43	1 000.00
1998	946.98	255.90	1 000.00	1 000.00	1 000.00	10.02	930.80	901.43	1 000.00
1999	941.32	256.92	1 000.00	1 000.00	1 000.00	10.02	934.80	901.43	1 000.00
2000	935.65	257.94	1 000.00	1 000.00	1 000.00	10.02	938.80	901.43	1 000.00
2001	933.77	258.28	1 000.00	1 000.00	1 000.00	10.02	940.13	901.43	1 000.00
2002	931.90	258.62	1 000.00	1 000.00	1 000.00	10.03	941.47	901.43	1 000.00
2003	930.02	258.96	1 000.00	1 000.00	1 000.00	10.03	942.81	901.43	1 000.00

IPCC	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C
SNAP	060305	060306	060307	060308	060309	060310	060311	060312	060314
Unit	kg/Mg Solvent								
2004	930.02	258.96	1 000.00	1 000.00	1 000.00	10.03	942.81	901.43	1 000.00
2005	930.02	258.96	1 000.00	1 000.00	1 000.00	10.03	942.81	901.43	1 000.00
2006	930.02	258.96	1 000.00	1 000.00	1 000.00	10.03	942.81	901.43	1 000.00
2007	930.02	258.96	1 000.00	1 000.00	1 000.00	10.03	942.81	901.43	1 000.00

IPCC	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5
SNAP	060403	060404	060405	060406	060407	060408	060411	060412
Unit	kg/Mg Solvent							
1990	687.55	200.89	690.49	990.78	850.00	841.13	940.86	750.66
1991	687.55	200.89	690.49	990.78	850.00	841.13	940.86	750.66
1992	687.55	200.89	690.49	990.78	850.00	841.13	940.86	750.66
1993	687.55	200.89	690.49	990.78	850.00	841.13	940.86	750.66
1994	687.55	200.89	690.49	990.78	850.00	841.13	940.86	750.66
1995	687.55	200.89	690.49	990.78	850.00	841.13	940.86	750.66
1996	681.47	200.89	680.13	990.95	850.00	841.49	940.86	726.54
1997	675.38	200.89	669.78	991.12	850.00	841.85	940.86	702.42
1998	669.29	200.89	659.42	991.28	850.00	842.20	940.86	678.29
1999	663.21	200.89	649.06	991.45	850.00	842.56	940.86	654.17
2000	657.12	200.89	638.70	991.62	850.00	842.92	940.86	630.05
2001	655.11	200.89	635.30	991.67	850.00	843.03	940.86	658.33
2002	653.10	200.89	631.91	991.73	850.00	843.15	940.86	686.61
2003	651.09	200.89	628.51	991.79	850.00	843.26	940.86	714.89
2004	651.09	200.89	628.51	991.79	850.00	843.32	940.86	745.00
2005	651.09	200.89	628.51	991.79	850.00	843.39	940.86	775.11
2006	651.09	200.89	628.51	991.79	850.00	843.39	940.86	775.11
2007	651.09	200.89	628.51	991.79	850.00	843.39	940.86	775.11

Table 5-10 - Implied NMVOC emission factors for Solvent Use in manufacturing processes 1990–2007 (based on total inputs)

IPCC	3.C	3.C	3.C	3.C
SNAP	060307	060308	060309	060314
Unit	kg/Mg Solvent			
1990	48.55	50.26	NO	50.49
1991	48.55	50.26	NO	50.49
1992	48.55	50.26	NO	50.49
1993	48.55	50.26	NO	50.49
1994	48.55	50.26	NO	50.49
1995	48.55	50.26	NO	50.49
1996	45.93	50.23	NO	50.64
1997	43.31	50.20	NO	50.79
1998	40.70	50.16	NO	50.95
1999	38.08	50.13	NO	51.10
2000	35.46	50.10	NO	51.25
2001	34.65	50.10	NO	50.93
2002	33.84	50.09	NO	50.60

IPCC	3.C	3.C	3.C	3.C
SNAP	060307	060308	060309	060314
Unit	kg/Mg Solvent			
2003	33.02	50.09	NO	50.27
2004	33.02	50.09	NO	49.90
2005	33.02	50.10	NO	49.53
2006	33.02	50.10	NO	49.53
2007	33.02	50.10	NO	49.53

Figure 5-5 - NMVOC emissions and trend from 1990–2006 by subcategories of Category 3 - Solvent and Other Product Use

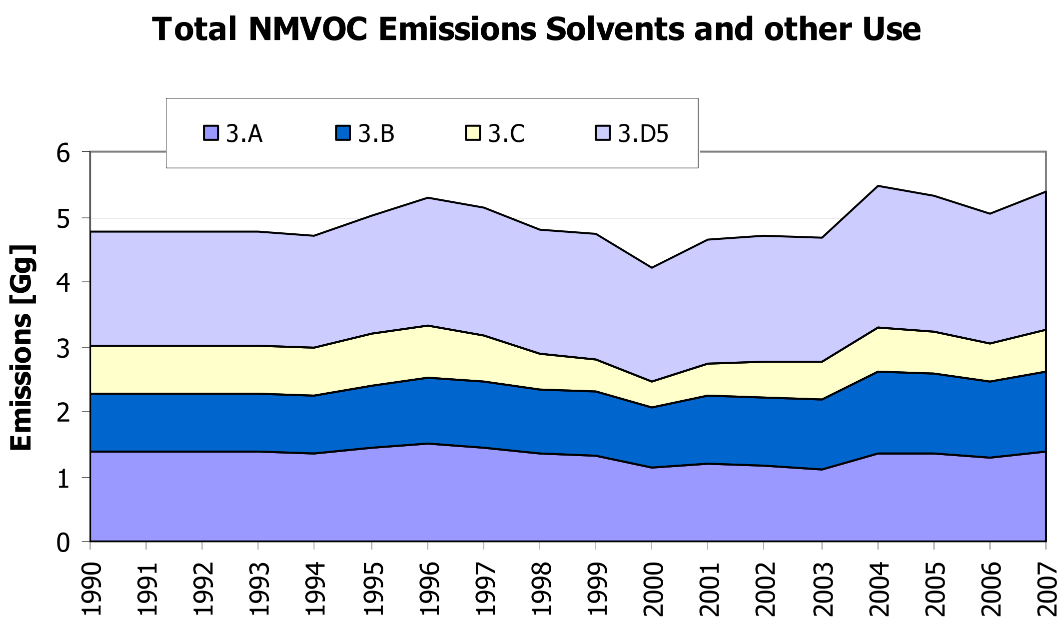

Table 5-11 - NMVOC emissions of Category 3 - Solvent and Other Product Use:[Mg] 1990–2007

IPCC	3.A	3.A	3.A	3.A	3.A	3.A	3.A	3.A
SNAP	0601	060101	060102	060103	060104	060105	060107	060108
Unit	Mg							
1990	1 379	10	65	426	76	208	194	402
1991	1 379	10	65	426	76	208	194	402
1992	1 379	10	65	426	76	208	194	402
1993	1 379	10	65	426	76	208	194	402
1994	1 364	10	64	421	75	206	191	397
1995	1 457	11	68	449	80	220	204	424
1996	1 517	11	70	459	86	244	201	446
1997	1 459	11	67	432	86	249	182	432
1998	1 350	10	61	392	82	245	157	403
1999	1 311	10	58	373	83	252	142	394
2000	1 151	9	51	320	75	233	116	347
2001	1 214	10	57	365	82	195	132	373
2002	1 167	10	59	380	81	135	136	365

IPCC	3.A	3.A	3.A	3.A	3.A	3.A	3.A	3.A
SNAP	0601	060101	060102	060103	060104	060105	060107	060108
Unit	Mg							
2003	1 105	11	60	390	78	75	139	352
2004	1 355	14	71	465	92	94	167	451
2005	1 369	16	70	460	89	97	165	471
2006	1 293	15	66	434	84	92	156	445
2007	1 382	16	71	464	90	98	167	476

IPCC	3.B	3.B	3.B	3.B
SNAP	060201	060202	060203	060204
Unit	Mg			
1990	883	459	19	0
1991	883	459	19	0
1992	883	459	19	0
1993	883	459	19	0
1994	873	454	18	0
1995	933	485	20	0
1996	1 014	493	21	0
1997	1 018	462	21	1
1998	984	417	20	1
1999	999	394	20	1
2000	917	338	19	1
2001	1 031	346	20	1
2002	1 058	324	20	1
2003	1 069	297	19	1
2004	1 257	335	23	1
2005	1 223	313	22	2
2006	1 154	295	21	1
2007	1 235	316	22	2

IPCC	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C
SNAP	0603	060305	060306	060307	060308	060309	060310	060311	060312	060314
Unit	Mg									
1990	766	556	8	73	57	0	2	1	5	63
1991	766	556	8	73	57	0	2	1	5	63
1992	766	556	8	73	57	0	2	1	5	63
1993	766	556	8	73	57	0	2	1	5	63
1994	757	550	8	72	57	0	2	1	5	62
1995	809	587	8	77	61	0	2	1	5	67
1996	778	548	9	74	63	0	2	1	5	75
1997	684	464	10	65	61	0	2	2	5	77
1998	573	369	10	54	57	0	1	2	4	77
1999	497	299	10	46	56	0	1	2	3	80
2000	382	209	10	35	50	0	0	2	2	75
2001	480	294	13	37	52	0	0	2	2	80
2002	542	358	16	37	50	0	0	1	1	78
2003	595	417	19	36	47	0	0	1	0	75
2004	676	481	18	42	54	0	1	1	0	79
2005	634	459	14	40	51	0	1	1	0	68

IPCC	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C
SNAP	0603	060305	060306	060307	060308	060309	060310	060311	060312	060314
Unit	Mg									
2006	599	434	14	38	48	0	0	1	0	64
2007	641	464	15	40	52	0	1	1	0	68

IPCC	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5
SNAP	0604	060403	060404	060405	060406	060407	060408	060411	060412
Unit	Mg								
1990	1 728	506	0	0	9	20	820	253	121
1991	1 728	506	0	0	9	20	820	253	121
1992	1 728	506	0	0	9	20	820	253	121
1993	1 728	506	0	0	9	20	820	253	121
1994	1 709	500	0	0	9	19	810	250	120
1995	1 825	534	0	0	9	21	866	267	128
1996	1 977	559	1	0	10	22	957	288	141
1997	1 976	541	1	0	9	21	975	287	142
1998	1 902	504	1	0	9	20	956	275	138
1999	1 924	494	2	0	9	20	984	277	139
2000	1 760	438	2	0	8	17	916	252	127
2001	1 930	484	3	0	12	19	1 006	273	133
2002	1 931	489	3	0	16	19	1 009	270	126
2003	1 903	486	3	0	19	18	997	263	116
2004	2 201	541	4	0	17	21	1 176	308	134
2005	2 106	496	4	0	11	20	1 148	299	128
2006	1 989	468	4	0	10	19	1 084	283	121
2007	2 127	501	4	0	11	20	1 159	302	129

5.2.5 Calculation of CO_2 emissions from Solvent Emissions

The basis for the calculation of the carbon dioxide emissions were the quantities of solvent emissions differentiated by the 15 groups of substances (acetone, methanol, propanol, solvent naphtha, paraffins, alcohols, glycols, ester, aromates, ketones, aldehydes, amines, organic acids, cyclic hydrocarbons, and others). Substance specific carbon dioxide factors for these 15 substance groups have been created in Austria (see Table 5-12) on the basis of the carbon content and the stoichiometrically formed CO_2.

Table 5-12 - Substance specific carbon dioxide emission factors

Substances	CO_2 factor [kg CO_2/kg substance]	Substances	CO_2 factor [kg CO_2/kg substance]
Acetone	2.28	Glycols	1.82
Aldehydes	2.44	Ketones	2.45
Alcohols	1.91	Methanol	1.38
Alcohols/Propanols	2.20	Paraffins	3.14
Aromates	3.33	Residuals	0.92
Cydic Hydrocarbons	3.14	Solvent naphta	3.14
Ester	2.16	Glycols	1.82

In Austria the amount of carbon dioxide emissions was disaggregated to SNAP level 3 according to the share of solvents used and solvent emissions that were calculated in the context of the bottom up approach. In Table 5-14, the implied CO_2 Emission factors of Austria, which were also used for Luxembourg, as well as in Table 5-13, the carbon dioxide emissions of Category *3-Solvent and Other Product Use* for the years 1990 to 2007 are shown.

Table 5-13 - CO_2 emission of Category 3 Solvent and Other Product Use 1990–2006.

IPCC	3.A	3.A	3.A	3.A	3.A	3.A	3.A	3.A
SNAP	0601	060101	060102	060103	060104	060105	060107	060108
Unit	Gg							
1990	4.09	0.04	0.18	1.25	0.20	0.85	0.50	1.08
1991	3.84	0.04	0.18	1.23	0.20	0.79	0.48	0.94
1992	3.58	0.03	0.18	1.20	0.19	0.72	0.45	0.80
1993	3.32	0.03	0.17	1.16	0.19	0.66	0.42	0.69
1994	3.02	0.03	0.17	1.10	0.18	0.59	0.38	0.57
1995	3.10	0.03	0.18	1.16	0.21	0.60	0.39	0.53
1996	3.12	0.03	0.18	1.15	0.22	0.64	0.37	0.54
1997	3.10	0.03	0.17	1.13	0.22	0.67	0.34	0.53
1998	2.90	0.02	0.16	1.04	0.22	0.66	0.30	0.50
1999	2.85	0.02	0.15	1.01	0.22	0.69	0.27	0.49
2000	2.56	0.02	0.14	0.89	0.20	0.65	0.23	0.43
2001	2.69	0.02	0.15	1.01	0.22	0.54	0.26	0.48
2002	2.58	0.03	0.16	1.05	0.22	0.38	0.27	0.48
2003	2.43	0.03	0.16	1.08	0.21	0.21	0.27	0.47
2004	2.98	0.03	0.19	1.28	0.25	0.26	0.32	0.63
2005	3.02	0.04	0.19	1.27	0.24	0.27	0.32	0.68
2006	2.85	0.04	0.18	1.20	0.23	0.26	0.30	0.64
2007	3.04	0.04	0.19	1.28	0.24	0.28	0.32	0.69

IPCC	3.B	3.B	3.B	3.B	3.B
SNAP	0602	060201	060202	060203	060204
Unit	Gg				
1990	4.16	3.00	0.02	0.00	1.14
1991	3.91	2.74	0.03	0.00	1.15
1992	3.62	2.46	0.03	0.00	1.13
1993	3.33	2.19	0.03	0.00	1.11
1994	2.98	1.90	0.03	0.00	1.05
1995	2.98	1.84	0.03	0.00	1.12
1996	3.05	1.76	0.03	0.00	1.26
1997	3.08	1.66	0.03	0.00	1.38
1998	2.95	1.49	0.03	0.00	1.43
1999	2.96	1.40	0.03	0.00	1.53
2000	2.72	1.20	0.03	0.00	1.49
2001	3.07	1.27	0.03	0.00	1.76
2002	3.16	1.23	0.03	0.00	1.90
2003	3.20	1.16	0.03	0.00	2.00
2004	3.76	1.32	0.04	0.00	2.39

IPCC	3.B	3.B	3.B	3.B	3.B
SNAP	0602	060201	060202	060203	060204
Unit			Gg		
2005	3.65	1.24	0.04	0.00	2.36
2006	3.44	1.17	0.04	0.00	2.23
2007	3.68	1.25	0.04	0.00	2.39

IPCC	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C
SNAP	0603	060305	060306	060307	060308	060309	060310	060311	060312	060314
Unit						Gg				
1990	2.11	1.66	0.03	0.20	0.10	0.00	0.01	0.00	0.01	0.09
1991	2.07	1.66	0.03	0.18	0.09	0.00	0.01	0.00	0.01	0.08
1992	2.00	1.65	0.02	0.15	0.08	0.00	0.01	0.00	0.01	0.08
1993	1.99	1.62	0.02	0.16	0.09	0.00	0.01	0.00	0.01	0.07
1994	1.92	1.57	0.02	0.16	0.08	0.00	0.01	0.00	0.01	0.07
1995	2.12	1.70	0.02	0.21	0.11	0.00	0.01	0.00	0.01	0.07
1996	1.92	1.52	0.02	0.18	0.10	0.00	0.01	0.00	0.01	0.07
1997	1.72	1.32	0.02	0.18	0.11	0.00	0.00	0.00	0.01	0.07
1998	1.40	1.06	0.02	0.14	0.09	0.00	0.00	0.00	0.01	0.07
1999	1.17	0.87	0.02	0.11	0.09	0.00	0.00	0.00	0.01	0.07
2000	0.90	0.62	0.02	0.09	0.09	0.00	0.00	0.00	0.01	0.07
2001	1.17	0.87	0.03	0.10	0.09	0.00	0.00	0.00	0.00	0.07
2002	1.36	1.06	0.03	0.10	0.09	0.00	0.00	0.00	0.00	0.07
2003	1.53	1.24	0.04	0.10	0.08	0.00	0.00	0.00	0.00	0.07
2004	1.75	1.43	0.04	0.11	0.10	0.00	0.00	0.00	0.00	0.07
2005	1.66	1.37	0.03	0.11	0.09	0.00	0.00	0.00	0.00	0.06
2006	1.57	1.29	0.03	0.10	0.09	0.00	0.00	0.00	0.00	0.06
2007	1.68	1.38	0.03	0.11	0.09	0.00	0.00	0.00	0.00	0.06

IPCC	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5
SNAP	0604	060403	060404	060405	060406	060407	060408	060411	060412
Unit					Gg				
1990	4.27	1.46	0.00	0.00	0.02	0.04	1.83	0.58	0.34
1991	4.24	1.38	0.00	0.00	0.02	0.04	1.87	0.59	0.32
1992	4.12	1.30	0.00	0.00	0.02	0.05	1.87	0.59	0.29
1993	3.98	1.22	0.00	0.00	0.02	0.05	1.84	0.58	0.27
1994	3.75	1.12	0.00	0.00	0.02	0.04	1.76	0.56	0.24
1995	3.95	1.16	0.00	0.00	0.02	0.05	1.87	0.60	0.24
1996	4.10	1.16	0.00	0.00	0.02	0.05	1.98	0.62	0.26
1997	4.21	1.14	0.00	0.00	0.02	0.05	2.07	0.64	0.28
1998	4.08	1.07	0.00	0.00	0.02	0.05	2.04	0.62	0.28
1999	4.13	1.04	0.01	0.00	0.02	0.05	2.10	0.62	0.29
2000	3.82	0.93	0.01	0.00	0.02	0.04	1.97	0.58	0.27
2001	4.19	1.04	0.01	0.00	0.03	0.04	2.17	0.62	0.27
2002	4.18	1.05	0.01	0.00	0.04	0.04	2.17	0.62	0.25
2003	4.12	1.05	0.01	0.00	0.05	0.04	2.15	0.60	0.22
2004	4.75	1.17	0.01	0.00	0.04	0.05	2.53	0.70	0.24
2005	4.54	1.07	0.01	0.00	0.03	0.05	2.47	0.68	0.22
2006	4.28	1.01	0.01	0.00	0.03	0.04	2.33	0.65	0.21
2007	4.58	1.08	0.01	0.00	0.03	0.05	2.50	0.69	0.22

Table 5-14 - Implied CO2 Emission factors for Category 3 Solvent and Other Product Use 1990–2007.

IPCC	3.A	3.A	3.A	3.A	3.A	3.A	3.A
SNAP	060101	060102	060103	060104	060105	060107	060108
Unit	kg/Mg Solvent						
1990	2.61	2.57	2.61	2.36	2.39	2.50	1.91
1991	2.42	2.58	2.58	2.29	2.21	2.36	1.66
1992	2.22	2.56	2.52	2.23	2.03	2.21	1.43
1993	2.02	2.52	2.44	2.19	1.86	2.06	1.22
1994	1.82	2.45	2.33	2.19	1.68	1.91	1.03
1995	1.70	2.47	2.30	2.35	1.59	1.84	0.90
1996	1.59	2.33	2.23	2.26	1.50	1.74	0.82
1997	1.60	2.37	2.31	2.32	1.51	1.77	0.81
1998	1.57	2.35	2.35	2.34	1.49	1.76	0.78
1999	1.54	2.33	2.39	2.35	1.47	1.74	0.75
2000	1.53	2.34	2.45	2.39	1.47	1.75	0.73
2001	1.53	2.34	2.45	2.39	1.47	1.75	0.73
2002	1.53	2.34	2.45	2.39	1.47	1.75	0.73
2003	1.53	2.34	2.45	2.39	1.47	1.75	0.73
2004	1.53	2.34	2.45	2.39	1.47	1.75	0.73
2005	1.53	2.34	2.45	2.39	1.47	1.75	0.73
2006	1.53	2.34	2.45	2.39	1.47	1.75	0.73
2007	1.53	2.34	2.45	2.39	1.47	1.75	0.73

IPCC	3.B	3.B	3.B	3.B
SNAP	060201	060202	060203	060204
Unit	kg/Mg Solvent			
1990	2.47	1.10	1.94	1.96
1991	2.25	1.18	1.75	1.98
1992	2.02	1.25	1.56	1.95
1993	1.80	1.29	1.38	1.91
1994	1.58	1.31	1.20	1.83
1995	1.43	1.38	1.08	1.82
1996	1.31	1.34	1.01	1.74
1997	1.29	1.39	1.00	1.79
1998	1.24	1.42	0.98	1.79
1999	1.20	1.44	0.96	1.79
2000	1.16	1.47	0.94	1.80
2001	1.16	1.47	0.94	1.80
2002	1.16	1.47	0.94	1.80
2003	1.16	1.47	0.94	1.80
2004	1.16	1.47	0.94	1.80
2005	1.16	1.47	0.94	1.80
2006	1.16	1.47	0.94	1.80
2007	1.16	1.47	0.94	1.80

IPCC	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C
SNAP	060305	060306	060307	060308	060309	060310	060311	060312	060314
Unit	kg/Mg Solvent								

IPCC	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C	3.C
SNAP	060305	060306	060307	060308	060309	060310	060311	060312	060314
Unit	kg/Mg Solvent								
1990	2.88	0.99	2.77	1.78	2.68	0.03	2.18	2.11	1.40
1991	2.88	0.90	2.46	1.61	2.45	0.03	2.23	2.11	1.32
1992	2.85	0.80	2.09	1.38	2.11	0.03	2.22	2.09	1.23
1993	2.81	0.71	2.24	1.49	2.27	0.03	2.19	2.07	1.15
1994	2.75	0.61	2.23	1.47	2.24	0.03	2.12	2.05	1.06
1995	2.79	0.54	2.71	1.76	2.65	0.03	2.13	2.14	1.02
1996	2.66	0.52	2.49	1.62	2.45	0.03	2.05	2.04	0.95
1997	2.71	0.54	2.77	1.80	2.72	0.03	2.12	2.09	0.95
1998	2.72	0.54	2.53	1.65	2.50	0.03	2.14	2.11	0.93
1999	2.73	0.54	2.34	1.53	2.32	0.03	2.15	2.13	0.91
2000	2.77	0.55	2.69	1.78	2.68	0.03	2.18	2.19	0.89
2001	2.77	0.55	2.69	1.78	2.68	0.03	2.18	2.19	0.89
2002	2.77	0.55	2.69	1.78	2.68	0.03	2.18	2.19	0.89
2003	2.77	0.55	2.69	1.78	2.68	0.03	2.18	2.19	0.89
2004	2.77	0.55	2.69	1.78	2.68	0.03	2.18	2.19	0.89
2005	2.77	0.55	2.69	1.78	2.68	0.03	2.18	2.19	0.89
2006	2.77	0.55	2.69	1.78	2.68	0.03	2.18	2.19	0.89
2007	2.77	0.55	2.69	1.78	2.68	0.03	2.18	2.19	0.89

IPCC	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5	3.D.5
SNAP	060403	060404	060405	060406	060407	060408	060411	060412
Unit	kg/Mg Solvent							
1990	1.98	0.66	2.55	2.70	1.89	1.87	2.15	2.13
1991	1.88	0.67	2.42	2.72	1.95	1.92	2.19	1.98
1992	1.77	0.66	2.29	2.69	1.96	1.92	2.19	1.82
1993	1.66	0.65	2.16	2.66	1.96	1.89	2.17	1.67
1994	1.54	0.64	2.02	2.59	1.93	1.82	2.11	1.52
1995	1.49	0.66	1.97	2.61	1.96	1.82	2.12	1.43
1996	1.41	0.63	1.86	2.51	1.88	1.74	2.04	1.36
1997	1.43	0.64	1.88	2.58	1.94	1.79	2.10	1.37
1998	1.42	0.65	1.86	2.60	1.96	1.80	2.11	1.36
1999	1.40	0.65	1.84	2.61	1.98	1.80	2.12	1.35
2000	1.40	0.66	1.84	2.65	2.03	1.82	2.15	1.35
2001	1.40	0.66	1.84	2.65	2.03	1.82	2.15	1.35
2002	1.40	0.66	1.84	2.65	2.03	1.82	2.15	1.35
2003	1.40	0.66	1.84	2.65	2.03	1.82	2.15	1.35
2004	1.40	0.66	1.84	2.65	2.03	1.82	2.15	1.35
2005	1.40	0.66	1.84	2.65	2.03	1.82	2.15	1.35
2006	1.40	0.66	1.84	2.65	2.03	1.82	2.15	1.35
2007	1.40	0.66	1.84	2.65	2.03	1.82	2.15	1.35

5.3 N_2O emissions from Anaesthesia (3D1)

N_2O emissions from anaesthesia usage are estimated by combining reported emissions in Germany with the relative population in Luxembourg. The reported emissions in Germany remained constant between 2002 and 2006 and the same value for Germany is also applied for 2007 in the estimation calculation for Luxembourg. Emissions are shown in Table 5-1 of section 5.1.1.

5.4 Uncertainty Assessment

In the latest study on uncertainties of the Austrian inventory (WINIWARTER 2008), the uncertainties of solvent emissions in Austria were determined, and were compared with the results of the detailed analysis of solvent emissions in Austria (WINDSPERGER et al. 2004). Differences between bottom-up and top-down methodology to estimate emissions were calculated at less than 10%, which is compatible with expert estimates on the uncertainties presented for national statistics. Additional uncertainty has been attributed to the released fraction of solvents employed, reflecting an emission factor (solvents are released as volatile organic compounds, which eventually are converted into CO_2 in the atmosphere).

Using the WINDSPERGER et al. (2004) data, an uncertainty of 5% is attributed to the activity data, and 10% to the emission factor of solvents. According to WINDSPERGER et al. (2004), the uncertainty should decrease and the overall quality improve between 1990 and current data. But according to WINIWARTER (2008) a general decrease in the quality of the import-export statistics, and a decrease in the released fraction of solvents (reflecting the emission factor) over the years results in a constant uncertainty.

In Table 5-15 and Table 5-16 the results of the studies are presented whereas the results of WINIWARTER (2008) are used for calculating the total uncertainty of the Austrian GHG inventory.

Table 5-15 - Uncertainties of Sector 3 - Solvent and other product use (Windsperger et al. 2004)

	1990	1995	2000
Uncertainty solvent emissions	-21 to +24%	-18 to +21%	-13 to +14%

Table 5-16 - Uncertainties of Sector 3 - Solvent and other product use (Winiwarter 2008)

IPCC Source category	Gas	AD	EF	Combined
			Uncertainty [%]	
3 -Solvent and other product use	CO_2	5.0	10.0	11.2

5.5 Recalculation for Emissions from Solvent and Other Product Use

The reasons for the recalculation are updates of activity data, non-solvent applications and methodology changes:

3.A, 3.B, 3.C and 3.D.5: CO_2 emissions from solvent use were calculated from NMVOC emissions of this sector. The basis for the calculation of the carbon dioxide emissions were the quantities of solvent emissions differentiated by the 15 groups of substances. Substance specific carbon dioxide factors for these 15 substance groups have been created in Austria on the basis of the carbon content and the stoichiometrically formed CO_2.

3.A, 3.B, 3.C and 3.D.5: NMVOC emissions from solvent use have been determined the quantity of solvents used in Luxembourg in the various applications, by combing a bottom-up and a top-down approach from an Austrian study.

3.A, 3.B, 3.C and 3.D.5: NMVOC emissions from solvent use have been updated using short-term economic data provided by STATEC.

3.A, 3.B, 3.C and 3.D.5: NMVOC emissions from solvent use have been updated using surveys on non-solvent-applications in companies.

3.A, 3.B, 3.C and 3.D.5: NMVOC emissions from solvent use have been updated using in the manufacturing sectors (060307 paints, 060308 inks, 060309 glues and 060314 other) the solvents emission as solvent activity data to avoid double counting (emission factor 1.00) and use these amounts in the distribution of the solvents among the different SNAPs.

Table 5-17 shows the recalculation difference of emissions from Sector *3-Solvent and Other Product Use* and its subcategories with respect to the previous submission[125].

Table 5-17 - Recalculation difference with respect to submission 2008

CO_2 Emission		Absolute difference [Gg CO_2 equivalent]		Relative difference [Δ%]	
		1990	2006	1990	2006
3	Solvent and Other Product Use	14.82	8.52	163%	91%
3 A	Paint application	-0.13	-1.46	-3%	-34%
3 B	Degreasing and dry cleaning	3.32	2.60	396%	310%
3 C	Chemical products, manufacture and processing	2.11	1.57	IE	IE
3 D 1	Use of N_2O	9.23	5.72	30887%	30905%
3 D 5	Other solvent use	0.28	0.09	7%	2%

125 TÜV Rheinland (1990): Emissionskataster für das Großherzogtum Luxemburg. Köln

5.6 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 5-18 will be explored.

Table 5-18 – Planned improvements for Sector 3 – Solvent and Other Product Use

GHG source & sink category	Planned improvement
3D1 – N_2O from Anaesthesia	investigate the possibility of acquiring data on the consumption of anaesthesia products in Luxembourg.[126]
3D2 - N_2O from fire extinguishers	correct CRF tables and change NE to NA, because no N_2O is used in fire extinguishers in Europe.

5.7 References

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[126] ARR 2008, § 82

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6 Agriculture (CRF Sector 4)

6.1 Sector Overview

Chapter 6 includes information on and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under CRF Sector 4 – Agriculture for the period 1990 to 2007.

Emissions from this sector comprise emissions from the following categories: enteric fermentation (4A), manure management (4B) and agricultural soils (4D). For more details on categories where emissions are not occurring and categories that are not estimated or included elsewhere, see Table 6-3 below.

The whole country of Luxembourg is lying in a cool climate region.

Other required information, as suggested in Annex I of document FCCC/SBSTA/2006/9, will be presented under each source category review (methodology, AD, EFs, etc.).

6.1.1 Emission Trends

This section briefly describes the emission trends from 1990 to 2007 for each of the IPCC Categories under CRF Sector 4 for which GHG emissions are reported – i.e. categories 4A, 4B and 4D.

As shown in Table 6-1, emissions of GHG related to agricultural activities have decreased by about 8.3% (-3.2% for methane and -12.7% for nitrous oxide). IPCC Category 4A – Enteric Fermentation saw its emissions falling by some 9%, whereas for IPCC category 4D – Agricultural Soils, the decrease reaches a bit more than 10%. For manure management (IPCC Category 4B), emissions remained quite stable between 1990 and 2007 (-1.8%), though opposite variations are observed for the two GHG emitted by this activity: methane increased by 14.8% and nitrous oxide declined by 36.8%.

Figure 6-1 and Figure 6-2 provide a quick overview on agriculture related emission trends between 1990 and 2007. More details and explanations are presented in the subsequent sections detailing each of the sector source categories.

Figure 6-1 – GHG emission trends in % for CRF Sector 4 – Agriculture: 1990-2007

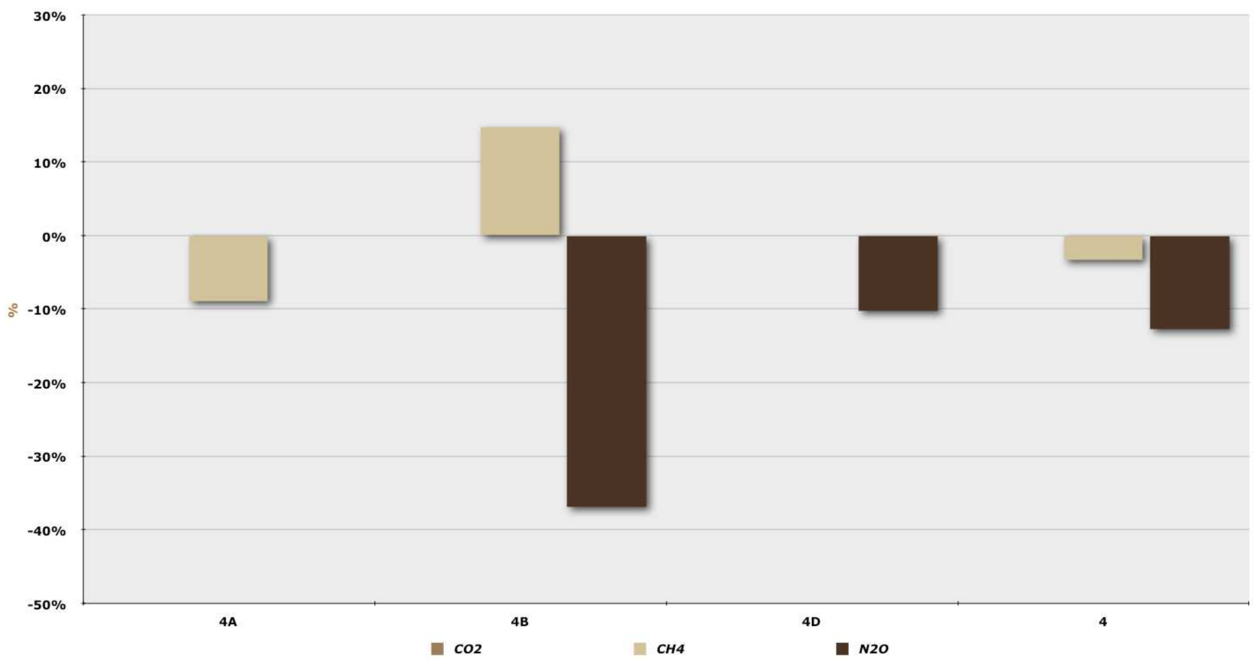


Figure 6-2 – GHG emission trends – indexes – for CRF Sector 4 – Agriculture: 1990-2007

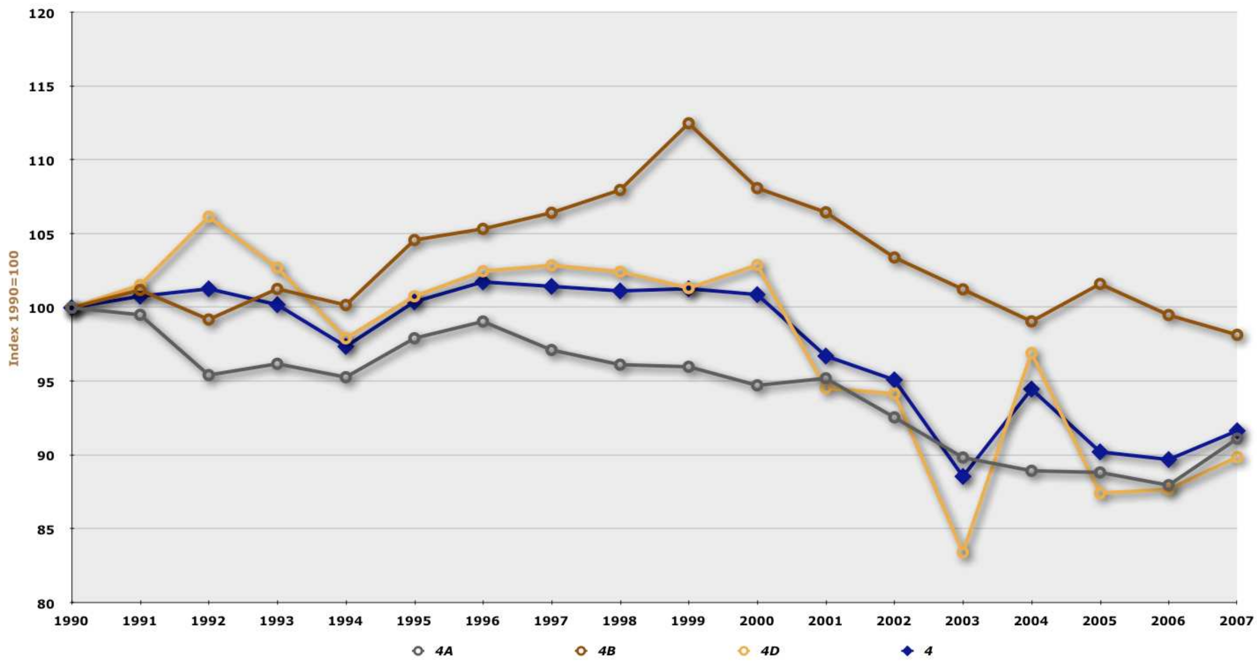


Table 6-1 – GHG emission trends in CO_2e for CRF Sector 4 – Agriculture: 1990-2007

Year	*CO_2e emissions (Gg)* — GHG source & sink category															
	4A - Enteric Fermentation				4B - Manure Management				4D - Agricultural Soils				4 - Agriculture			
	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O
1990	270.93	*NA*	*270.93*	*NA*	126.20	*NA*	*85.59*	*40.61*	378.14	*NA*	*NA*	*378.14*	**775.27**	*NA*	*356.52*	*418.75*
1991	269.63	*NA*	*269.63*	*NA*	127.72	*NA*	*92.85*	*34.87*	383.95	*NA*	*NA*	*383.95*	**781.29**	*NA*	*362.47*	*418.82*
1992	258.56	*NA*	*258.56*	*NA*	125.20	*NA*	*93.46*	*31.74*	401.44	*NA*	*NA*	*401.44*	**785.20**	*NA*	*352.02*	*433.18*
1993	260.63	*NA*	*260.63*	*NA*	127.81	*NA*	*96.52*	*31.29*	388.40	*NA*	*NA*	*388.40*	**776.84**	*NA*	*357.15*	*419.69*
1994	258.18	*NA*	*258.18*	*NA*	126.43	*NA*	*96.47*	*29.96*	370.30	*NA*	*NA*	*370.30*	**754.92**	*NA*	*354.65*	*400.27*
1995	265.32	*NA*	*265.32*	*NA*	131.99	*NA*	*101.05*	*30.94*	381.07	*NA*	*NA*	*381.07*	**778.38**	*NA*	*366.37*	*412.01*
1996	268.40	*NA*	*268.40*	*NA*	132.94	*NA*	*101.59*	*31.35*	387.48	*NA*	*NA*	*387.48*	**788.82**	*NA*	*369.98*	*418.83*
1997	263.17	*NA*	*263.17*	*NA*	134.32	*NA*	*104.20*	*30.12*	388.98	*NA*	*NA*	*388.98*	**786.47**	*NA*	*367.37*	*419.10*
1998	260.47	*NA*	*260.47*	*NA*	136.27	*NA*	*107.74*	*28.53*	387.36	*NA*	*NA*	*387.36*	**784.10**	*NA*	*368.21*	*415.89*
1999	260.09	*NA*	*260.09*	*NA*	141.97	*NA*	*117.94*	*24.02*	383.18	*NA*	*NA*	*383.18*	**785.24**	*NA*	*378.04*	*407.20*
2000	256.68	*NA*	*256.68*	*NA*	136.43	*NA*	*112.99*	*23.45*	389.07	*NA*	*NA*	*389.07*	**782.18**	*NA*	*369.67*	*412.51*
2001	257.97	*NA*	*257.97*	*NA*	134.36	*NA*	*110.94*	*23.42*	357.56	*NA*	*NA*	*357.56*	**749.90**	*NA*	*368.91*	*380.98*
2002	250.81	*NA*	*250.81*	*NA*	130.50	*NA*	*108.21*	*22.29*	356.09	*NA*	*NA*	*356.09*	**737.40**	*NA*	*359.02*	*378.38*
2003	243.43	*NA*	*243.43*	*NA*	127.77	*NA*	*105.13*	*22.65*	315.45	*NA*	*NA*	*315.45*	**686.65**	*NA*	*348.56*	*338.09*
2004	241.00	*NA*	*241.00*	*NA*	125.04	*NA*	*102.51*	*22.53*	366.52	*NA*	*NA*	*366.52*	**732.56**	*NA*	*343.51*	*389.05*
2005	240.69	*NA*	*240.69*	*NA*	128.24	*NA*	*106.33*	*21.90*	330.62	*NA*	*NA*	*330.62*	**699.54**	*NA*	*347.03*	*352.52*
2006	238.35	*NA*	*238.35*	*NA*	125.58	*NA*	*104.74*	*20.83*	331.61	*NA*	*NA*	*331.61*	**695.54**	*NA*	*343.10*	*352.44*
2007	246.90	*NA*	*246.90*	*NA*	123.89	*NA*	*98.24*	*25.65*	339.85	*NA*	*NA*	*339.85*	**710.64**	*NA*	*345.13*	*365.50*
Trend 1990-2007	*-8.87%*	*NA*	*-8.87%*	*NA*	*-1.84%*	*NA*	*14.77%*	*-36.84%*	*-10.12%*	*NA*	*NA*	*-10.12%*	*-8.34%*	*NA*	*-3.19%*	*-12.72%*

Source: Ministry of the Environment.

Notes:

CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

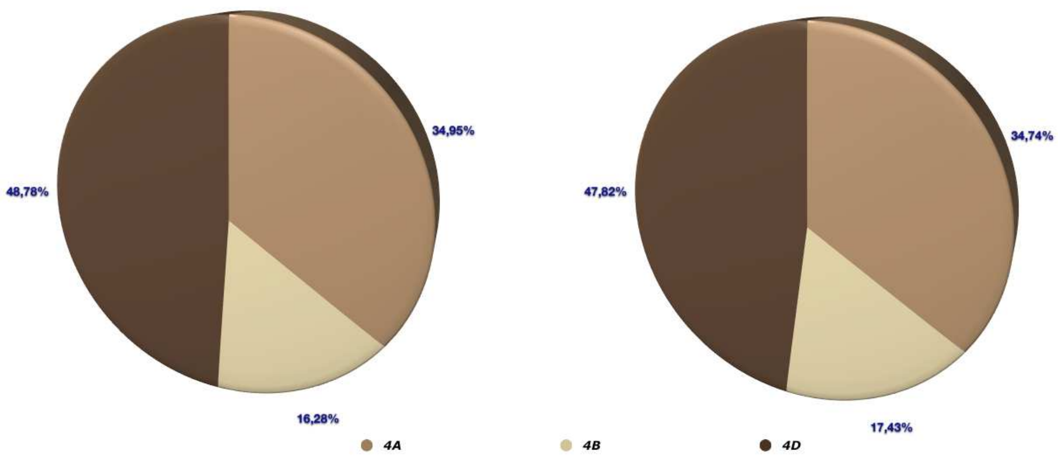
N_2O emissions are converted in CO_2e by multiplying the emissions by 310, i.e. the global warming potential (*GWP*) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

As shown in Figure 6-2, IPCC Category *4D – Agricultural Soils* presents an erratic evolution towards the end of the period. This is explained mainly by important changes in crops, especially N-fixing crops, as well as in N-fertilizer use which showed a slack in 2003 and a peak in 2004. The lower N-fertilizer use in 2003 was the result of the drought that characterized that year's summer.

The evolution of IPCC Category 4D also shapes the overall agriculture emission pattern. Indeed, as depicted in Figure 6-3, for both the years 1990 and 2007, IPCC Category 4D is the biggest contributor to agriculture related emissions. It is also worth noting that the shares of each IPCC Category under CRF Sector 4 for which GHG emissions are reported have barely changed over the period.

Figure 6-3 – IPCC Categories weights in GHG emissions for CRF Sector 4 – Agriculture: 1990 and 2007

<u>*1990*</u> <u>*2007*</u>



In order to facilitate and complement the explanations provided in Sections 6.2 to 6.8 below, it is highly recommended to explore the Microsoft Excel™ file that has been developed to calculate GHG emissions from the agriculture sector. This file (**Agriculture_GHG Estimates.xls**) details all the calculations and is indicating (activity) data sources, methods, formulas, parameters, coefficients and equations used to estimate CH_4 and N_2O emissions. It is available and downloadable at the following address: http://cdr.eionet.europa.eu/lu/eu/ghgmm/envshq85a.

6.1.2 Key sources

The methodology and results of the key source analysis are presented in Chapter 1. Table 6-2 presents the key source categories of IPCC Category 2 Industrial processes.

Table 6-2 – Key sources of IPCC Category 4 - Agriculture

4 - Agriculture *Key sources*						
IPCC Category	Category Name	GHG	LA excl. LULUCF	LA incl. LULUCF	TA excl. LULUCF	TA incl. LULUCF
4A1	Enteric Fermentation - Cattle	CH4	90-07	90-07		
4B1	Manure Management - Cattle	CH4	91-06	91		
4D1	Agricultural Soils - direct soil emissions	N2O	90-07	90-92, 94-95, 98-01		
4D2	Agricultural Soils - pasture, range & paddock manure	N2O	90-91, 95-01	90-91		
4D3	Agricultural Soils - indirect emissions	N2O	90-07	90-91, 94-95		

Source: Environment Agency

Notes: LA = Level Assessement including respectively exluding LULUCF

TA = Trend Assessement 2007 including respectively excluding LULUCF

6.1.3 Completeness

Table 6-3 gives an overview of the IPCC categories included under CRF Sector 4 and provides information on the status of emission estimates of all subcategories.

Table 6-3 – Overview of subcategories of CRF Sector 4 – Agriculture: status of emission estimates for CO_2, CH_4 and N_2O

GHG source & sink category	Description	Status		
		CO_2	CH_4	N_2O
4A1 – option B	enteric fermentation – cattle		X	
4A2	enteric fermentation – buffalo		NO	
4A3	enteric fermentation – sheep		X	
4A4	enteric fermentation – goats		NE (1990-1996) X (1997-2007)	
4A5	enteric fermentation – camels & llamas		NO	
4A6	enteric fermentation – horses		X	
4A7	enteric fermentation – mules & asses		IE (1990-2004) * X (2005-2007)	
4A8	enteric fermentation – swine		X	
4A9	enteric fermentation – poultry		X	
4A10	enteric fermentation – other livestock		NE (1990-1996) X (1997-2007)	
4B1 – option B	manure management – cattle		X	
4B2	manure management – buffalo		NO	
4B3	manure management – sheep		X	
4B4	manure management – goats		NE (1990-1996) X (1997-2007)	
4B5	manure management – camels & llamas		NO	
4B6	manure management – horses		X	
4B7	manure management – mules & asses		IE (1990-2004) * X (2005-2007)	
4B8	manure management – swine		X	
4B9	manure management – poultry		X	
4B10	manure management – other livestock		NE (1990-1996)	

GHG source & sink category	Description	Status		
		CO_2	CH_4	N_2O
			X (1997-2007)	
4B11	manure management – anaerobic lagoons			NO
4B12	manure management – liquid systems			X
4B13	manure management – solid storage & dry lot			X
4B14	manure management – other AWMS			X
4C1	rice cultivation – irrigated		NO	
4C2	rice cultivation – rainfed		NO	
4C3	rice cultivation – deep water		NO	
4C4	rice cultivation – other		NA	
4D1	agricultural soils – direct soil emissions		NE **	X
4D2	agricultural soils – pasture, range & paddock manure			X
4D3	agricultural soils – indirect emissions		NE **	X
4D4	agricultural soils – other		NA	NA
4E	prescribed burning of savannas		NO	NO
4F1	field burning of agricultural residues – cereals		NO	NO
4F2	field burning of agricultural residues – pulses		NO	NO
4F3	field burning of agricultural residues – tubers & roots		NO	NO
4F4	field burning of agricultural residues – sugar cane		NO	NO
4F5	field burning of agricultural residues – other		NO	NO
4G	other		NA	NA

Note: a **X** indicates that emissions from this sub-category have been estimated, the grey shaded cells are those also shaded in the CRF tables.

* = the number of mules & asses where recorded together with horses (category 4A6) up to 2004 included.

** = NE but not indicated in the sectoral background data for agriculture table 4D.

IPCC sub-categories *4A1 – Enteric Fermentation – Cattle*, *4B1 – Manure Management – Cattle* and *4D – Agricultural Soils* have been identified as key source categories, whether LULUCF is included or not (see Section 1.5).

6.2 Enteric Fermentation (4A)

This section describes the estimation of methane emissions resulting from enteric fermentation. In 2007, this source category was responsible for 71.5% of agricultural methane emissions and for 54.4% of the total methane emissions estimated for Luxembourg. It represented 1.9% of the total GHG emissions in CO_2e (excluding LULUCF).

6.2.1 Key source

With 1.86% of the total GHG emissions in CO_2e, excluding LULUCF in 2007 (1.92% of the total GHG emissions in CO_2e, including LULUCF), methane emissions from cattle (IPCC Sub-category 4A1) is a key source, whether LULUCF is included or excluded. It has been a key source in both cases without interruption since 1990.

Table 6-4 – Domestic livestock population and trends: 1990-2007

Year	4A1 Cattle - Mature Dairy Cattle	4A1 Non-Dairy Cattle	*4A1 Cattle - Mature Non-Dairy Cattle - Females*	*4A1 Cattle - Mature Non-Dairy Cattle - Males*	*4A1 Cattle - Young Cattle - Calves*	*4A1 Cattle - Young Cattle - Growing Heifers*	4A2 Buffalo	4A3 Sheep	4A4 Goats	4A5 Camels & Llamas	4A6 Horses	4A7 Mules & Asses	4A8 Swine	4A9 Poultry - Chickens	4A10 Other - Other Poultry	4A10 Other - Rabbits	4A10 Other - Cervidae Species
	Population size (heads) Livestock category																
1990	58 840	158 611	*22 048*	*5 442*	*59 553*	*71 568*	NO	7 281	NE	NO	1 722	IE	75 463	69 021	NE	NE	NE
1991	55 604	163 940	*25 319*	*5 624*	*59 254*	*73 743*	NO	7 726	NE	NO	1 829	IE	66 592	63 559	NE	NE	NE
1992	51 110	158 225	*25 713*	*4 728*	*56 214*	*71 570*	NO	6 924	NE	NO	1 835	IE	67 837	60 281	NE	NE	NE
1993	50 182	158 696	*27 314*	*4 714*	*55 747*	*70 921*	NO	6 775	NE	NO	1 925	IE	71 800	63 444	NE	NE	NE
1994	48 978	159 766	*28 884*	*4 247*	*58 026*	*68 609*	NO	7 744	NE	NO	2 123	IE	68 854	60 451	NE	NE	NE
1995	48 599	165 288	*30 732*	*4 936*	*57 582*	*72 038*	NO	7 552	NE	NO	2 164	IE	72 640	55 618	NE	NE	NE
1996	47 953	169 974	*31 989*	*5 064*	*59 094*	*73 827*	NO	7 152	NE	NO	2 198	IE	72 494	61 855	NE	NE	NE
1997	46 305	166 030	*30 847*	*5 576*	*57 000*	*72 607*	NO	8 009	360	NO	2 295	IE	77 149	66 293	1 937	7 240	174
1998	45 952	162 788	*30 696*	*5 270*	*55 319*	*71 503*	NO	8 237	294	NO	2 342	IE	81 392	68 364	1 390	6 773	284
1999	45 102	162 760	*32 097*	*4 812*	*55 384*	*70 467*	NO	8 220	263	NO	2 818	IE	85 830	62 061	982	6 132	333
2000	43 346	161 726	*32 871*	*4 383*	*54 806*	*69 666*	NO	7 971	297	NO	3 154	IE	80 141	71 785	849	6 638	383
2001	42 854	162 339	*33 427*	*4 833*	*54 331*	*69 748*	NO	8 476	311	NO	3 126	IE	78 540	84 317	999	6 542	339
2002	42 076	155 181	*32 782*	*4 188*	*53 723*	*64 488*	NO	9 104	1 103	NO	3 117	IE	79 665	77 968	958	6 993	318
2003	40 599	149 075	*31 499*	*3 820*	*51 325*	*62 431*	NO	9 446	1 878	NO	3 449	IE	84 140	79 288	1 010	6 516	238
2004	39 879	146 846	*31 133*	*3 571*	*50 819*	*61 323*	NO	9 743	2 010	NO	3 686	IE	84 611	73 111	1 082	6 603	285
2005	39 340	145 995	*31 693*	*3 432*	*49 195*	*61 675*	NO	10 277	2 203	NO	4 072	121	90 147	83 407	1 122	6 514	234
2006	38 617	145 023	*31 616*	*3 169*	*49 453*	*60 785*	NO	9 644	1 950	NO	4 161	175	84 151	81 252	1 153	6 840	244
2007	40 042	151 886	*32 818*	*2 803*	*52 699*	*63 566*	NO	9 339	2 814	NO	4 182	152	83 255	81 908	814	4 792	175
Trend 1990-2007	*-31.95%*	*-4.24%*	*48.85%*	*-48.49%*	*-11.51%*	*-11.18%*	*NA*	*28.27%*	*681.67%*	*NA*	*142.86%*	*25.62%*	*10.33%*	*18.67%*	*-57.98%*	*-33.81%*	*0.57%*

Sources : SER: http://www.ser.public.lu/statistik/agrarstrukturen/statec_15_mai_pluriannuel.pdf

STATEC, *Statistical Yearbook*, Table C.2107: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=148&IF_Language=fra&MainTheme=3&FldrName=2&RFPath=6

data extracted on 15 September 2008 (subject to changes since that date)

Table 6-5 – CH_4 emission trends for IPCC Category 4A – Enteric Fermentation: 1990-2007

Year	4A1 Cattle - Mature Dairy Cattle	4A1 Non-Dairy Cattle	*4A1 Cattle - Mature Non-Dairy Cattle - Females*	*4A1 Cattle - Mature Non-Dairy Cattle - Males*	*4A1 Cattle - Young Cattle - Calves*	*4A1 Cattle - Young Cattle - Growing Heifers*	4A2 Buffalo	4A3 Sheep	4A4 Goats	4A5 Camels & Llamas	4A6 Horses	4A7 Mules & Asses	4A8 Swine	4A9 Poultry - Chickens	4A10 Other - Other Poultry	4A10 Other - Rabbits	4A10 Other - Cervidae Species	4A Total
	CH_4 emissions (Mg) Livestock category																	
1990	6 210.06	6 487.93	*1 196.12*	*289.65*	*1 864.07*	*3 138.09*	NO	58.25	NE	NO	31.00	IE	113.19	0.84	NE	NE	NE	**12 901.26**
1991	5 881.05	6 762.95	*1 373.76*	*299.33*	*1 855.97*	*3 233.89*	NO	61.81	NE	NO	32.92	IE	99.89	0.77	NE	NE	NE	**12 839.38**
1992	5 571.59	6 550.12	*1 396.82*	*251.64*	*1 762.50*	*3 139.15*	NO	55.39	NE	NO	33.03	IE	101.76	0.73	NE	NE	NE	**12 312.61**
1993	5 614.86	6 598.78	*1 487.59*	*250.90*	*1 748.80*	*3 111.50*	NO	54.20	NE	NO	34.65	IE	107.70	0.77	NE	NE	NE	**12 410.96**
1994	5 458.38	6 631.80	*1 574.18*	*226.04*	*1 821.09*	*3 010.49*	NO	61.95	NE	NO	38.21	IE	103.28	0.73	NE	NE	NE	**12 294.35**
1995	5 519.14	6 906.15	*1 674.14*	*262.71*	*1 807.98*	*3 161.31*	NO	60.42	NE	NO	38.95	IE	108.96	0.67	NE	NE	NE	**12 634.28**
1996	5 466.82	7 107.69	*1 741.76*	*269.53*	*1 856.20*	*3 240.21*	NO	57.22	NE	NO	39.56	IE	108.74	0.75	NE	NE	NE	**12 780.79**
1997	5 348.27	6 955.78	*1 681.02*	*296.78*	*1 790.99*	*3 187.00*	NO	64.07	1.80	NO	41.31	IE	115.72	0.80	NE	0.59	3.48	**12 531.84**
1998	5 334.81	6 829.93	*1 672.48*	*280.49*	*1 738.15*	*3 138.80*	NO	65.90	1.47	NO	42.16	IE	122.09	0.83	NE	0.55	5.68	**12 403.41**
1999	5 293.32	6 837.56	*1 747.90*	*256.11*	*1 740.22*	*3 093.32*	NO	65.76	1.32	NO	50.72	IE	128.75	0.75	NE	0.50	6.66	**12 385.33**
2000	5 167.51	6 804.07	*1 789.91*	*233.28*	*1 722.71*	*3 058.17*	NO	63.77	1.49	NO	56.77	IE	120.21	0.87	NE	0.54	7.66	**12 222.89**
2001	5 182.91	6 849.63	*1 821.90*	*257.23*	*1 708.43*	*3 062.07*	NO	67.81	1.56	NO	56.27	IE	117.81	1.02	NE	0.53	6.78	**12 284.31**
2002	5 150.59	6 530.79	*1 786.87*	*222.90*	*1 689.60*	*2 831.43*	NO	72.83	5.52	NO	56.11	IE	119.50	0.94	NE	0.57	6.36	**11 943.21**
2003	5 035.32	6 277.14	*1 718.42*	*203.32*	*1 614.17*	*2 741.24*	NO	75.57	9.39	NO	62.08	IE	126.21	0.96	NE	0.53	4.76	**11 591.96**
2004	5 007.49	6 180.35	*1 699.49*	*190.06*	*1 598.21*	*2 692.58*	NO	77.94	10.05	NO	66.35	IE	126.92	0.88	NE	0.54	5.70	**11 476.22**
2005	4 984.13	6 168.28	*1 730.40*	*182.66*	*1 547.20*	*2 708.02*	NO	82.22	11.02	NO	73.30	1.21	135.22	1.01	NE	0.53	4.68	**11 461.59**
2006	4 932.28	6 121.73	*1 728.49*	*168.67*	*1 555.61*	*2 668.97*	NO	77.15	9.75	NO	74.90	1.75	126.23	0.98	NE	0.56	4.88	**11 350.21**
2007	5 070.28	6 391.34	*1 793.06*	*149.19*	*1 657.88*	*2 791.22*	NO	74.71	14.07	NO	75.28	1.52	124.88	0.99	NE	0.39	3.50	**11 756.97**
Trend 1990-2007	*-18.35%*	*-1.49%*	*49.91%*	*-48.49%*	*-11.06%*	*-11.05%*	*NA*	*28.27%*	*681.67%*	*NA*	*142.86%*	*25.62%*	*10.33%*	*18.67%*	*NA*	*-33.81%*	*0.57%*	*-8.87%*

Source: Ministry of the Environment.

Notes for Tables 6-3 and 6-4:

Livestock population is coming from the yearly agricultural census. The situation is the one on the 15th of May of each year. Thus, the number of heads included in the inventory for a certain year corresponds to the population on the 15th of May.

Accurate data on the population size for certain livestock categories (4A4 and 4A10) is only available since the 1997 census (hence the NE notation key).

Mules & Asses population was reported together with horses population up to the 2004 census included.

Livestock description:

4A1 – Cattle – Mature Dairy Cattle: dairy cows

4A1 – Cattle – Mature Non-Dairy Cattle – Females: suckler cows & other cows

4A1 – Cattle – Mature Non-Dairy Cattle – Males: male cattle over 2 years

4A1 – Cattle – Young Cattle – Calves: calves for slaughtering & other calves

4A1 – Cattle – Young Cattle – Growing Heifers: cattle from 1 to 2 years (males & females), heifers for slaughtering & other heifers

4A3 – Sheep: ovine

4A4 – Goats: caprine

4A6 – Horses: ponies, foals, mares, stallions & geldings; includes farming & horsemanship animals, the latter only for horse clubs registered as farms

4A7 – Mules & Asses: asses (included with horses up to 2004 included)

4A8 – Swine: porcine including piglets, sows, pigs & boars

4A9 – Poultry – Chickens: broiler & layer chickens, roosters & chicks

4A10 – Other – Other Poultry: ducks, geeses, turkeys, guinea-fowls & wild poultry

4A10 – Other – Rabbits: breeding females & other rabbits

4A10 – Other – Cervidae Species: breeding females & other cervidae species

6.2.2 Source category description

Table 6-4 identifies and describes the various animal categories that have been taken into account for estimating methane emissions from enteric fermentation. Livestock statistics in Luxembourg are detailed enough to go for option B for cattle. Under other livestock, Luxembourg has included the following animals: other poultry (i.e. ducks, geese, turkeys, guinea fowls and wild poultry), rabbits and cervidae species (mainly deer). Some farm animals recorded in statistics are not yet included in the inventory. It is the case for ostriches and a category labelled "other productive animals". However, in 2006, there were 182 ostriches and only 17 "productive animals" reported.

Looking at animal species for which data are available for the whole period 1990-2007, horses have experienced the biggest increase in their population. Nevertheless, as shown in Table 6-5, which recapitulates methane emissions from enteric fermentation for each of the livestock categories, horse related methane emissions are relatively low compared to emissions originating from cattle and swine, the two main methane emitting animal categories with regard to enteric fermentation.

On the whole, methane emissions from enteric fermentation decreased by around 9% over the period 1990-2007. This was mainly the result from declining emissions generated by cattle – -18.4% for dairy cattle and -1.5% for non-dairy cattle – whilst increasing emissions were recorded for the other livestock categories – with +10.3% for swine, +28.3% for sheep and +142.9% for horses, naming only the biggest contributors. It is worth noting that because a Tier 1 method has been applied to estimate methane emissions from enteric fermentation for all animal categories except cattle (see Section 6.2.3), population and methane emission growths are exactly the same.[127]

With regard to cattle, its total population size declined throughout the period 1990-2007. However, a shift did occur within the cattle population with a reduction for dairy cattle (-32%) and an increase for female mature non-dairy cattle (+48.9%). In fact, cattle population and its evolution are strongly influenced by changes in the agricultural policy and, more precisely, in the Common Agricultural Policy of the EU (*CAP*). This is the case for dairy cows, whose declining population results from the combination of increasing milk yields and the introduction of a milk production cap (administrative quota system for milk production). Furthermore, several reductions in the milk quota were decided in the framework of the CAP. Another factor influencing cattle population is, of course, prices (which, themselves are affected by agricultural policy changes and targets). As an example, the peak in the non-dairy cattle population observed in 1991 can be explained by a sharp

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127 Actually, even in the case of a Tier 2 method, it would be possible to have equality between population and emission growth. This occurs when default and invariable values for the components of the gross energy intake are chosen for every inventory year (see Section 6.2.3.2 below).

price fall of the bovine meat price that year. This price fall led farmers to postpone slaughtering until early 1992.

Finally, if the dairy cattle population decreased by 32% between 1990 and 2007, related methane emissions only declined by 18.4%. This is explained by increasing milk yield over the period which, in turn, led to an augmentation of the gross energy intake for dairy cattle.[128]

6.2.3 Methodological issues

The IPCC Tier 1 method has been applied to all farm animal categories with the exception of cattle (IPCC Sub-category 4A1) for which a Tier 2 method has been used together with option B.

6.2.3.1 Activity data

The following activity data have been extracted from national statistics:

- number of animals: see Table 6-4 in Section 6.2.2;

the milk yield and the fat content of milk for dairy cattle: see The milk yield is obtained by dividing the milk production by the number of dairy cows. It is measured in kg per head. The SER calculates the milk production by adding up:

- the amount of milk collected by the dairy industry directly from the farmers;
- the amount of milk and milk products directly sold by the farmers;
- the milk consumption within the farms (for the farmer and its family, and for its animals).

Over the period 1990-2007, the milk yield has increased by a bit more than 43%. At the same time – see Table 6-4 above – the dairy cattle population declined by 32%. As these two parameters are the main drivers for the calculation of the IEF under the Tier 2 method, it is no surprise to record a 20% increase since 1990 for the IEF expressed in CH_4/head/year – see Table 6-11 in Section 6.2.3.2.

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6.2.3.1.1 Milk yield and fat content

The milk yield is obtained by dividing the milk production by the number of dairy cows. It is measured in kg per head. The SER calculates the milk production by adding up:

- the amount of milk collected by the dairy industry directly from the farmers;
- the amount of milk and milk products directly sold by the farmers;
- the milk consumption within the farms (for the farmer and its family, and for its animals).

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128 Via an increase of one of the component of the gross energy intake: the net energy for lactation (see Section 6.2.3.2 below).

Over the period 1990-2007, the milk yield has increased by a bit more than 43%. At the same time – see Table 6-4 above – the dairy cattle population declined by 32%. As these two parameters are the main drivers for the calculation of the IEF under the Tier 2 method, it is no surprise to record a 20% increase since 1990 for the IEF expressed in CH_4/head/year – see Table 6-11 in Section 6.2.3.2.

Table 6-6 – Milk yield and fat content of milk for dairy cattle: 1990-2007

Year	Milk yield *kg/cow/year*	Fat content of milk *%*
1990	4787	4.09%
1991	4767	4.16%
1992	5095	4.16%
1993	5345	4.22%
1994	5341	4.16%
1995	5527	4.20%
1996	5536	4.25%
1997	5700	4.23%
1998	5745	4.25%
1999	5909	4.20%
2000	6103	4.19%
2001	6293	4.17%
2002	6433	4.18%
2003	6579	4.20%
2004	6734	4.20%
2005	6856	4.19%
2006	6942	4.21%
2007	6849	4.19%
Trend 1990-2007	*43.07%*	*NA*

Sources : SER: http://www.ser.public.lu/statistik/tier_produktion/milchliefermenge_erzeugerpreis_jahr.pdf
STATEC, *Statistical Yearbook*, Table C.2111:
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=152&IF_Language=fra&MainTheme=3&FldrName=2&RFPath=6
data extracted on 29 September 2008 (subject to changes since that date)

6.2.3.1.2 Live-weight

Live-weight for most animal categories have been provided by SER. These data are not published as such and, therefore, might be considered as expert judgments. However, they rely on measurements and are not purely speculative. These weights are constant over time and are provided in Table 6-7.

Table 6-7 – Live-weight for farm animals reported in the inventory

Livestock category	Live-weight in kg used for estimating enteric fermentation emissions	Comments
4A1 – Cattle – Mature Dairy Cattle	650.00	
4A1 – Cattle – Mature Non-Dairy Cattle – Females	700.00	
4A1 – Cattle – Mature Non-Dairy Cattle – Males	750.00	
4A1 – Cattle – Young Cattle – Calves	110.00	
4A1 – Cattle – Young Cattle – Growing Heifers	350.00	

Livestock category	Live-weight in kg used for estimating enteric fermentation emissions	Comments
4A2 – Buffalo	NO	
4A3 – Sheep	45.00	*This is a simple average between the estimated weights of a lamb (30 kg) and of a mature sheep (60 kg).*
4A4 – Goats	40.00	
4A5 – Camels & Llamas	NO	
4A6 – Horses	600.00	
4A7 – Mules & Asses	300.00	
4A8 – Swine	100.00	
4A9 – Poultry – Chickens	2.00	
4A10 – Other – Other Poultry	NE	*Not yet estimated in Luxembourg. Moreover, no default value was found in the literature.*
4A10 – Other – Rabbits	1.60	*Value taken from table 10A-9 of the 2006 IPCC Guidelines. It is obtained from the 2004 GHG inventory of Italy.*
4A10 – Other – Cervidae Species	120.00	*Value taken from table 10.10 of the 2006 IPCC Guidelines. It refers to deer.*

Source: SER, not published (provided on 1st June 2007), otherwise indicated.

6.2.3.2 Emission factors

EFs for enteric fermentation related methane emissions are actually IEFs obtained by combining the average gross energy intake (*GE* in MJ per day) of each animal category with a methane conversion rate (*Ym* in %) provided in the IPCC Guidelines:

$$IEF_i = [GE_i \bullet Ym_i \bullet 365] / 55.65$$

with i = each livestock category

IEF_i expressed in kg CH_4/head/year

the factor 55.65 expressed in MJ/kg of CH_4

➔ see equation 4.14 of the 2000 IPCC-GPG.

For the Tier 1 method, default GE is usually provided in the IPCC Guidelines. For the Tier 2 method, GE is the combination of various feed intake – or net energy – estimates relating to maintenance, activity, growth, etc. of the animals.

Table 6-8 indicates, for each animal category, which method has been used to estimate methane emissions as well as the corresponding IEF type.

Table 6-8 – Method and type of EF used in the inventory

Livestock category	Estimation method	IEF	Comments
4A1 – Cattle – Mature Dairy Cattle	T2	CS	*The IEF is CS because GE is obtained by combining national AD, default coefficients/parameters from the IPCC Guidelines and, in some cases, other country values.*
4A1 – Cattle – Mature Non-Dairy Cattle – Females	T2	CS	
4A1 – Cattle – Mature Non-Dairy Cattle – Males	T2	CS	
4A1 – Cattle – Young Cattle – Calves	T2	CS	

Livestock category	Estimation method	IEF	Comments
4A1 – Cattle – Young Cattle – Growing Heifers	T2	CS	
4A2 – Buffalo	NO	NO	
4A3 – Sheep	T1	D	
4A4 – Goats	T1	D	
4A5 – Camels & Llamas	NO	NO	
4A6 – Horses	T1	D	
4A7 – Mules & Asses	T1	D	
4A8 – Swine	T1	D	
4A9 – Poultry – Chickens	T1	OTH	*GE and Ym values used are obtained from the EC GHG inventory.*
4A10 – Other – Other Poultry	NE	NE	*There are no methods and default values provided in the literature for estimating emissions for this source category.*
4A10 – Other – Rabbits	T1	OTH	*GE and Ym values used are obtained from the 2004 GHG inventory of Italy.*
4A10 – Other – Cervidae Species	T1	D	*Value taken from table 10.10 of the 2006 IPCC Guidelines. It refers to deer in developed countries.*

Source: Ministry of the Environment.

Abbreviations: T1 = Tier 1 ; T2 = Tier 2 ; CS = Country Specific ; D = IPCC Default ; OTH = Other

6.2.3.2.1 Tier 2 method – cattle

For dairy cattle, the IEF has been calculated by combining the following activity data, coefficients and parameters:

Table 6-9 – Activity data, coefficients and parameters used for IPCC Sub-category 4A1 – Cattle – Mature Dairy Cattle

AD, parameter, coefficient	Unit	Source(s)	Type of value
Livestock (# of heads)	#	SER & STATEC (updated 080915)	AD (see Table 6-3)
Live Weight	kg	SER, not published (provided 070601)	AD (see Table 6-6), invariable
Live Body Weight	kg	equation 7 – Revised 1996 IPCC Guidelines	calculated, invariable
Daily Weight Gain	kg/day	-	NA
Milk Yield	kg/cow/year	SER (updated 080929)	AD (see Table 6-5)
Daily Milk Production	kg/cow/day	-	calculated using 365.25 days/year
Fat Content of Milk	%	SER (updated 080929)	AD (see Table 6-5)
Digestible Energy	%	German value	invariable
Net Energy for Maintenance	MJ/day	equation 4.1 & table 4.4 – 2000 IPCC-GPG	calculated using the default coefficient for lactating cattle, invariable
Net Energy for Activity	MJ/day	equation 4.2a & table 4.5 – 2000 IPCC-GPG	calculated using the default cattle coefficient for pasture, invariable
Net Energy for Growth	MJ/day	equation 4.3a – 2000 IPCC-GPG	calculated, nil by definition
Net Energy due to Weight Loss	MJ/day	equation 4.4a – 2000 IPCC-GPG	NO
Net Energy for Lactation	MJ/day	equation 4.5a – 2000 IPCC-GPG	calculated using daily milk production
Net Energy for Work	MJ/day	equation 4.6 – 2000 IPCC-GPG	NO
Net Energy for Pregnancy	MJ/day	equation 4.8 & table 4.7 – 2000 IPCC-GPG	calculated using the default pregnancy coefficient for cattle and corrected by a factor of 0.936 (expert judgment), invariable
Ratio of Net Energy in a Diet for Maintenance to Digestible Energy Consumed	#	equation 4.9 – 2000 IPCC-GPG	calculated, invariable

AD, parameter, coefficient	Unit	Source(s)	Type of value
Ratio of Net Energy Available for Growth in a Diet to Digestible Energy Consumed	#	equation 4.10 – 2000 IPCC-GPG	calculated, invariable
Gross Energy Intake (average)	MJ/day	equation 4.11 – 2000 IPCC-GPG	calculated
CH_4 Conversion Rate (average)	%	table 4.8 – 2000 IPCC-GPG	default for developed countries

For other cattle sub-categories, the IEF has been calculated by combining the following activity data, coefficients and parameters:

Table 6-10 – Activity data, coefficients and parameters used for IPCC Sub-category 4A1 – Cattle – Non-Dairy Cattle

AD, parameter, coefficient	Unit	Source(s)	Type of value
Livestock (# of heads)	#	SER & STATEC (updated 080915)	AD (see Table 6-3)
Live Weight	kg	SER, not published (provided 070601)	AD (see Table 6-6), invariable
Live Body Weight	kg	equation 7 – Revised 1996 IPCC Guidelines	calculated, invariable for male & female non-dairy cattle, variable for young cattle (weighted averages of young cattle sub-categories default weights)
Daily Weight Gain	kg/day	- mature non-dairy cattle: NA - young cattle: SER, not published (provided 070601)	- NA - AD: 0.8 for calves and 0.6 for growing heifers
Digestible Energy	%	- mature non-dairy cattle: German value - young cattle: table A-2 – Revised 1996 IPCC Guidelines	- invariable - default for Western Europe
Net Energy for Maintenance	MJ/day	equation 4.1 & table 4.4 – 2000 IPCC-GPG	calculated using the default coefficient for non-lactating cattle, invariable
Net Energy for Activity	MJ/day	equation 4.2a & table 4.5 – 2000 IPCC-GPG	calculated using the default cattle coefficient for pasture, invariable
Net Energy for Growth	MJ/day	equation 4.3a – 2000 IPCC-GPG	calculated, nil by definition for mature non-dairy cattle
Net Energy due to Weight Loss	MJ/day	equation 4.4b – 2000 IPCC-GPG	NO
Net Energy for Lactation	MJ/day	equation 4.5a – 2000 IPCC-GPG	NA
Net Energy for Work	MJ/day	equation 4.6 – 2000 IPCC-GPG	NO
Net Energy for Pregnancy	MJ/day	equation 4.8 & table 4.7 – 2000 IPCC-GPG	calculated using the default pregnancy coefficient for female non-dairy cattle and corrected by a factor of 0.936 (expert judg-ment) for suckler cows, invariable (NA for other female mature non-dairy cattle, male and young cattle)
Ratio of Net Energy in a Diet for Maintenance to Digestible Energy Consumed	#	equation 4.9 – 2000 IPCC-GPG	calculated, invariable
Ratio of Net Energy Available for Growth in a Diet to Digestible Energy Consumed	#	equation 4.10 – 2000 IPCC-GPG	calculated, invariable
Gross Energy Intake (average)	MJ/day	equation 4.11 – 2000 IPCC-GPG	calculated
CH_4 Conversion Rate (average)	%	table 4.8 – 2000 IPCC-GPG	default for developed countries

Note: variable values for live body weight explain why population and methane emission growths presented in Tables 6-3 and 6-4 differ slightly.

6.2.3.2.2 Tier 1 method – all farm animal categories except cattle

For farm animals, which are not cattle, the IEF is generally the default enteric fermentation EF for developed countries presented in Table 4-3 of the Revised 1996 IPCC Guidelines. More details are provided in Table 6-11.

Table 6-11 – Activity data, coefficients and parameters used for IPCC Sub-categories 4A3 to 4A10[129]

AD, parameter, coefficient	Unit	Source(s)	Type of value
Livestock (# of heads)	#	SER & STATEC (updated 080915)	AD (see Table 6-3)
Live Weight	kg	- 4A3 to 4A9: SER, not published (provided 070601) - 4A10 – rabbits: table 10A-9 – 2006 IPCC Guidelines (italian value) - 4A10 – cervidae species: table 10.10 – 2006 IPCC Guidelines (deer's value)	AD (see Table 6-6), invariable
Gross Energy Intake (average)	MJ/day	- 4A3 to 4A8: table A-4 – Revised 1996 IPCC Guidelines - 4A9: EC average value - 4A10 – rabbits: Italian reported value	- default for developed countries - invariable - invariable
CH_4 Conversion Rate (average)	%	- 4A3 to 4A8: table A-4 – Revised 1996 IPCC Guidelines - 4A9: EC average value - 4A10 – rabbits: Italian reported value	- default for developed countries - invariable - invariable

Notes:

If an animal category is not indicated, it means that the value is NE for that particular AD, parameter or coefficient.

When default values have been used for both GE and Ym, the IEF calculated equals the enteric fermentation EF provided for developed countries in table 4-3 of the Revised 1996 IPCC Guidelines.

For sub-categories 4A9 & 4A10 – rabbits, equation 4.14 of the 2000 IPCC-GPG has been used to calculate the IEF.

For sub-category 4A10 – cervidae species, the default EF for deer in developed countries presented in table 10.10 of the 2006 IPCC Guidelines has been used.

6.2.3.2.3 Methane IEFs for 4A – Enteric Fermentation

Table 6-11 presents the IEFs obtained for each farm animal category using the Tier 1 or Tier 2 methods described above.

For those animal categories for which no accurate data are available in official statistics for the years prior to 1997 (i.e. 4A4 and 4A10), it has not been attempted to "backcast" the methane emissions back to the base year, because:

- not estimated (NE) emissions under- but not overestimate the base year GHG emissions;
- it would not make much sense to devote efforts for estimating the missing years since CH_4 emissions for the concerned animal categories are particularly low and almost negligible.

129 IPCC Sub-categories 4A2 – Buffalo and 4A5 – Camels & Llamas do not exist in Luxembourg.

Table 6-12 – CH_4 IEFs trends for IPCC Category 4A – Enteric Fermentation: 1990-2007

Year	IEF for CH_4 (kg CH_4/head/year) Livestock category																
	4A1 Cattle - Mature Dairy Cattle	4A1 Non-Dairy Cattle	*4A1 Cattle - Mature Non-Dairy Cattle - Females*	*4A1 Cattle - Mature Non-Dairy Cattle - Males*	*4A1 Cattle - Young Cattle - Calves*	*4A1 Cattle - Young Cattle - Growing Heifers*	4A2 Buffalo	4A3 Sheep	4A4 Goats	4A5 Camels & Llamas	4A6 Horses	4A7 Mules & Asses	4A8 Swine	4A9 Poultry - Chickens	4A10 Other - Other Poultry	4A10 Other - Rabbits	4A10 Other - Cervidae Species
1990	105.54	40.90	*54.25*	*53.22*	*31.30*	*43.85*	NO	8.00	NE	NO	18.00	IE	1.50	0.01	NE	NE	NE
1991	105.77	41.25	*54.26*	*53.22*	*31.32*	*43.85*	NO	8.00	NE	NO	18.00	IE	1.50	0.01	NE	NE	NE
1992	109.01	41.40	*54.32*	*53.22*	*31.35*	*43.86*	NO	8.00	NE	NO	18.00	IE	1.50	0.01	NE	NE	NE
1993	111.89	41.58	*54.46*	*53.22*	*31.37*	*43.87*	NO	8.00	NE	NO	18.00	IE	1.50	0.01	NE	NE	NE
1994	111.45	41.51	*54.50*	*53.22*	*31.38*	*43.88*	NO	8.00	NE	NO	18.00	IE	1.50	0.01	NE	NE	NE
1995	113.56	41.78	*54.48*	*53.22*	*31.40*	*43.88*	NO	8.00	NE	NO	18.00	IE	1.50	0.01	NE	NE	NE
1996	114.00	41.82	*54.45*	*53.22*	*31.41*	*43.89*	NO	8.00	NE	NO	18.00	IE	1.50	0.01	NE	NE	NE
1997	115.50	41.89	*54.50*	*53.22*	*31.42*	*43.89*	NO	8.00	5.00	NO	18.00	IE	1.50	0.01	NE	0.08	20.00
1998	116.10	41.96	*54.49*	*53.22*	*31.42*	*43.90*	NO	8.00	5.00	NO	18.00	IE	1.50	0.01	NE	0.08	20.00
1999	117.36	42.01	*54.46*	*53.22*	*31.42*	*43.90*	NO	8.00	5.00	NO	18.00	IE	1.50	0.01	NE	0.08	20.00
2000	119.22	42.07	*54.45*	*53.22*	*31.43*	*43.90*	NO	8.00	5.00	NO	18.00	IE	1.50	0.01	NE	0.08	20.00
2001	120.94	42.19	*54.50*	*53.22*	*31.44*	*43.90*	NO	8.00	5.00	NO	18.00	IE	1.50	0.01	NE	0.08	20.00
2002	122.41	42.09	*54.51*	*53.22*	*31.45*	*43.91*	NO	8.00	5.00	NO	18.00	IE	1.50	0.01	NE	0.08	20.00
2003	124.03	42.11	*54.55*	*53.22*	*31.45*	*43.91*	NO	8.00	5.00	NO	18.00	IE	1.50	0.01	NE	0.08	20.00
2004	125.57	42.09	*54.59*	*53.22*	*31.45*	*43.91*	NO	8.00	5.00	NO	18.00	IE	1.50	0.01	NE	0.08	20.00
2005	126.69	42.25	*54.60*	*53.22*	*31.45*	*43.91*	NO	8.00	5.00	NO	18.00	10.00	1.50	0.01	NE	0.08	20.00
2006	127.72	42.21	*54.67*	*53.22*	*31.46*	*43.91*	NO	8.00	5.00	NO	18.00	10.00	1.50	0.01	NE	0.08	20.00
2007	126.62	42.08	*54.64*	*53.22*	*31.46*	*43.91*	NO	8.00	5.00	NO	18.00	10.00	1.50	0.01	NE	0.08	20.00
Trend 1990-2007	*19.98%*	*2.87%*	*0.71%*	*NA*	*0.51%*	*0.14%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
IEF type	*CS*	*CS*	*CS*	*CS*	*CS*	*CS*	*NA*	*D*	*D*	*NA*	*D*	*D*	*D*	*OTH*	*NA*	*OTH*	*D*

Source: Ministry of the Environment.

Notes:

Accurate data on the population size for certain livestock categories (4A4 and 4A10) is only available since the 1997 census (hence the NE notation key).

Mules & asses were recorded together with horses (sub-category 4A6) up to and including 2004.

CS variable IEFs: the result of changing milk yields for dairy cattle and of changing live body weight for young cattle (other constituting parameters and coefficients show constant values).

CS invariable IEFs: the result of the use of constant values for live body weights as well as for other constituting parameters and coefficients.

6.2.4 Recalculations

Table 6-13 presents the main revisions and recalculations between submissions 2008v1.2 and 2009v1.4 (see also CRF tables 8).

Table 6-13 – Changes in GHG inventories: submissions 2008v1.2 and 2009v1.4

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
4A1	- revised calculation of Gross Energy Intake for mature dairy and non-dairy female cattle: for dairy cows, the parameter net energy for pregnancy is weighted by a factor of 93.6% instead of 90% in the previous submission; for mature female suckler cows, this parameter is weighted by a factor of 100% instead of 90%; for other mature female non-dairy cows, this parameter is set to NA : expert judgements	- refinement
4A10	- rabbits: the methane conversion rate has been corrected: 0.60% instead of 0.06% in the previous submission	- error correction

6.2.5 Category specific QA/QC procedures

Consistency and completeness checks have been performed directly within the Microsoft Excel™ file that has been developed by the Ministry of the Environment to calculate GHG emissions from the agriculture sector as well as by using the tools embedded in CRF Reporter.

The plausibility of the estimates, as well as the calculation methods, were extensively discussed between the Ministry of the Environment and the sector experts, SER and ASTA.

6.2.6 Planned improvement

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 6-14 will be explored.

Table 6-14 – Planned improvements for IPCC Category 4A – Enteric Fermentation

GHG source & sink category	Planned improvement
4A – Enteric Fermentation	analyze whether it would be possible to replace some default parameter values – such as GE – by national values.
4A1 – Cattle: net energy for activity	refine the calculation for this parameter taking into account the time spent by animals in stalls and on pastures.
4A3 – Sheep: live-weight	national statistics allow for a breakdown of sheep between lambs and mature animals, hence allow for calculating a more precise live-weight for this animal category since estimated weights are known for both lambs and mature animals.
4A4 - Goats	completing the time serie for the years prior to 1997 (through the estimation of the number of animals).
4A8 – Swine	national statistics allow for a breakdown of swine in various sub-categories for which more precise parameter values could be applied.
4A9 – Poultry – Chickens	national statistics allow for a breakdown of chickens in various sub-categories for which more precise parameter values could be applied.
4A10 – Other	completing the time serie for the years prior to 1997 (through the estimation of the number of animals) and investigate whether it would be worth, straightforward and not time/resources consuming to include the missing farm animals (ostriches, "productive animals").

6.3 Manure Management (4B)

This section describes the estimation of methane and nitrous oxide emissions resulting from manure management. In 2007, this source category was responsible for 17.4% of the total GHG emissions from the agriculture sector and it represented 0.96% of the total GHG emissions in CO_2e (excluding LULUCF). For each of the two gases reported, excluding LULUCF, in 2007:

- CH_4 represented 28.5% of agricultural methane emissions and 21.7% of the total methane emissions estimated for Luxembourg;
- N_2O represented 7% of agricultural nitrous oxide emissions and 4.9% of the total nitrous oxide emissions estimated for Luxembourg.

6.3.1 Key source

With 0.48% of the total GHG emissions in CO_2e, excluding LULUCF in 2007 (0.50% of the total GHG emissions in CO_2e, including LULUCF), methane emissions from cattle (IPCC Sub-category 4B1) is a key source, whether LULUCF is included or excluded. It has been a key source from 1991 to 2006 when LULUCF is excluded and only in 1991 when LULUCF is included.

6.3.2 Source category description

Table 6-4 in Section 6.2.2 identifies and describes the various animal categories that have been taken into account for estimating methane and nitrous oxide emissions from manure management. The farm animal population recorded for estimating manure related emissions is, of course, identical to the population reported for enteric fermentation. Consequently, here too, livestock statistics are detailed enough to go for option B for cattle.

Looking at methane emissions from manure management –Table 6-16 – an increase by a bit less than 15% can be observed for the period 1990-2007. Animals who did contribute the most of these emissions are cattle, swine and, to a lesser extent, chicken. For the other farm animal categories, methane emissions can be considered as negligible. Similarly to enteric fermentation methane related emissions, when a Tier 1 method has been applied to estimate methane emissions from manure management – i.e. for all animal categories except cattle (see Section 6.3.3) – population and methane emission growths are exactly the same.

Looking at nitrous oxide emissions from manure management – Table 6-17 – a decrease of almost 37% is observed for the period 1990-2007. These emissions are mainly due to cattle. However, if cattle were responsible for more than 95% of manure related N_2O emissions in 1990, this share dropped to 87% in 2007. This evolution is the result of a declining cattle population at the same time as other farm animal categories saw their number grow. Here too, for some livestock categories, the observed nitrous oxide emissions developments between 1990 and 2007 are identical to those of their population size: it is the case for all categories except cattle and swine. Since a Tier 1 method has been applied to estimate nitrous oxide emissions from manure management for **all** farm animal categories (see Section 6.3.4), the reason behind disparate growths lies elsewhere. In fact, for cattle, the inventory records varying values for some of the animal waste management systems (*AWMS*) as well as, for some cattle sub-categories, varying values for nitrogen excretion (see Table 6-25 in Section 6.3.4.1). For swine, nitrogen excretion is changing through time.

Actually, with regard to nitrous oxide, the CRF requires reporting emissions by AWMS categories rather than by livestock categories. As shown in Table 6-16, solid storage is the main source of N_2O (96% in 1990, 91% in 2007). In the same time, liquid system share almost doubled (from 3.9% to 7.6%). Another category is taking more and more importance, even if its share in the total AWMS related N_2O emissions remains modest: anaerobic digesters – recorded under "other AWMS" – for the production of biogas. Finally, anaerobic lagoons, daily spread and dry lots are AWMS that do not or barely exist in Luxembourg, hence the NO notation key.

Table 6-15– N_2O emission trends for IPCC Category 4B – Manure Management: 1990-2007 per AWMS

Year	*N_2O emissions (Mg)* AWMS category							
	Anaerobic Lagoon	Liquid System	Daily Spread	Solid Storage	Dry Lot	*Pasture, Range & Paddock (PRP)*	Other AWMS (anaerobic digester)	Total (excl. PRP)
1990	NO	5.07	NO	125.86	NO	*188.94*	0.08	**131.00**
1991	NO	5.94	NO	106.48	NO	*190.61*	0.07	**112.49**
1992	NO	5.97	NO	96.34	NO	*181.38*	0.07	**102.38**
1993	NO	6.08	NO	94.77	NO	*181.35*	0.07	**100.93**
1994	NO	6.16	NO	90.42	NO	*180.06*	0.07	**96.66**
1995	NO	6.68	NO	93.05	NO	*190.65*	0.07	**99.80**
1996	NO	6.72	NO	94.35	NO	*193.44*	0.07	**101.14**
1997	NO	6.80	NO	90.27	NO	*188.30*	0.08	**97.15**
1998	NO	6.96	NO	85.00	NO	*186.09*	0.08	**92.04**
1999	NO	7.72	NO	69.69	NO	*185.55*	0.08	**77.50**
2000	NO	7.41	NO	67.96	NO	*182.98*	0.26	**75.63**
2001	NO	7.25	NO	67.85	NO	*183.17*	0.45	**75.55**
2002	NO	6.94	NO	64.36	NO	*176.91*	0.61	**71.91**
2003	NO	6.73	NO	65.54	NO	*176.00*	0.79	**73.06**
2004	NO	6.66	NO	65.05	NO	*173.50*	0.95	**72.66**
2005	NO	6.86	NO	62.83	NO	*173.65*	0.96	**70.65**
2006	NO	6.82	NO	59.44	NO	*171.50*	0.94	**67.21**
2007	NO	6.30	NO	75.46	NO	*177.79*	0.97	**82.74**
Trend 1990-2007	*NA*	*24.31%*	*NA*	*-40.04%*	*NA*	*-5.90%*	*1172.14%*	*-36.84%*

Source: Ministry of the Environment.

Note: N_2O emissions from pasture, range & paddock (*PRP*) are excluded from the total N_2O emissions in IPCC Category 4B since they have to be accounted for in IPCC Sub-category 4D2 – Emissions from PRP Manure.

Table 6-16 – CH_4 emission trends for IPCC Category 4B – Manure Management: 1990-2007

Year	*CH_4 emissions (Mg)* Livestock category																	
	4B1 Cattle - Mature Dairy Cattle	**4B1** Non-Dairy Cattle	***4B1*** *Cattle - Mature Non-Dairy Cattle - Females*	***4B1*** *Cattle - Mature Non-Dairy Cattle - Males*	***4B1*** *Cattle - Young Cattle - Calves*	***4B1*** *Cattle - Young Cattle - Growing Heifers*	**4B2** Buffalo	**4B3** Sheep	**4B4** Goats	**4B5** Camels & Llamas	**4B6** Horses	**4B7** Mules & Asses	**4B8** Swine	**4B9** Poultry - Chickens	**4B10** Other - Other Poultry	**4B10** Other - Rabbits	**4B10** Other - Cervidae Species	**4B** Total
1990	1 529.41	1 014.34	*154.66*	*37.45*	*281.20*	*541.02*	NO	1.35	NE	NO	2.39	IE	1 472.97	55.36	NE	NE	NE	**4 075.82**
1991	1 787.43	1 279.00	*215.58*	*46.97*	*339.80*	*676.65*	NO	1.43	NE	NO	2.53	IE	1 299.81	50.98	NE	NE	NE	**4 421.19**
1992	1 779.03	1 295.06	*229.27*	*41.30*	*337.50*	*686.99*	NO	1.28	NE	NO	2.54	IE	1 324.11	48.35	NE	NE	NE	**4 450.38**
1993	1 819.83	1 320.20	*247.74*	*41.78*	*339.78*	*690.90*	NO	1.26	NE	NO	2.67	IE	1 401.47	50.89	NE	NE	NE	**4 596.31**
1994	1 832.04	1 365.01	*270.67*	*38.87*	*365.31*	*690.17*	NO	1.44	NE	NO	2.94	IE	1 343.97	48.49	NE	NE	NE	**4 593.88**
1995	1 894.86	1 450.21	*293.89*	*46.12*	*370.28*	*739.93*	NO	1.40	NE	NO	3.00	IE	1 417.86	44.61	NE	NE	NE	**4 811.95**
1996	1 876.90	1 491.62	*305.76*	*47.31*	*380.15*	*758.40*	NO	1.33	NE	NO	3.05	IE	1 415.01	49.62	NE	NE	NE	**4 837.52**
1997	1 892.73	1 504.88	*304.18*	*53.70*	*378.09*	*768.91*	NO	1.48	0.04	NO	3.18	IE	1 505.88	53.18	0.15	0.58	0.04	**4 962.14**
1998	1 954.60	1 526.65	*312.68*	*52.44*	*379.11*	*782.42*	NO	1.53	0.03	NO	3.25	IE	1 588.70	54.84	0.11	0.54	0.06	**5 130.30**
1999	2 183.53	1 701.69	*364.57*	*53.42*	*423.46*	*860.24*	NO	1.52	0.03	NO	3.90	IE	1 675.32	49.78	0.08	0.49	0.07	**5 616.42**
2000	2 095.57	1 656.27	*365.52*	*47.64*	*410.43*	*832.68*	NO	1.48	0.03	NO	4.37	IE	1 564.28	57.58	0.07	0.53	0.08	**5 380.26**
2001	2 055.68	1 619.99	*361.92*	*51.10*	*395.94*	*811.04*	NO	1.57	0.04	NO	4.33	IE	1 533.03	67.63	0.08	0.52	0.07	**5 282.95**
2002	2 016.82	1 511.59	*348.24*	*43.44*	*384.16*	*735.75*	NO	1.69	0.13	NO	4.32	IE	1 554.99	62.54	0.07	0.56	0.07	**5 152.77**
2003	1 902.67	1 389.95	*320.18*	*37.88*	*350.88*	*681.00*	NO	1.75	0.22	NO	4.78	IE	1 642.33	63.60	0.08	0.52	0.05	**5 005.95**
2004	1 840.37	1 323.13	*306.18*	*34.24*	*335.92*	*646.79*	NO	1.81	0.23	NO	5.11	IE	1 651.53	58.64	0.08	0.53	0.06	**4 881.49**
2005	1 877.28	1 351.16	*319.02*	*33.68*	*332.79*	*665.68*	NO	1.90	0.26	NO	5.64	0.09	1 759.58	66.90	0.09	0.52	0.05	**5 063.48**
2006	1 900.41	1 371.00	*325.93*	*31.80*	*342.22*	*671.04*	NO	1.79	0.23	NO	5.77	0.13	1 642.55	65.17	0.09	0.55	0.05	**4 987.73**
2007	1 714.86	1 263.91	*298.27*	*24.82*	*321.75*	*619.08*	NO	1.73	0.33	NO	5.80	0.11	1 625.06	65.70	0.06	0.38	0.04	**4 677.98**
Trend 1990-2007	*12.13%*	*24.60%*	*92.85%*	*-33.74%*	*14.42%*	*14.43%*	*NA*	*28.27%*	*681.67%*	*NA*	*142.86%*	*25.62%*	*10.33%*	*18.67%*	*-57.98%*	*-33.81%*	*0.57%*	*14.77%*

Table 6-17 – N_2O emission trends for IPCC Category 4B – Manure Management: 1990-2007 by livestock category

Year	*N_2O emissions (Mg)* Livestock category																	
	4B1 Cattle - Mature Dairy Cattle	**4B1** Non-Dairy Cattle	***4B1*** *Cattle - Mature Non-Dairy Cattle - Females*	***4B1*** *Cattle - Mature Non-Dairy Cattle - Males*	***4B1*** *Cattle - Young Cattle - Calves*	***4B1*** *Cattle - Young Cattle - Growing Heifers*	**4B2** Buffalo	**4B3** Sheep	**4B4** Goats	**4B5** Camels & Llamas	**4B6** Horses	**4B7** Mules & Asses	**4B8** Swine	**4B9** Poultry - Chickens	**4B10** Other - Other Poultry	**4B10** Other - Rabbits	**4B10** Other - Cervidae Species	**4B** Total
1990	52.11	73.14	*15.10*	*3.73*	*17.60*	*36.72*	NO	1.56	NE	NO	1.16	NE	2.35	0.68	NE	NE	NE	**131.00**
1991	40.77	66.11	*14.98*	*3.33*	*15.05*	*32.75*	NO	1.65	NE	NO	1.23	NE	2.10	0.63	NE	NE	NE	**112.49**
1992	35.40	61.49	*14.58*	*2.68*	*13.74*	*30.49*	NO	1.48	NE	NO	1.24	NE	2.17	0.60	NE	NE	NE	**102.38**
1993	34.12	61.15	*15.27*	*2.63*	*13.43*	*29.82*	NO	1.45	NE	NO	1.30	NE	2.28	0.63	NE	NE	NE	**100.93**
1994	31.81	58.97	*15.62*	*2.30*	*13.48*	*27.58*	NO	1.66	NE	NO	1.43	NE	2.18	0.60	NE	NE	NE	**96.66**
1995	33.64	60.23	*16.24*	*2.61*	*13.06*	*28.31*	NO	1.61	NE	NO	1.46	NE	2.31	0.55	NE	NE	NE	**99.80**
1996	33.19	62.08	*16.91*	*2.68*	*13.41*	*29.08*	NO	1.53	NE	NO	1.48	NE	2.25	0.61	NE	NE	NE	**101.14**
1997	30.63	58.20	*15.74*	*2.85*	*12.21*	*27.41*	NO	1.71	0.08	NO	1.55	NE	2.40	0.66	0.07	1.84	0.02	**97.15**
1998	28.73	54.99	*15.04*	*2.58*	*11.41*	*25.95*	NO	1.76	0.06	NO	1.58	NE	2.44	0.68	0.05	1.72	0.03	**92.04**
1999	22.15	46.81	*13.38*	*2.01*	*9.61*	*21.82*	NO	1.76	0.06	NO	1.90	NE	2.57	0.61	0.03	1.56	0.04	**77.50**
2000	20.93	45.91	*13.50*	*1.80*	*9.38*	*21.23*	NO	1.70	0.06	NO	2.13	NE	2.43	0.71	0.03	1.69	0.04	**75.63**
2001	20.57	45.97	*13.66*	*1.98*	*9.17*	*21.16*	NO	1.81	0.07	NO	2.11	NE	2.45	0.83	0.03	1.67	0.04	**75.55**
2002	19.61	42.94	*13.13*	*1.68*	*8.89*	*19.23*	NO	1.95	0.24	NO	2.10	NE	2.45	0.77	0.03	1.78	0.04	**71.91**
2003	21.14	42.10	*12.87*	*1.56*	*8.76*	*18.91*	NO	2.02	0.40	NO	2.33	NE	2.57	0.78	0.03	1.66	0.03	**73.06**
2004	20.82	41.38	*12.72*	*1.46*	*8.61*	*18.58*	NO	2.08	0.43	NO	2.49	NE	2.99	0.72	0.04	1.68	0.03	**72.66**
2005	19.40	40.04	*12.50*	*1.35*	*8.19*	*17.99*	NO	2.20	0.47	NO	2.75	0.06	3.18	0.83	0.04	1.66	0.03	**70.65**
2006	17.99	38.25	*12.02*	*1.21*	*7.99*	*17.04*	NO	2.06	0.42	NO	2.81	0.09	2.97	0.80	0.04	1.74	0.03	**67.21**
2007	24.63	47.56	*14.95*	*1.28*	*9.97*	*21.37*	NO	2.00	0.60	NO	2.82	0.08	2.96	0.81	0.03	1.22	0.02	**82.74**
Trend 1990-2007	*-52.74%*	*-34.97%*	*-1.02%*	*-65.75%*	*-43.35%*	*-41.79%*	*NA*	*28.27%*	*681.67%*	*NA*	*142.86%*	*25.62%*	*26.00%*	*18.67%*	*-57.98%*	*-33.81%*	*0.57%*	*-36.84%*

Source for Tables 6-14 and 6-15: Ministry of the Environment.

Notes for Tables 6-14 and 6-15:

Accurate data on the population size for certain livestock categories (4B4 and 4B10) is only available since the 1997 census (hence the NE notation key). Mules & asses were recorded together with horses (sub-category 4B6) up to and including 2004. N_2O emissions by livestock category excludes emissions from pasture, range & paddock (*PRP*) since they have to be accounted for in IPCC Sub-category 4D2 – Emissions from PRP Manure.

Combining both gases – CH_4 and N_2O – manure management related emissions, expressed in CO_2e, remained fairly stable between 1990 and 2007: 123.89 Gg CO_2e in 2007, i.e. 1.84% lower than the value obtained for the base year (126.20 Gg CO_2e) – see Table 6-17. Beside livestock population developments, the methane emission increase is mainly driven by the changes in the AWMS for cattle: the liquid system share in AWMS went from 23% to about 33% for dairy cattle and from 18.9% to 25.2% for non-dairy cattle.[130] Now, liquid system is the AWMS that has the highest methane conversion factor: 39%. This explains why, despite a decreasing cattle population, related CH_4 emissions did rise over the period 1990-2007. Nevertheless, at the end of the day, the higher variation in absolute terms recorded for nitrous oxide between 1990 and 2007 counterbalanced the increasing methane emissions from manure management (|36.84%| for N_2O and |14.77%| for CH_4), leading to a, nowadays, fairly stable emission trend for manure management.[131]

Table 6-18 – CH_4 & N_2O emission trends for IPCC Category 4B – Manure Management: 1990-2007

Year	*CO_2e emissions (Gg)* 4B - Manure Management CH_4	N_2O	Total
1990	85.59	40.61	**126.20**
1991	92.85	34.87	**127.72**
1992	93.46	31.74	**125.20**
1993	96.52	31.29	**127.81**
1994	96.47	29.96	**126.43**
1995	101.05	30.94	**131.99**
1996	101.59	31.35	**132.94**
1997	104.20	30.12	**134.32**
1998	107.74	28.53	**136.27**
1999	117.94	24.02	**141.97**
2000	112.99	23.45	**136.43**
2001	110.94	23.42	**134.36**
2002	108.21	22.29	**130.50**
2003	105.13	22.65	**127.77**
2004	102.51	22.53	**125.04**
2005	106.33	21.90	**128.24**
2006	104.74	20.83	**125.58**
2007	98.24	25.65	**123.89**
Trend 1990-2007	*14.77%*	*-36.84%*	*-1.84%*

Source: Ministry of the Environment.

Note: N_2O emissions from pasture, range & paddock (*PRP*) are excluded from the total N_2O emissions in IPCC Category 4B since they have to be accounted for in IPCC Sub-category 4D2 – Emissions from PRP Manure.

6.3.3 Methodological issues – methane emissions

The IPCC Tier 1 method has been applied to all farm animal categories with the exception of cattle (IPCC Sub-category 4B1) for which a Tier 2 method has been used together with option B. It

130 See also above: liquid system share in AWMS almost doubled over the period.

131 A peak was reached in 1999 with regard to manure management GHG related emissions (see also Figure 6-2 in Section 6.1.3 above).

should be underlined that, essentially, the same calculation method characterizes both tiers. What distinguishes one tier from the other is the fact that, for cattle, the average gross energy intake – as a component of the volatile solid daily excretion – is not a default value but, rather, the value obtained when estimating enteric fermentation methane related emissions with a Tier 2 method (see Section 6.2.3.2).

6.3.3.1 Activity data

The only activity data that have been extracted from national statistics are those relating to the livestock population: see Table 6-4 in Section 6.2.2.

Other activity data have been prepared by state departments under the authority of the Ministry of Agriculture: SER and ASTA. Some of these data (such as live-weight – see Table 6-7 in Section 6.2.3.1) are used to calculate parameters that are also needed for estimating enteric fermentation methane emissions (such as GE). They will not be presented again in this sub-section (see also Table 6-22 and Table 6-23 on activity data, parameters and coefficients used).

ASTA provided an expert judgement with regard to the recent situation of AWMS for each farm animal category. The percentage of each manure system has been estimated by this Administration on the basis of various information and its knowledge on agricultural practices in Luxembourg. These percentages are presented in the Table 6-19.

Table 6-19 – AWMS per livestock category: estimates for the year 2004

Livestock category	AWMS						
	Anaerobic Lagoon	Liquid System	Daily Spread	Solid Storage	Dry Lot	PRP	Other: Anaerobic Digester
4B1 – Cattle – Mature Dairy Cattle	NO	35.75%	NO	14.25%	NO	45.00%	5.00%
4B1 – Cattle – Mature Non-Dairy Cattle – Females	NO	27.50%	NO	17.50%	NO	50.00%	5.00%
4B1 – Cattle – Mature Non-Dairy Cattle – Males	NO	27.50%	NO	17.50%	NO	50.00%	5.00%
4B1 – Cattle – Young Cattle – Calves	NO	27.50%	NO	17.50%	NO	50.00%	5.00%
4B1 – Cattle – Young Cattle – Growing Heifers	NO	27.50%	NO	17.50%	NO	50.00%	5.00%
4B2 – Buffalo	NO	NO	NO	NO	NO	NO	NO
4B3 – Sheep	NO	NO	NO	40.00%	NO	60.00%	NO
4B4 – Goats	NO	NO	NO	40.00%	NO	60.00%	NO
4B5 – Camels & Llamas	NO	NO	NO	NO	NO	NO	NO
4B6 – Horses	NO	NO	NO	40.00%	NO	60.00%	NO
4B7 – Mules & Asses	NO	NO	NO	40.00%	NO	60.00%	NO
4B8 – Swine	NO	90.00%	NO	5.00%	NO	NO	5.00%
4B9 – Poultry – Chickens	NO	25.00%	NO	50.00%	NO	NO	25.00%
4B10 – Other – Other Poultry	NO	NO	NO	100.00%	NO	NO	NO
4B10 – Other – Rabbits	NO	NO	NO	100.00%	NO	NO	NO
4B10 – Other – Cervidae Species	NO	NO	NO	10.00%	NO	90.00%	NO

Source: ASTA expert judgement (not published): prepared on 7 June 2007.

Note: for the other livestock categories (4B10), percentages are first expert judgements discussed between the SER and the Ministry of the Environment.

ASTA provided some additional information together with the AWMS estimates:

- liquid system: liquid manure storage is present around 6 months/year – during the winter season – for a certain number of farms. It is present the whole year for porcine breeding;
- solid storage: manure storage is present around 6 months/year – during the winter season – for a certain number of farms;
- PRP: this system is present around 6 months/year when the animals are grazing (summer season);
- anaerobic digester: biogas installations are more and more frequent at farms (and/or manure is more regularly collected to supply municipal or private biomethanization units). Hence, if the percentages presented in Table 6-18 could be seen as reasonable for the latest years, this would not be the case for the early 1990s. However, the choice of the methane conversion factor for anaerobic digester solves that issue (see Tables 6-21 and 6-22).[132]

Consequently, due to the uncertainty going along with the first AWMS expert judgement, ASTA and SER decided to improve the AWMS breakdown for the main emitting animal category, i.e. cattle.[133] The result of this exercise is presented in Table 6-20.

Table 6-20 – Revised AWMS for cattle: 1990-2007

Year	AWMS			
	Liquid System	Solid Storage	PRP	Other: Anaerobic Digester
4B1 – Cattle – Mature Dairy Cattle				
1990	23.00%	32.00%	45.00%	0.00%
1991	29.00%	26.00%	45.00%	0.00%
1992	30.60%	24.40%	45.00%	0.00%
1993	31.10%	23.90%	45.00%	0.00%
1994	32.30%	22.70%	45.00%	0.00%
1995	33.10%	21.90%	45.00%	0.00%
1996	33.10%	21.90%	45.00%	0.00%
1997	34.20%	20.80%	45.00%	0.00%
1998	35.50%	19.50%	45.00%	0.00%
1999	40.30%	14.70%	45.00%	0.00%
2000	39.60%	14.40%	45.00%	1.00%
2001	38.70%	14.30%	45.00%	2.00%
2002	38.20%	13.80%	45.00%	3.00%
2003	36.80%	14.20%	45.00%	4.00%
2004	35.75%	14.25%	45.00%	5.00%

132 Most of the installations producing biogas from manure are operating in Luxembourg since around the year 2000. Consequently, being new, they are usually very efficient and a gas tight coverage is present (expert judgement). Therefore emissions to be accounted for in CRF Sector 4 (leakages, as well as emissions due to storage in the digester) are very low (the methane produced should be recorded under the energy sector). Hence, it has been decided to use a methane conversion factor of 0% for anaerobic digester. It is a conservative estimate reducing/limiting our emissions for the base year.

133 Another livestock category which is responsible for relatively high methane emissions is sub-category 4B8 – Swine. However, it has not yet been possible to perform an exercise similar to the one for cattle for this sub-category.

Year	AWMS			
	Liquid System	Solid Storage	PRP	Other: Anaerobic Digester
4B1 – Cattle – Mature Dairy Cattle				
2005	36.70%	13.30%	45.00%	5.00%
2006	37.60%	12.40%	45.00%	5.00%
2007	32.70%	17.30%	45.00%	5.00%
4B1 – Cattle – Mature Non-Dairy Cattle				
1990	18.90%	31.10%	50.00%	0.00%
1991	23.50%	26.50%	50.00%	0.00%
1992	24.70%	25.30%	50.00%	0.00%
1993	25.10%	24.90%	50.00%	0.00%
1994	26.00%	24.00%	50.00%	0.00%
1995	26.60%	23.40%	50.00%	0.00%
1996	26.60%	23.40%	50.00%	0.00%
1997	27.50%	22.50%	50.00%	0.00%
1998	28.50%	21.50%	50.00%	0.00%
1999	32.10%	17.90%	50.00%	0.00%
2000	31.40%	17.60%	50.00%	1.00%
2001	30.50%	17.50%	50.00%	2.00%
2002	29.90%	17.10%	50.00%	3.00%
2003	28.50%	17.50%	50.00%	4.00%
2004	27.50%	17.50%	50.00%	5.00%
2005	28.20%	16.80%	50.00%	5.00%
2006	28.90%	16.10%	50.00%	5.00%
2007	25.20%	19.80%	50.00%	5.00%
4B1 – Cattle – Young Cattle				
1990	18.90%	31.10%	50.00%	0.00%
1991	23.50%	26.50%	50.00%	0.00%
1992	24.70%	25.30%	50.00%	0.00%
1993	25.10%	24.90%	50.00%	0.00%
1994	26.00%	24.00%	50.00%	0.00%
1995	26.60%	23.40%	50.00%	0.00%
1996	26.60%	23.40%	50.00%	0.00%
1997	27.50%	22.50%	50.00%	0.00%
1998	28.50%	21.50%	50.00%	0.00%
1999	32.10%	17.90%	50.00%	0.00%
2000	31.40%	17.60%	50.00%	1.00%
2001	30.50%	17.50%	50.00%	2.00%
2002	29.90%	17.10%	50.00%	3.00%
2003	28.50%	17.50%	50.00%	4.00%
2004	27.50%	17.50%	50.00%	5.00%
2005	28.20%	16.80%	50.00%	5.00%
2006	28.90%	16.10%	50.00%	5.00%
2007	25.20%	19.80%	50.00%	5.00%

Source: SER & ASTA calculations (not published): prepared on 19 June 2007 and updated by the Ministry of the Environment on 20 January 2009.

These revised AWMS shares for cattle were produced by SER using information collected in the framework of the yearly agricultural census.[134] Cowshed numbers and capacity (in number of heads) are known for various types of cowsheds. On this basis, an estimated share of the liquid system was possible. For PRP, the first expert judgement formulated by ASTA has been kept (Table 6-19). For anaerobic digesters, the hypothesis has been made that specific manure collection started around the year 2000 and has been increasing since then to reach the first expert judgement value of 5%. Finally, solid storage has been deduced from the other three AWMS estimates.

As a result, the following AWMS shares are reported in Luxembourg's GHG inventory:

- for IPCC Sub-category 4B1: shares recorded in Table 6-19 (with the same percentages for both females and males mature non-dairy cattle, on the one hand, and the same percentages for both calves and growing heifers, on the other hand);
- for the other IPCC Sub-categories (4B3 to 4B10): first expert judgement recorded in Table 6-19.

6.3.3.2 Emission factors

EFs for manure management related methane emissions are actually IEFs obtained by combining, for each livestock category, the volatile solids excreted daily by the animals (or volatile solid daily excretion, *VS* in kg-dm per day), the maximum methane producing capacity for the manure (or methane producing potential, *Bo* in m^3CH_4/kg of VS) and the sum of the fractions of animals by AWMS (in %) multiplied by their corresponding methane conversion factor (*MCF* in %):

$$IEF_i = VS_i \bullet 365 \bullet Bo_i \bullet 0.67 \bullet [\sum_j MCF_j \bullet AWMS_{ij}]$$

with j = the various AWMS identified for each livestock category i

IEF_i expressed in kg CH_4/head/year

the factor 0.67 expressed in kg/m^3

➔ see equation 4.17 of the 2000 IPCC-GPG.

For most of the farm animal categories, VS is calculated using equation 4.16 of the 2000 IPCC-GPG which combines average gross energy intake (*GE*), digestible energy of the feed (*DE*) and the ash content of the manure (*ASH*). It is at that level that the distinction between tiers is made for manure management related methane emissions. Tier 2 is indicated for those animal categories for which GE is not a default value but rather an estimated value, whereas Tier 1 is specified when a default GE has been chosen to determine VS. GE being one of the parameters needed for estimating enteric fermentation methane emissions, values obtained in that case have been applied for estimating manure management related methane emissions.

134 See http://www.ser.public.lu/statistik/agrarstrukturen/statec_15_mai_pluriannuel.pdf, section 3.2.

Table 6-21 indicates, for each animal category, which method has been used to estimate methane emissions as well as the corresponding IEF type.

Table 6-21 – Method and type of EF used in the inventory

Livestock category	Estimation method	IEF	Comments
4B1 – Cattle – Mature Dairy Cattle	T2	CS	*The IEF is CS because GE and DE are obtained by combining national AD, default coefficients/parameters from the IPCC Guidelines and, in some cases, other country values.*
4B1 – Cattle – Mature Non-Dairy Cattle – Females	T2	CS	
4B1 – Cattle – Mature Non-Dairy Cattle – Males	T2	CS	
4B1 – Cattle – Young Cattle – Calves	T2	CS	
4B1 – Cattle – Young Cattle – Growing Heifers	T2	CS	
4B2 – Buffalo	NO	NO	
4B3 – Sheep	T1	D	*VS calculated but equal to the default value provided for developed countries in table B-7 of the Revised 1996 IPCC Guidelines.*
4B4 – Goats	T1	D	
4B5 – Camels & Llamas	NO	NO	
4B6 – Horses	T1	D	*VS calculated but equal to the default value provided for developed countries in table B-7 of the Revised 1996 IPCC Guidelines.*
4B7 – Mules & Asses	T1	D	
4B8 – Swine	T1	D	*VS calculated but equal to the default value provided for Western Europe in table B-6 of the Revised 1996 IPCC Guidelines.*
4B9 – Poultry – Chickens	T1	D	*VS for developed countries directly taken from table B-7 of the Revised 1996 IPCC Guidelines.*
4B10 – Other – Other Poultry	T1	D	
4B10 – Other – Rabbits	T1	D	*Value taken from table 10.16 of the 2006 IPCC Guidelines.*
4B10 – Other – Cervidae Species	T1	D	*Value taken from table 10.16 of the 2006 IPCC Guidelines. It refers to deer.*

Source: Ministry of the Environment.

Abbreviations: T1 = Tier 1 ; T2 = Tier 2 ; CS = Country Specific ; D = IPCC Default

6.3.3.2.1 Tier 2 method – cattle

For cattle, the IEF has been calculated by combining the following activity data, coefficients and parameters:

Table 6-22 – Activity data, coefficients and parameters used for IPCC Sub-category 4B1 – Cattle

AD, parameter, coefficient	Unit	Source(s)	Type of value
Livestock (# of heads)	#	SER & STATEC (updated 080915)	AD (see Table 6-3)
Live Weight	kg	SER, not published (provided 070601)	AD (see Table 6-6), invariable
Gross Energy Intake (average)	MJ/day	equation 4.11 – 2000 IPCC-GPG	calculated
Digestible Energy	%	- mature dairy & non-dairy cattle: German value - young cattle: table A-2 – 1996 Revised IPCC Guidelines	- invariable - default for Western Europe
Ash Content of the Manure	%	table B-1 – 1996 Revised IPCC Guidelines	default
Volatile Solid Daily Excretion	kg-dm/day	equation 4.16 – 2000 IPCC-GPG	calculated
CH_4 Producing Potential	$m^3 CH_4/kg$ VS	table B-1 – 1996 Revised IPCC Guidelines	default for Western Europe

AD, parameter, coefficient	Unit	Source(s)	Type of value
Manure System/AWMS	%	SER & ASTA, not published (prepared 070619, updated 090120)	expert judgement (see Table 6-19), invariable for PRP
CH_4 Conversion Factor	%	- table 4.10 – 2000 IPCC-GPG	default for a cool region, except for anaerobic digester (0%) for which an expert judgement has been applied

6.3.3.2.2 Tier 1 method – all farm animal categories except cattle

For farm animals that are not cattle, the IEF is generally the default manure management EF for a cool region in developed countries presented in Table 4-5 of the Revised 1996 IPCC Guidelines. More details are provided in Table 6-23.

Table 6-23 – Activity data, coefficients and parameters used for IPCC Sub-categories 4B3 to 4B10[135]

AD, parameter, coefficient	Unit	Source(s)	Type of value
Livestock (# of heads)	#	SER & STATEC (updated 080915)	AD (see Table 6-3)
Live Weight	kg	- 4B3 to 4B9: SER, not published (provided 070601) - 4B10 – rabbits: table 10A-9 – 2006 IPCC Guidelines (italian value) - 4B10 – cervidae species: table 10.10 – 2006 IPCC Guidelines (deer's value)	AD (see Table 6-6), invariable
Gross Energy Intake (average)	MJ/day	- 4B3 to 4B8: table A-4 – Revised 1996 IPCC Guidelines - 4B9: EC average value - 4B10 – rabbits: Italian reported value	- default for developed countries - invariable - invariable
Digestible Energy	%	- 4B3 to 4B7: table B-7 – Revised 1996 IPCC Guidelines - 4B8: table B-2 – Revised 1996 IPCC Guidelines	default for developed countries
Ash Content of the Manure	%	- 4B3 to 4B7: table B-7 – Revised 1996 IPCC Guidelines - 4B8: table B-2 – 1996 Revised IPCC Guidelines	default for developed countries
Volatile Solid Daily Excretion	kg-dm/day	- 4B3 to 4B8: equation 4.16 – 2000 IPCC-GPG - 4B9 & 4B10 – other poultry: table B-7 – Revised 1996 IPCC Guidelines	- calculated - default for developed countries
CH_4 Producing Potential	m^3CH_4/kg VS	- 4B3 to 4B7, 4B9, 4B10 – other poultry: table B-7 – Revised 1996 IPCC Guidelines - 4B8: table B-2 – Revised 1996 IPCC Guidelines	default for developed countries
Manure System/AWMS	%	- 4B3 to 4B9: SER & ASTA, not published (prepared 070607) - 4B10: SER & Ministry of the Environment	expert judgement (see Table 6-18), invariable
CH_4 Conversion Factor	%	table 4.10 – 2000 IPCC-GPG	default for a cool region, except for anaerobic digester (0%) for which an expert judgement has been applied

Notes: If an animal category is not indicated, it means that the value is NE for that particular AD, parameter or coefficient. When default values were used for GE, DE and ASH, the VS calculated equals the default VS provided for developed countries in table B-6 (4B8) and B-7 (4B3 to 4B7) of the Revised 1996 IPCC Guidelines.

135 CRF Categories 4B2 – Buffalo and 4B5 – Camels & Llamas do not exist in Luxembourg.

6.3.3.2.3 Methane IEFs for 4B – Manure Management

Table 6-24 presents the IEFs obtained for each farm animal category using the Tier 1 or Tier 2 methods described above.

For those animal categories for which no accurate data are available in official statistics for the years prior to 1997 (i.e. 4B4 and 4B10), it has not been attempted to "backcast" the methane emissions back to the base year, because:

- not estimated (NE) emissions under- but not overestimate the base year GHG emissions;
- it would not make much sense to devote efforts for estimating the missing years since CH_4 emissions for the concerned animal categories are particularly low and almost negligible.

6.3.4 Methodological issues – nitrous oxide emissions

The IPCC Tier 1 method has been applied to all farm animal categories.

6.3.4.1 Activity data

The following activity data were used to calculate N_2O emissions per AWMS and animal category:

- livestock population extracted from national statistics: see Table 6-4 in Section 6.2.2;
- AWMS shares per animal category: see Tables 6-18 and Table 6-20 in Section 6.3.3.1;
- yearly nitrogen excretion (Nex_i) per head for each animal category i: see Table 6-25.

Most of the Nex_i proposed by SER have been prepared in the framework of an EC Directive on nitrate and good agricultural practice [136] and/or for the OECD Agro-environmental Indicators Database. The Nex_i also apply for the cross compliance measures provided for the single farm payment scheme of the CAP.[137] Since they are not officially published in Luxembourg, Nex_i values should therefore be considered as an expert judgement.

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136 Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources.

137 Council Regulation (EC) No 1782/2003 of 29 September 2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers.

Table 6-24 – CH_4 IEFs trends for IPCC Category 4B – Manure Management: 1990-2007

IEF for CH_4 (kg CH_4/head/year) – Livestock category

Year	4B1 Cattle - Mature Dairy Cattle	4B1 Non-Dairy Cattle	*4B1 Cattle - Mature Non-Dairy Cattle - Females*	*4B1 Cattle - Mature Non-Dairy Cattle - Males*	*4B1 Cattle - Young Cattle - Calves*	*4B1 Cattle - Young Cattle - Growing Heifers*	4B2 Buffalo	4B3 Sheep	4B4 Goats	4B5 Camels & Llamas	4B6 Horses	4B7 Mules & Asses	4B8 Swine	4B9 Poultry - Chickens	4B10 Other - Other Poultry	4B10 Other - Rabbits	4B10 Other - Cervidae Species
1990	25.99	6.40	*7.01*	*6.88*	*4.72*	*7.56*	NO	0.19	NE	NO	1.39	IE	19.52	0.80	NE	NE	NE
1991	32.15	7.80	*8.51*	*8.35*	*5.73*	*9.18*	NO	0.19	NE	NO	1.39	IE	19.52	0.80	NE	NE	NE
1992	34.81	8.18	*8.92*	*8.74*	*6.00*	*9.60*	NO	0.19	NE	NO	1.39	IE	19.52	0.80	NE	NE	NE
1993	36.26	8.32	*9.07*	*8.86*	*6.10*	*9.74*	NO	0.19	NE	NO	1.39	IE	19.52	0.80	NE	NE	NE
1994	37.41	8.54	*9.37*	*9.15*	*6.30*	*10.06*	NO	0.19	NE	NO	1.39	IE	19.52	0.80	NE	NE	NE
1995	38.99	8.77	*9.56*	*9.34*	*6.43*	*10.27*	NO	0.19	NE	NO	1.39	IE	19.52	0.80	NE	NE	NE
1996	39.14	8.78	*9.56*	*9.34*	*6.43*	*10.27*	NO	0.19	NE	NO	1.39	IE	19.52	0.80	NE	NE	NE
1997	40.88	9.06	*9.86*	*9.63*	*6.63*	*10.59*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
1998	42.54	9.38	*10.19*	*9.95*	*6.85*	*10.94*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
1999	48.41	10.46	*11.36*	*11.10*	*7.65*	*12.21*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
2000	48.35	10.24	*11.12*	*10.87*	*7.49*	*11.95*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
2001	47.97	9.98	*10.83*	*10.57*	*7.29*	*11.63*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
2002	47.93	9.74	*10.62*	*10.37*	*7.15*	*11.41*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
2003	46.87	9.32	*10.16*	*9.92*	*6.84*	*10.91*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
2004	46.15	9.01	*9.83*	*9.59*	*6.61*	*10.55*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
2005	47.72	9.25	*10.07*	*9.81*	*6.76*	*10.79*	NO	0.19	0.12	NO	1.39	0.76	19.52	0.80	0.08	0.08	0.22
2006	49.21	9.45	*10.31*	*10.04*	*6.92*	*11.04*	NO	0.19	0.12	NO	1.39	0.76	19.52	0.80	0.08	0.08	0.22
2007	42.83	8.32	*9.09*	*8.85*	*6.11*	*9.74*	NO	0.19	0.12	NO	1.39	0.76	19.52	0.80	0.08	0.08	0.22
Trend 1990-2007	*64.76%*	*30.12%*	*29.56%*	*28.65%*	*29.30%*	*28.83%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
IEF type	*CS*	*CS*	*CS*	*CS*	*CS*	*CS*	*NA*	*D*	*D*	*NA*	*D*	*D*	*D*	*D*	*D*	*D*	*D*

Source: Ministry of the Environment.

Notes:

Accurate data on the population size for certain livestock categories (4B4 and 4B10) is only available since the 1997 census (hence the NE notation key).

Mules & asses were recorded together with horses (sub-category 4B6) up to and including 2004.

CS variable IEFs: the result of changing VS and manure systems for liquid and solid storages for dairy and young cattle and of manure systems for liquid and solid storages for mature non-dairy cattle (other constituting parameters and coefficients show constant values).

Table 6-25 – Nitrogen excretion for farm animals reported in the inventory

Livestock category	Nitrogen excretion *N/head/year*	Comments
4B1 – Cattle – Mature Dairy Cattle	85.00 93.50 102.00	*85.00 for a milk yield < 5500 kg/cow/year;* *93.50 for a milk yield comprises between 5500 & 6500 kg/cow/year;* *102.00 for a milk yield > 6500 kg/cow/year.*
4B1 – Cattle – Mature Non-Dairy Cattle – Females	68.00	
4B1 – Cattle – Mature Non-Dairy Cattle – Males	68.00	
4B1 – Cattle – Young Cattle – Calves	[28.08;29.34]	*weighted average using population size:* *Nex_i = 12.10 for calves for slaughter;* *Nex_i = 29.75 for other calves.*
4B1 – Cattle – Young Cattle – Growing Heifers	[50.11;51.16]	*weighted average using population size:* *Nex_i = 42.00 for bovine from 1 to 2 years;* *Nex_i = 68.00 for heifers.*
4B2 – Buffalo	NO	
4B3 – Sheep	17.00	
4B4 – Goats	17.00	
4B5 – Camels & Llamas	NO	
4B6 – Horses	53.70	*Belgian value.*
4B7 – Mules & Bsses	42.50	
4B8 – Swine	[9.77;11.53]	*weighted average using population size:* *Nex_i = 2.30 for pigs < 20kg;* *Nex_i = 11.05 for pigs weighing between 20 & 50 kg;* *Nex_i = 11.05 for fattening pigs > 50kg;* *Nex_i = 28.50 for breeding pigs.*
4B9 – Poultry – Chickens	0.60	*EC average value.*
4B10 – Other – Other Poultry	1.10	*Austrian value.*
4B10 – Other – Rabbits	8.10	*Table 10.19 – 2006 IPCC Guidelines value for Western Europe*
4B10 – Other – Cervidae Species	35.48	*Estimate based on 2000 IPCC-GPG order of magnitude calculations suggested pages 4.20 & 4.21. The calculation has been made using sheep as a basis.*

Source: SER, not published (provided on 1st June 2007), otherwise indicated.

6.3.4.2 Emission factors

Since the Tier 1 method has been applied to estimate manure management N_2O related emissions, default EFs have been used for all animal categories. These EFs are presented in Table 6-26 and are extracted from table 4.12 of the 2000 IPCC-GPG.[138]

Table 6-26 – Default EFs for N_2O emissions per selected AWMS

	AWMS			
	Liquid System	Solid Storage	PRP	Other: Anaerobic Digester
Default EF (kg N_2O-N/kg N)	0.001	0.020	0.020	0.001

138 These EFs are labelled EF_3 in this table.

Nitrous oxide emissions are obtained by adding up, for each AWMS, nitrogen excretion estimated for each animal category. This gives the total nitrogen excretion per AWMS for all the livestock categories included in the inventory (Nex_j). Then, these total nitrogen excretion values per AWMS (in kg N/year) are multiplied by the corresponding EF of Table 6-25. This multiplication provides nitrous oxide losses per AWMS in kg N_2O-N/year. To obtain N_2O emissions, the latest figure should be multiplied by the molecular weight ratio (44/28) ➔ see below and equation 4.18 of the 2000 IPCC-GPG.

For each animal category, nitrogen excretion per AWMS was calculated using the following formula:[139]

$$Nex_{ij} = Nex_i \bullet (\#\ of\ heads)_i \bullet AWMS_{ij}$$

with j = the various AWMS identified for each livestock category i

Nex_{ij} expressed in kg N/year

Nex_i expressed in kg N/head/year (provided in Table 6-24)

and, therefore:

$$Nex_j = \sum_i Nex_{ij}$$

with Nex_j = the total nitrogen excretion per AWMS j in kg N/year

then, N_2O emissions per AWMS are:

$$N_2O_j = [Nex_j \bullet EF_j] \bullet (44/28)$$

with Nex_j = the total nitrogen excretion per AWMS j in kg N/year

EF_j expressed in kg N_2O-N/kg N (see Table 6-25)

Nitrous oxide emissions reported under the source category manure management are the sum of the N_2O_j **with the exception of j = PRP**. Indeed, to avoid double counting, and to allow for certain logic in the emission reporting, emissions related to PRP are accounted for under IPCC Category 4D – Agricultural Soils (see Section 6.5).

6.3.5 Recalculations

Table 6-27 presents the main revisions and recalculations between submissions 2008v1.2 and 2009v1.4 (see also CRF tables 8).

139 As for methane emission estimates, for those animal categories for which no accurate data are available in official statistics for the years prior to 1997 (i.e. 4B4 and 4B10), it has not been attempted to "backcast" the nitrogen excretion per AWMS back to the base year. Hence, the total nitrogen excretion values per AWMS do not comprise these livestock categories for the years prior to 1997.

Table 6-27 – Changes in GHG inventories: submissions 2008v1.2 and 2009v1.4

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
4B1	the revised calculation of Gross Energy Intake for mature dairy and non-dairy female cattle (see 4A1) had effects on the volatile solid daily excretion calculation	- refinement

6.3.6 Category specific QA/QC procedures

Consistency and completeness checks have been performed directly within the Microsoft Excel™ file that has been developed by the Ministry of the Environment to calculate GHG emissions from the agriculture sector as well as by using the tools embedded in CRF Reporter.

The plausibility of the estimates, as well as the calculation methods, were extensively discussed between the Ministry of the Environment and the sector experts, SER and ASTA.

6.3.7 Planned improvement

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 6-28 will be explored.

Table 6-28 – Planned improvements for IPCC Category 4B – Manure Management

GHG source & sink category	Planned improvement
4B – Manure Management - AWMS	analyzing whether it would be feasible to refine AWMS per livestock category and through the reporting years.
4B – Manure Management – Other AWMS: Anaerobic Digester	analyze if it would be possible to use formula 1 under table 4.10 of the 2000 IPCC-GPG (p. 4.36) in order to refine/produce a reliable emission estimate for manure used in anaerobic digesters.
4B – Manure Management - Nex	analyzing whether it would be feasible to refine Nex per livestock category and through the reporting years.
4B4 - Goats	completing the time serie for the years prior to 1997 (through the estimation of the number of animals).
4B8 – Swine	national statistics allow for a breakdown of swine in various sub-categories for which more precise parameter values could be applied.
4B9 – Poultry – Chickens	national statistics allow for a breakdown of chickens in various sub-categories for which more precise parameter values could be applied.
4B10 – Other	completing the time serie for the years prior to 1997 (through the estimation of the number of animals) and investigate whether it would be worth, straightforward and not time/resources consuming to include the missing farm animals (ostriches, “productive animals”).

6.4 Rice Cultivation (4C)

This source category does not exist in Luxembourg.

6.5 Agricultural Soils (4D)

This section describes the estimation of nitrous oxide emissions linked to agricultural soils, whether these are direct or indirect emissions originating from crops or from spreading on soils. In

2007, this source category was responsible for 93% of agricultural nitrous oxide emissions and for 64.7% of the total nitrous oxide emissions estimated for Luxembourg. It represented 47.8% of the total emissions due to agricultural activities and 2.63% of the total GHG emissions in CO_2e (excluding LULUCF).

6.5.1 Key source

With 2.63% of the total GHG emissions in CO_2e, excluding LULUCF in 2007 (2.71% of the total GHG emissions in CO_2e, including LULUCF), nitrous oxide emissions from agricultural soils (IPCC Category 4D) is a key source, whether LULUCF is included or excluded. It has been a key source in both cases without interruption since 1990.

Going down at the level of Sub-categories, IPCC Sub-category 4D1 has been a key source for all years when LULUCF is excluded and from 1990 to 1992, in 1994, in 1995 and from 1998 to 2001 when LULUCF is included. For IPCC Sub-category 4D2, it has been a key source, excluding LULUCF, in 1990, in 1991 and from 1995 to 2001, whereas it has only been a key source in 1990 and 1991 when LULUCF is included. Finally, Sub-category 4D3 has been a key source for all years if LULUCF is excluded and in 1990, 1991, 1994 and 1995 when LULUCF is included.

6.5.2 Source category description

The source category agricultural soils covers:

- direct soil emissions (IPCC Sub-category 4D1): nitrogen input to soils (such as application of synthetic fertilizers and manure) and nitrogen fixed by crops or crop residues;
- nitrogen excretion on PRP (IPCC Sub-category 4D2) calculated under IPCC Category 4B but to be reported in this category (see Section 6.3.4.2);
- indirect soil emissions (IPCC Sub-category 4D3) due to atmospheric deposition as well as to nitrogen from fertilizers and animals that is lost through leaching and run-off.

As Table 6-29 shows, about half of the nitrous oxide emissions from agricultural soils stems from direct soil emissions. A bit more than one third of the emissions are due to indirect soil emissions and the remaining 15% are the result of PRP manure. All these percentages remained pretty stable during the 1990-2007 period. Within each of the agricultural soil categories, the main emitting activities are nitrogen leaching and run-off (sub-category 4D32) and nitrogen input from the application of synthetic fertilizers (sub-category 4D11).

Since 1990, agricultural soil N_2O related emissions declined by some 10%. Actually, all agricultural soil source categories showed decreasing emissions over the period 1990-2007 but two: nitrogen fixed by N-fixing crops (sub-category 4D13) and nitrogen in crop residues returned to soils (sub-category 4D14). These positive evolutions are the result of a 81% increase in N-fixing crops between 1990 and 2007 (see Section 6.5.3.1).

Table 6-29 – N_2O emission trends for IPCC Category 4D – Agricultural Soils: 1990-2007

Year	*N_2O emissions (Mg)* Agricultural soils category											
	4D1 Direct Soil Emissions	*4D11 Synthetic Fertilizers*	*4D12 Animal Manure Applied to Soils*	*4D13 N-fixing Crops*	*4D14 Crop Residue*	*4D15 Cultivation Histosols*	*4D16 Other: Sewage Sludge Spreading*	4D2 PRP	4D3 Indirect Soil Emissions	*4D31 Atmospheric Deposition*	*4D32 N Leaching & Run-off*	4D Total
1990	574.44	*334.05*	*114.36*	*37.87*	*80.76*	*NO*	*7.41*	188.94	456.41	*72.64*	*383.77*	**1 219.79**
1991	581.07	*348.07*	*113.36*	*32.50*	*79.72*	*NO*	*7.41*	190.61	466.85	*73.86*	*392.99*	**1 238.53**
1992	634.85	*375.58*	*108.55*	*51.86*	*91.35*	*NO*	*7.50*	181.38	478.75	*74.43*	*404.32*	**1 294.98**
1993	617.10	*342.63*	*108.96*	*60.75*	*96.97*	*NO*	*7.79*	181.35	454.45	*71.63*	*382.82*	**1 252.90**
1994	574.80	*325.29*	*107.56*	*51.37*	*82.44*	*NO*	*8.14*	180.06	439.67	*69.74*	*369.94*	**1 194.53**
1995	592.39	*319.17*	*114.08*	*57.74*	*93.32*	*NO*	*8.09*	190.65	446.23	*71.54*	*374.68*	**1 229.26**
1996	607.59	*320.69*	*115.14*	*60.85*	*103.89*	*NO*	*7.02*	193.44	448.91	*72.00*	*376.90*	**1 249.94**
1997	624.66	*315.74*	*113.91*	*77.32*	*110.33*	*NO*	*7.36*	188.30	441.81	*70.86*	*370.96*	**1 254.78**
1998	628.48	*309.38*	*112.85*	*83.06*	*115.81*	*NO*	*7.38*	186.09	434.96	*69.86*	*365.10*	**1 249.53**
1999	608.50	*319.05*	*112.88*	*65.65*	*103.59*	*NO*	*7.34*	185.55	442.01	*70.66*	*371.34*	**1 236.06**
2000	637.11	*315.01*	*110.69*	*88.70*	*116.29*	*NO*	*6.42*	182.98	434.96	*69.47*	*365.50*	**1 255.05**
2001	570.26	*268.71*	*110.94*	*77.02*	*107.56*	*NO*	*6.02*	183.17	400.00	*65.35*	*334.65*	**1 153.43**
2002	569.11	*279.94*	*107.65*	*67.46*	*107.69*	*NO*	*6.37*	176.91	402.65	*65.12*	*337.53*	**1 148.68**
2003	479.32	*228.14*	*107.97*	*45.99*	*92.36*	*NO*	*4.86*	176.00	362.24	*60.25*	*301.99*	**1 017.56**
2004	601.47	*289.13*	*108.62*	*79.30*	*120.07*	*NO*	*4.35*	173.50	407.36	*65.47*	*341.89*	**1 182.34**
2005	512.57	*251.57*	*109.62*	*51.49*	*95.17*	*NO*	*4.73*	173.65	380.29	*62.41*	*317.88*	**1 066.50**
2006	522.72	*248.10*	*107.39*	*60.55*	*100.70*	*NO*	*5.98*	171.50	375.49	*61.64*	*313.85*	**1 069.71**
2007	536.72	*248.10*	*110.46*	*68.65*	*102.99*	*NO*	*6.52*	177.79	381.79	*62.97*	*318.83*	**1 096.30**
Trend 1990-2007	*-6.57%*	*-25.73%*	*-3.41%*	*81.30%*	*27.53%*	*NA*	*-12.02%*	*-5.90%*	*-16.35%*	*-13.32%*	*-16.92%*	*-10.12%*

Source: Ministry of the Environment.

Note: 2006 and 2007 data are provisional for sub-categories 4D16 (hence 4D1) as well as 4D31 and 4D32 (hence 4D3), hence 4D. 2007 data are also provisional for sub-category 4D11.

Soil categories description:

4D11 – Direct Soil Emissions – Synthetic Fertilizers: nitrogen input from application of synthetic (nitrogenous) fertilizers

4D12 – Direct Soil Emissions – Animal Manure Applied to Soils: nitrogen input from manure applied to soils

4D13 – Direct Soil Emissions – N-fixing Crops: nitrogen fixed by N-fixing crops

4D14 – Direct Soil Emissions – Crop Residue: nitrogen in crop residues returned to soils

4D15 – Direct Soil Emissions – cultivation of histosols: area of cultivated organic soils

4D16 – Direct Soil Emissions – Other – Sewage Sludge Spreading: nitrogen input from application of sewage sludge

4D2 – PRP Manure: nitrogen excretion on PRP

4D31 – Indirect Emissions – Atmospheric Deposition: volatized nitrogen from fertilizers, animal manures and other

4D32 – Indirect Emissions – Nitrogen Leaching & Run-off: nitrogen from fertilizers, animal manures and other that is lost through leaching and run-off

As already underlined in Section 6.1.3, IPCC Category 4D – Agricultural Soils presented an irregular evolution towards the end of the period running from 1990 to 2007. This is explained mainly by important changes in crops, and especially N-fixing crops, as well as in fertilizer use which, both, showed a slack in 2003 and a peak in 2004 (see Table 6-31 and Table 6-33 in Section 6.5.3.1).

6.5.3 Methodological issues

Estimating nitrous oxide emissions from agricultural soils requests, according to IPCC Guidelines, the use of certain **fractions**. For most of these fractions, as shown in Table 6-29, Luxembourg did use default values presented in the Revised 1996 IPCC Guidelines.

Table 6-30 – Fractions used for estimating N_2O emissions for IPCC Category 4D – Agricultural Soils

Fraction	Description	Unit	Value	Source
$Frac_{BURN}$	Fraction of crop residue burned	kg N/kg crop-N	NO	table 4.19 – Revised 1996 IPCC Guidelines
$Frac_{FUEL}$	Fraction of livestock N excretion in excrements burned for fuel	kg N/kg N excreted	NO	table 4.19 – Revised 1996 IPCC Guidelines
$Frac_{GASF}$	Fraction of synthetic fertilizer N applied to soils that volatilizes as NH_3 and NOx	kg NH3-N+NOx-N/kg synthetic fertilizer N applied	0.100	table 4.19 – Revised 1996 IPCC Guidelines
$Frac_{GASM}$	Fraction of livestock N excretion that volatilizes as NH_3 and NOx	kg NH3-N+NOx-N/kgN excreted	0.200	table 4.19 – Revised 1996 IPCC Guidelines
$Frac_{GRAZ}$/$Frac_{PRP}$	Fraction of livestock N excreted and deposited onto soil during grazing	% of kgN/year	$Nex_{PRP}/\sum_j Nex_j$ j = AWMS	IPCC Category 4B calculations
$Frac_{LEACH}$	Fraction of N input to soils that is lost through leaching and run-off	kg N/kg fertilizer or manure-N	0.300	table 4.24 – Revised 1996 IPCC Guidelines
$Frac_{NCRBF}$	Fraction of total above-ground biomass of N-fixing crop that is N	kg N/kg dry biomass	0.030	table 4.19 – Revised 1996 IPCC Guidelines
$Frac_{NCRO}$	Fraction of residue dry biomass that is N	kg N/kg dry biomass	0.015	table 4.19 – Revised 1996 IPCC Guidelines
$Frac_R$	Fraction of total above-ground crop biomass that is removed from the field as a crop product	kg N/kg crop-N	0.450	table 4.19 – Revised 1996 IPCC Guidelines

Consequently, the use of default fractions – combined with default EFs – implies that Tier 1 methods (Tier 1, 1a or 1b) have been applied for estimating direct and indirect N_2O emissions from agricultural soils.

6.5.3.1 Activity data

Only a limited number of activity data has been used to provide N_2O estimates for IPCC Category 4D.

Some activity data are extracted from national statistics:

- the consumption of synthetic fertilizers: seeTable 6-31;

- various crop productions: see Table 6-33.

For emissions due to sewage sludge spreading on fields, data have been estimated by both the Ministry of the Environment and the Environment Agency on the basis of annual reports and official statistics on wastewater treatment in Luxembourg.

6.5.3.1.1 Fertilizers use

Table 6-31 – Nitrogenous fertilizers consumption: 1990-2007

Year	Nitrogenous fertilizers consumption *t N*
1990	18896
1991	19689
1992	21245
1993	19381
1994	18400
1995	18054
1996	18140
1997	17860
1998	17500
break in time serie	
1999	18047
2000	17819
2001	15200
2002	15835
2003	12905
2004	16355
2005	14230
2006	14034
2007	14034p
Trend 1990-2007	***-25.73%***

Sources : SER: http://www.ser.public.lu/statistik/betriebsmittel/duenger.pdf
STATEC, *Statistical Yearbook*, Table C.2112:
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=153&IF_Language=fra&MainTheme=3&FldrName=2&RFPath=6
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=1224
data extracted on 20 January 2009 (subject to changes since that date)

Only nitrogenous fertilizers have been considered as synthetic fertilizers since these are the ones generating nitrous oxide emissions. Up to 1998 included, statistics were not recording fertilizer application but well fertilizer sales in Luxembourg. Therefore, for the years prior to 1999, the **hypothesis that fertilizers consumption/application equals fertilizer sales** (i.e. no stocks and stock changes) has been made. For the year 2007, at the time calculations were made for submission 2009v1.4, fertilizers consumption was not yet known, hence the 2006 amount has been used as a proxy for the 2007 figure.

6.5.3.1.2 Crop production

The various crop productions are to be recorded for IPCC Category 4F – Field Burning of Agricultural Residues. Nevertheless:

- being necessary to calculate some direct soil emissions, and
- since field burning of agricultural residues does not occur in Luxembourg (see Section 6.7.2),

crop production data are described in this section on the methodology for agricultural soil emission estimates.

Crop production by categories are presented in Table 6-31. It is mainly the various aggregated categories (see under "Total") that are used to estimate some direct soil nitrous oxide emissions.

6.5.3.1.3 Sewage sludge spreading on fields

Under IPCC Sub-category 4D16 – Other Direct Soil Emissions, first estimates are provided for the use of sewage sludge in agriculture as a complement/replacement to nitrogenous, phosphate or potassic fertilizers. These estimates cover sewage sludge spreading on fields and, for 2000 onwards, spreading of compost made, among other components, out of sewage sludge. The latter is the result of the starting of a pilot project called "Soil-Concept" that aims at reducing direct spreading of sludge on agricultural lands thanks to the spreading of compost which is less harmful to the environment.[140]

Sewage sludge data used in the inventory are derived from:

- estimates for the total sewage sludge produced in the various wastewater treatment plant (*WWTP*) of the country. For the years up to 2005 included, these estimates have been prepared by the Environment Agency on 24 July 2007. For 2006 and 2007, it has been estimated by the Ministry of the Environment on the basis of various reports and an expert judgement[141] – this explains the "provisional data" note in Table 6-29 above;
- annual reports on sewage sludge that are regularly issued since 2003.[142] These reports are based on a questionnaire sent to WWTPs with at least 2000 inhabitants-eq., hence not all the WWTPs are interrogated. The questionnaire requests, among other things, to indicate the destination and the use of the sludge, both in Luxembourg and abroad: agriculture – what matters here –, composting – information used for IPCC Category 6D – and incineration – an operation done in Germany.

Consequently, activity data used as basis for calculating sewage sludge spreading related N_2O emissions should be associated with an expert judgement. They are summarized in theTable 6-32. It is also recommended to have a look at the Microsoft Excel™ file that has been developed to calculate GHG emissions from the agriculture sector (**Agriculture_GHG Estimates.xls**).

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140 See http://www.soil-concept.lu/.

141 The latest annual activity report of the Ministry of Internal Affairs and Spatial Planning (http://www.gouvernement.lu/publications/informations_gouvernementales/rapports_activite/rapport_activite2006/13int/miat.pdf), the latest report on sewage sludge (http://www.environnement.public.lu/dechets/statistiques_indicateurs/boues_d_epuration_2007.pdf) as well as expert judgements from the Environment Agency.

142 See http://www.environnement.public.lu/dechets/statistiques_indicateurs/index.html under "*Statistiques sur les boues d'épuration*".

Table 6-32 – Sewage sludge estimates and trends: 1990-2007

Year	*Sewage sludge from WWTPs (tonnes 100% dry matter)* Estimates			
	All WWTPs	WWTPs over 2000 inhab.-eq.	*going to the agri. sector in Luxembourg*	Sewage sludge spreading on fields
	(a)	(b)	(c)	(d)
1990	9 668.23	NE	*NE*	**9 668.23**
1991	9 673.95	NE	*NE*	**9 673.95**
1992	9 785.35	NE	*NE*	**9 785.35**
1993	10 165.71	NE	*NE*	**10 165.71**
1994	10 631.70	NE	*NE*	**10 631.70**
1995	10 556.94	NE	*NE*	**10 556.94**
1996	11 461.86	NE	*NE*	**9 169.49**
1997	12 012.56	NE	*NE*	**9 610.05**
1998	12 047.69	NE	*NE*	**9 638.15**
1999	11 983.06	NE	*NE*	**9 586.45**
2000	12 080.38	NE	*NE*	**8 382.70**
2001	12 142.25	NE	*NE*	**7 855.90**
2002	12 914.66	NE	*NE*	**8 313.62**
2003	12 916.77	7 750.00	*3 807.58*	**6 346.01**
2004	13 663.05	7 503.94	*3 116.92*	**5 675.24**
2005	13 373.38	8 191.54	*3 780.15*	**6 171.41**
2006	15 186.53	8 298.83	*4 267.56*	**7 809.48**
2007	16 163.15	8 336.48	*4 387.21*	**8 506.11**
Trend 1990-2007	*67.18%*	*7.57%*	*15.22%*	*-12.02%*

Sources: columns (a) to (c): Environment Agency (1990-2005) and Ministry of the Environment estimate (2006 & 2007);
column (d): Environment Agency & Ministry of the Environment estimates.

Note: For column (d), the estimates have been calculated as follows:
1990 to 1995: (d) = (a);
1996 to 1999: (d) = (a) ● 0.8;
2000 to 2002: (d) = [(a) ● 0.8] – fraction of sludge diverted for composting;
2003 to 2007: (d) = [(c) / (b)] ● (a).

Table 6-33 – Crop production and trends: 1990-2007

Year	Crop production (tonnes) – Crop category – 4F1								4F2					4F3		
	Cereals	*Wheat*	*Barley*	*Maize*	*Oats*	*Rye*	*Rice*	*Other*	Pulses	*Dry Bean*	*Peas*	*Soybeans*	*Other*	Tubers & Roots	*Potatoes*	*Other*
1990	272 985	*43 511*	*69 611*	*125 546*	*18 757*	*2 366*	*NO*	*13 194*	1 410	*NO*	*50*	*NO*	*1 360*	23 593	*22 963*	*630*
1991	266 192	*44 301*	*73 480*	*109 816*	*19 481*	*2 218*	*NO*	*16 896*	1 678	*NO*	*30*	*NO*	*1 648*	20 009	*19 499*	*510*
1992	334 537	*46 124*	*70 386*	*182 196*	*17 237*	*1 923*	*NO*	*16 671*	2 214	*NO*	*30*	*NO*	*2 184*	27 236	*26 866*	*370*
1993	313 285	*48 534*	*68 059*	*161 405*	*17 109*	*1 826*	*NO*	*16 352*	2 202	*NO*	*28*	*NO*	*2 174*	26 079	*25 654*	*425*
1994	268 170	*45 243*	*59 882*	*134 540*	*12 369*	*1 519*	*NO*	*14 617*	1 866	*NO*	*30*	*NO*	*1 836*	18 304	*17 859*	*445*
1995	328 246	*52 745*	*62 822*	*180 661*	*12 150*	*1 703*	*NO*	*18 165*	1 410	*NO*	*30*	*NO*	*1 380*	23 292	*22 857*	*435*
1996	355 581	*64 398*	*72 456*	*180 079*	*13 278*	*2 326*	*NO*	*23 044*	1 949	*NO*	*32*	*NO*	*1 917*	20 744	*20 244*	*500*
1997	337 428	*57 378*	*68 627*	*177 705*	*13 247*	*2 715*	*NO*	*17 756*	1 561	*NO*	*30*	*NO*	*1 531*	23 230	*22 820*	*410*
1998	342 111	*60 073*	*63 203*	*179 187*	*11 693*	*4 051*	*NO*	*23 904*	1 451	*NO*	*31*	*NO*	*1 420*	22 853	*22 313*	*540*
1999	283 883	*46 379*	*67 775*	*133 200*	*12 246*	*3 535*	*NO*	*20 748*	2 337	*NO*	*30*	*NO*	*2 307*	26 174	*25 704*	*470*
2000	283 066	*61 184*	*53 533*	*132 276*	*9 217*	*3 603*	*NO*	*23 253*	1 270	*NO*	*35*	*NO*	*1 235*	28 403	*27 858*	*545*
2001	302 235	*54 022*	*53 566*	*162 267*	*7 799*	*4 803*	*NO*	*19 778*	2 312	*NO*	*35*	*NO*	*2 277*	23 210	*22 770*	*440*
2002	314 970	*71 656*	*51 823*	*148 499*	*10 219*	*7 470*	*NO*	*25 303*	2 359	*NO*	*32*	*NO*	*2 327*	20 600	*20 105*	*495*
2003	339 347	*68 648*	*55 330*	*177 110*	*11 414*	*4 606*	*NO*	*22 239*	2 166	*NO*	*20*	*NO*	*2 146*	18 564	*18 329*	*235*
2004	363 347	*79 978*	*52 761*	*187 975*	*9 458*	*7 921*	*NO*	*25 254*	1 749	*NO*	*20*	*NO*	*1 729*	22 644	*22 244*	*400*
2005	345 288	*71 745*	*52 853*	*186 779*	*7 734*	*5 715*	*NO*	*20 462*	1 501	*NO*	*13*	*NO*	*1 488*	19 731	*19 329*	*402*
2006	314 797	*75 603*	*50 061*	*155 210*	*6 650*	*6 156*	*NO*	*21 117*	1 198	*NO*	*13*	*NO*	*1 185*	16 779	*16 449*	*330*
2007	345 742	*70 469*	*44 640*	*199 510*	*5 634*	*6 953*	*NO*	*18 536*	833	*NO*	*9*	*NO*	*824*	20 204	*19 968*	*236*
Trend 1990-2007	*26.65%*	*61.96%*	*-35.87%*	*58.91%*	*-69.96%*	*193.87%*	*NA*	*40.49%*	*-40.92%*	*NA*	*-82.00%*	*NA*	*-39.41%*	*-14.36%*	*-13.04%*	*-62.54%*

Year	Crop production (tonnes) – Crop category – 4F4	4F5			Total			
	Sugar Cane	Other	*Non N-fixing crops*	*N-fixing crops*	Non N-fixing crops	N-fixing crops	Fodder crops	Non N-fixing crops excluding fodder crops
1990	NO	77 116	*7 147*	*69 969*	303 725	71 379	*197 313*	*106 412*
1991	NO	67 820	*8 232*	*59 588*	294 433	61 266	*170 988*	*123 445*
1992	NO	100 022	*4 472*	*95 550*	366 245	97 764	*279 908*	*86 338*
1993	NO	118 789	*6 464*	*112 325*	345 828	114 527	*275 694*	*70 135*
1994	NO	100 432	*5 470*	*94 962*	291 944	96 828	*231 242*	*60 702*
1995	NO	115 854	*8 420*	*107 434*	359 958	108 844	*289 720*	*70 238*
1996	NO	121 776	*9 017*	*112 759*	385 342	114 708	*294 223*	*91 119*
1997	NO	153 304	*9 102*	*144 202*	369 760	145 763	*320 859*	*48 901*
1998	NO	165 258	*10 108*	*155 150*	375 072	156 601	*330 966*	*44 106*
1999	NO	136 078	*14 668*	*121 410*	324 725	123 747	*252 598*	*72 127*
2000	NO	175 876	*9 925*	*165 951*	321 394	167 221	*297 045*	*24 349*
2001	NO	153 156	*10 264*	*142 892*	335 709	145 204	*294 241*	*41 468*
2002	NO	138 773	*13 965*	*124 808*	349 535	127 167	*271 601*	*77 934*
2003	NO	98 428	*13 908*	*84 520*	371 819	86 686	*260 221*	*111 598*
2004	NO	165 918	*18 161*	*147 757*	404 152	149 506	*332 709*	*71 443*
2005	NO	111 847	*16 286*	*95 561*	381 305	97 062	*281 804*	*99 501*
2006	NO	130 497	*17 540*	*112 957*	349 116	114 155	*266 740*	*82 376*
2007	NO	148 044	*19 445*	*128 599*	385 391	129 432	*326 485*	*58 906*
Trend 1990-2007	*NA*	*91.98%*	*172.07%*	*83.79%*	*26.89%*	*81.33%*	*65.47%*	*-44.64%*

Sources : SER: http://www.ser.public.lu/statistik/pflanz_produktion/mengen_marktfruchtbau.pdf and http://www.ser.public.lu/statistik/pflanz_produktion/mengen_obst_gemuesebau.pdf

STATEC, *Statistical Yearbook*, Table C.2104: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=145&IF_Language=fra&MainTheme=3&FldrName=2&RFPath=6 and Table C.2106: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=147&IF_Language=fra&MainTheme=3&FldrName=2&RFPath=6

data extracted on 22 January 2009 (subject to changes since that date)

Crop description:

4F1 – Wheat: winter & spring wheat (for fodder & bakeries)

4F1 – Barley: winter & spring barley (for fodder & breweries)

4F1 – Maize: fodder maize and maize seeds

4F1 – Oats: oats

4F1 – Rye: winter & summer rye (for fodder & breads)

4F1 – Rice: rice

4F1 – Other: triticale (winter & summer) and secondary & mixed cereals not indicated elsewhere (winter & spring)

4F2 – Dry Bean: dry beans

4F2 – Peas: peas (quantity sold !)

4F2 – Soybeans: soybeans

4F2 – Other: dry vegetable cropped for their grains & used as fodder (mainly peas & beans)

4F3 – Potatoes: potatoes

4F3 – Other: carrots & leeks (quantity sold !)

4F4 – Sugar Cane: sugar cane

4F5 – Other – Non N-fixing Crops: colza & seeds from/for fodder plants

4F5 – Other – N-fixing Crops: clovers (including clover-grass mixes), lucernes & beets used as forage

Total – Non N-fixing crops = 4F1 + 4F3 + 4F5(non N-fixing crops)

Total – N-fixing Crops = 4F2 + 4F5(N-fixing crops)

Total – Fodder Crops = fodder maize, fodder crops (including leguminous plants for fodder)

Total - Non N-fixing Crops excluding Fodder Crops = Total-non N-fixing crops – Total-fodder crops.

6.5.3.2 Emission factors

For estimating agricultural soils nitrous oxide emissions, as indicated above, Tier 1 methods have been applied. Table 6-34 specifies, for each source category, which method has been used for estimating the emissions as well as the corresponding EF type.

Table 6-34 – Method and type of EF used in the inventory

Agricultural soils sub-category	Estimation method	EF	Comments
4D11 – Direct Soil Emissions – Synthetic Fertilizers	T1a	D	*Equation 4.20 – 2000 IPCC-GPG has been used for calculating N_2O emissions. It is referenced as a T1a or b method.*
4D12 – Direct Soil Emissions – Animal Manure Applied to Soils	T1b	D	
4D13 – Direct Soil Emissions – N-fixing Crops	T1b	D	*Though equation 4.20 – 2000 IPCC-GPG has been used for calculating N_2O emissions, N fixed by crops has been estimated using equation 4.26 – 2000 IPCC-GPG which is referenced as a T1b method.*
4D14 – Direct Soil Emissions – Crop Residue	T1a	D	*Both equations used (4.20 & 4.28 2000 IPCC-GPG) are referenced as T1a methods.*
4D15 – Direct Soil Emissions – cultivation of histosols	NO	NO	
4D16 – Direct Soil Emissions – Other – Sewage Sludge Spreading	T1b	D	*The method followed is the one applied by Austria in its inventory. It is referenced as a T1b method.*
4D2 – PRP Manure	T1	D	*Equation 4.18 – 2000 IPCC-GPG has been used for calculating N_2O emissions (see Section 6.3.4.2). It is referenced as a T1 method.*
4D31 – Indirect Emissions – Atmospheric Deposition	T1b	D	*Equation 4.30 – 2000 IPCC-GPG has been used for calculating N_2O emissions. However, both atmospheric deposition and nitrogen leaching & run-off have been estimated using equations 4.32 and 4.36 – 2000 IPCC-GPG which are referenced as T1b methods.*
4D32 – Indirect Emissions – Nitrogen Leaching & Run-off	T1b	D	

Source: Ministry of the Environment.

Abbreviations: T1, T1a & T1b = Tier 1 methods ; D = IPCC Default

6.5.3.2.1 Direct Soil Emissions – Synthetic Fertilizers (4D11)

For synthetic fertilizers – i.e. nitrogenous fertilizers – application to soils, N_2O emissions have been estimated using equations 4.20 and 4.22 – 2000 IPCC-GPG:

$$N_2O_{FERT} = N_2O\text{-}N_{FERT} \bullet (44/28)$$

with:

$$N_2O\text{-}N_{FERT} = [EF_{FERT} \bullet F_{SN}] / 10^6$$

with EF_{FERT} in kg N_2O-N/kg N extracted from table 4.17 – 2000 IPCC-GPG

F_{SN} in kg N calculated using equation 4.22 – 2000 IPCC-GPG

activity data used for calculating F_{SN} = nitrogenous fertilizers consumption (see Table 6.30)

6.5.3.2.2 Direct Soil Emissions – Animal Manure Applied to Soils (4D12)

For animal manure application to soils, N_2O emissions have been estimated using equations 4.20 and 4.23 – 2000 IPCC-GPG:

$$N_2O_{AM} = N_2O\text{-}N_{AM} \bullet (44/28)$$

with:

$$N_2O\text{-}N_{AM} = IEF_{AM} \bullet F_{AM}] / 10^6$$

with EF_{AM} in kg N_2O-N/kg N extracted from table 4.17 – 2000 IPCC-GPG

F_{AM} in kg N calculated using equation 4.23 – 2000 IPCC-GPG

activity data used for calculating F_{AM} = total nitrogen excretion ($\sum_j Nex_j$) (j = AWMS types including PRP): see Microsoft Excel™ file Agriculture_GHG Estimates.xls

6.5.3.2.3 Direct Soil Emissions – N-fixing Crops (4D13)

For determining nitrogen fixed by N-fixing crops and its related N_2O emissions, equations 4.20 and 4.26 – 2000 IPCC-GPG have been used:

$$N_2O_{BN} = N_2O\text{-}N_{BN} \bullet (44/28)$$

with:

$$N_2O\text{-}N_{BN} = [EF_{BN} \bullet F_{BN}] / 10^6$$

with EF_{BN} in kg N_2O-N/kg N extracted from table 4.17 – 2000 IPCC-GPG

F_{BN} in kg N calculated using equation 4.26 – 2000 IPCC-GPG

activity data used for calculating F_{BN} are crop productions of N-fixing crops, the residue/crop ratio and the dry matter fraction

F_{BN} has not been calculated for the N-fixing crops as a whole, but rather for each of the crops that constitute the total N-fixing crops, i.e. peas (4F2), other pulses (i.e. dry vegetable cropped for their grains & used as fodder – 4F2) and other N-fixing crops (4F5): see Table 6-33. For each of these crop categories, ratios and fractions are extracted from the following sources (see also Section 6.7.3.2):

- peas: residue/crop ratio & dry matter fraction come from table 4.16 – 2000 IPCC-GPG;
- other pulses: residue/crop ratio comes from table 4.16 – 2000 IPCC-GPG & dry matter fraction from table 11.2 of the Revised 1996 IPCC Guidelines;
- other N-fixing crops: as indicated page 4.57 of the 2000 IPCC-GPG, forage N-fixing crops will have a residue/crop ratio equals to zero. The dry matter fraction comes from table 11.2 of the Revised 1996 IPCC Guidelines.

6.5.3.2.4 Direct Soil Emissions – Crop Residue (4D14)

For N_2O emissions related to nitrogen in crop residue returned to soils, equations 4.20 and 4.28 – 2000 IPCC-GPG have been used:

$$N_2O_{CR} = N_2O\text{-}N_{CR} \bullet (44/28)$$

with:

$$N_2O\text{-}N_{CR} = [EF_{CR} \bullet F_{CR}] / 10^6$$

with EF_{CR} in kg N_2O-N/kg N extracted from table 4.17 – 2000 IPCC-GPG

F_{CR} in kg N calculated using equation 4.28 – 2000 IPCC-GPG

activity data used for calculating F_{CR} are the total crop productions excluding fodder crops

The calculation of F_{CR} has been realized using a slightly modified equation 4.28 as suggested in the 2000 IPCC-GPG on pages 4.58-4.59. More precisely, the crops included in the calculation are the N-fixing crops and the non N-fixing crops excluding fodder crops (or, in other words, the total crops excluding fodder crops). Indeed, the 2000 IPCC-GPG says that "*The Tier 1a approach (i.e. equation 4.28) can be modified in several ways to estimate more accurately the amount of crop residue nitrogen that is incorporated into soils:*

- *(…)*
- *fourth, the equation should be modified to account for additional uses of crop residues, specifically as fuel, construction material, and* ***fodder****. (…).*"

6.5.3.2.5 Direct Soil Emissions – Cultivation of Histosols (4D15)

This source category does not exist in Luxembourg.

6.5.3.2.6 Direct Soil Emissions – Other (4D16): Sewage Sludge Spreading

For sewage sludge spreading application to soils, N_2O emissions have been estimated using equation 4.20 – 2000 IPCC-GPG:

$$N_2O_{SSlu} = N_2O\text{-}N_{SSlu} \bullet (44/28)$$

with:

$$N_2O\text{-}N_{SSlu} = [EF_{SSlu} \bullet F_{SSlu}] / 10^6$$

with EF_{SSlu} in kg N_2O-N/kg N extracted from table 4.17 – 2000 IPCC-GPG[143]

F_{SSlu} in kg N calculated using the method proposed by Austria:

$$F_{SSlu} = SSlu_{DM}AS \bullet SSlu_N$$

with $SSlu_{DM}AS$ = sewage sludge spreading on agricultural soils – dry matter (see Table 6.32, column (d))

$SSlu_N$ = N content in dry matter: default value from the Austrian inventory (3.90%)

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143 By hypothesis, the IEF for sewage sludge spreading equals the one used for other direct soil emissions, i.e. 1.25% (referenced as EF_1 in table 4.17 – 2000 IPCC-GPG).

6.5.3.2.7 PRP Manure (4D2)

For Nex on PRP, N_2O emissions have been estimated using equation 4.18 – 2000 IPCC-GPG. The calculation has been presented in Section 6.3.4.2. Nitrous oxide emissions reported under sub-category 4D2 are:

$$N_2O_j = [Nex_j \bullet EF_j] \bullet (44/28)$$

with Nex_j = the total nitrogen excretion per AWMS j in kg N/year

EF_j expressed in kg N_2O-N/kg N

for **j = PRP**.

6.5.3.2.8 Atmospheric Deposition (4D31)

For volatized nitrogen from fertilizers, animal manures and other, N_2O emissions have been estimated using equations 4.30 and 4.32 – 2000 IPCC-GPG:

$$N_2O_{(G\text{-}SOIL)} = N_2O\text{-}N_{(G\text{-}SOIL)} \bullet (44/28)$$

with $N_2O\text{-}N_{(G\text{-}SOIL)}$ in Gg calculated using equation 4.32 – 2000 IPCC-GPG

and $EF_{(G\text{-}SOIL)}$ in kg N_2O-N/kg N extracted from table 4.18 – 2000 IPCC-GPG

activity data & parameters used for calculating $N_2O\text{-}N_{(G\text{-}SOIL)}$ = nitrogenous fertilizers

consumption (see Table 6.30), Nex (see Section 6.3.4.2) and N Input from sewage sludge applied to agricultural soils (F_{SSlu})

fractions used for calculating $N_2O\text{-}N_{(G\text{-}SOIL)}$ = $Frac_{GASF}$ & $Frac_{GASM}$ (see Table 6-29)

6.5.3.2.9 Nitrogen Leaching & Run-off (4D32)

For nitrogen from fertilizers, animal manures and other that is lost through leaching and run-off, N_2O emissions have been estimated using equations 4.30 and 4.36 – 2000 IPCC-GPG:

$$N_2O_{(L\text{-}SOIL)} = N_2O\text{-}N_{(L\text{-}SOIL)} \bullet (44/28)$$

with $N_2O\text{-}N_{(L\text{-}SOIL)}$ in Gg calculated using equation 4.36 – 2000 IPCC-GPG

and $EF_{(L\text{-}SOIL)}$ in kg N_2O-N/kg N extracted from table 4.18 – 2000 IPCC-GPG

activity data & parameters used for calculating $N_2O\text{-}N_{(L\text{-}SOIL)}$ = nitrogenous fertilizers

consumption (see Table 6.30), Nex (see Section 6.3.4.2) and N Input from sewage sludge applied to agricultural soils (F_{SSlu})

fraction used for calculating $N_2O\text{-}N_{(L\text{-}SOIL)}$ = $Frac_{LEACH}$ (see Table 6-29)

6.5.3.2.10 Nitrous oxide EFs for Agricultural Soils (4D)

Table 6-35 summarizes the default EFs used for estimating nitrous oxide emissions from agricultural soils.

Table 6-35 – N_2O default EFs for IPCC Category 4D – Agricultural Soils

Agricultural soils sub-category	Default EF	Value *kg N_2O-N/kg N*	Source
4D11 – Direct Soil Emissions – Synthetic Fertilizers	$EF_{FERT} = EF_1$	0.0125	table 4-17 – 2000 IPCC-GPG
4D12 – Direct Soil Emissions – Animal Manure Applied to Soils	$EF_{AM} = EF_1$ for F_{AM}	0.0125	
4D13 – Direct Soil Emissions – N-fixing Crops	$EF_{BN} = EF_1$ for F_{BN}	0.0125	
4D14 – Direct Soil Emissions – Crop Residue	$EF_{CR} = EF_1$ for F_{CR}	0.0125	
4D15 – Direct Soil Emissions – cultivation of histosols	NO	NO	
4D16 – Direct Soil Emissions – Other – Sewage Sludge Spreading	$EF_{SSlu} = EF_1$	0.0125	table 4-17 – 2000 IPCC-GPG
4D2 – PRP Manure	EF_3	D	table 4-12 – 2000 IPCC-GPG
4D31 – Indirect Emissions – Atmospheric Deposition	$EF_{(G\text{-}SOIL)} = EF_4$	0.0100	table 4-18 – 2000 IPCC-GPG
4D32 – Indirect Emissions – Nitrogen Leaching & Run-off	$EF_{(L\text{-}SOIL)} = EF_5$	0.0250	

6.5.4 Recalculations

Table 6-35 presents the main revisions and recalculations between submissions 2008v1.2 and 2009v1.4 (see also CRF tables 8).

Table 6-36 – Changes in GHG inventories: submissions 2008v1.2 and 2009v1.4

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
4D12	- the method is set to Tier 1b instead of Tier 1a in the previous submission	- error correction
4D13	- reallocation of crops activity data between N-fixing and non N-fixing crops for all the years	- misallocation correction
4D14	- reallocation of crops activity data between N-fixing and non N-fixing crops for all the years	- misallocation correction
4D16	- revised activity data for sewage sludge production and spreading on fields for the years 2000 to 2004 and 2006	- revised AD
4D2	- the revised activity data for sewage sludge production and spreading on fields for the years 2000 to 2004 and 2006 had effects on the calculated parameter "volatized N from fertilizers, animal manures and other sources"	- revised AD
4D3	- the revised activity data for sewage sludge production and spreading on fields for the years 2000 to 2004 and 2006 had effects on the calculated parameter "N leaching & run-off from fertilizers, animal manures and other sources"	- revised AD

6.5.5 Category specific QA/QC procedures

Consistency and completeness checks have been performed directly within the Microsoft Excel™ file that has been developed by the Ministry of the Environment to calculate GHG emissions from the agriculture sector as well as by using the tools embedded in CRF Reporter.

The plausibility of the estimates, as well as the calculation methods, were extensively discussed between the Ministry of the Environment and the sector experts, SER and ASTA.

6.5.6 Planned improvement

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 6-36 will be explored.

Table 6-37 – Planned improvements for IPCC Category 4D – Agricultural Soils

GHG source & sink category	Planned improvement
4D – Agricultural Soils	analyze whether it would be possible to replace some default parameters, coefficients or EFs by national values.
4D13 & 4D14 – Agricultural Soils – N-fixing Crops & Crop Residue	refine the various crop categories: allocation, possible correction, etc. especially with regard to the non N-fixing & the fixing crops as well with regard to forage crops contribution to emissions.
4D16 – Agricultural Soils – Other – Sewage Sludge Spreading	analyze further the impact of sludge spreading and compost application on agriculture GHG emissions in order to refine first estimates presented in the inventory.
4D3 – Indirect Emissions from Agricultural Soils	Reviewing the ammonia balance so to refine first estimates for this source sub-category.

6.6 Prescribed Burning of Savannas (4E)

This source category does not exist in Luxembourg.

6.7 Field Burning of Agricultural Residues (4F)

This section describes emissions resulting from field burning of agricultural residues. However, as explained in Section 6.7.2, field burning of residues is not a common practice and, therefore, does not occur in Luxembourg.

6.7.1 Key source

Since field burning of agricultural residues is not occurring in Luxembourg, there are no key sources for IPCC Source Category 4F.

6.7.2 Source category description

Article 17, paragraph 2, indent b), of the Law of 19 January 2004 relating to the preservation of the nature and of the natural resources[144] forbids clearing and burning[145] of fields, meadows, grasslands, roadsides, forests between the 1st of March and the 30th of September. According to the law, the clearing and burning of agricultural residues (such as straw) is not strictly forbidden. However, for economic reasons (residues can be used as litter, as feeding stuff for animals or can be sold),

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144 See http://www.legilux.public.lu/leg/a/search/resultHighlight/index.php?linkId=24&SID=ae766f0dc925893886f2004b9672cc8d.

145 "essartement" in French.

field burning is not practiced in Luxembourg and, therefore, emission estimates have been recorded as not occurring (notation key NO) in the inventory.

Though there are no emission estimates recorded, the crop production, the residue/crop ratio as well as the dry matter fraction have been reported in CRF tables 4F. Indeed, production data are used as inputs for calculating some agricultural soils sub-categories of IPCC Category 4D (see Section 6.5.3.1).

6.7.3 Methodological issues

6.7.3.1 Activity data

See Section 6.5.3.1 above.

6.7.3.2 Ratios

CRF tables on field burning of agricultural residues report two ratios for each crop category: the residue/crop ratio and the dry matter fraction of the residue. Both parameters are indicated for the sake of completeness only since they are, for most of the crops, not used.[146] The values recorded in the tables come from:

- table 4.16 of the 2000 IPCC-GPG for the residue/crop ratio;
- table 4.16 of the 2000 IPCC-GPG and, for other pulses and potatoes, table 11.2 of the 2006 IPCC Guidelines for the dry matter fraction of the residue.

6.7.4 Recalculations

Table 6-38 presents the main revisions and recalculations between submissions 2008v1.2 and 2009v1.4 (see also CRF tables 8).

Table 6-38 – Changes in GHG inventories: submissions 2008v1.2 and 2009v1.4

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
4F	- notation keys revisions: several “NOs” put to “NAs”	- refinement
4F5	- revised activity data for N-fixing and non N-fixing crops for all the years	- revised AD

6.7.5 Category specific QA/QC procedures

Not applicable.

146 As indicated in Section 6.5.3.2 above, these ratios have been used for estimating N_2O emissions for the sub-category 4D13 which covers only N-fixing crops.

6.7.6 Planned improvement

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented Table 6-39 will be explored.

Table 6-39 – Planned improvements for IPCC Category 4F – Field Burning of Agricultural Residues

GHG source & sink category	Planned improvement
4F – Field Burning of Agricultural Residues	refine the various crop categories: allocation, possible correction, etc. especially with regard to the non N-fixing & the fixing crops as well with regard to forage crops contribution to emissions.

6.8 Other (IPCC Source Category 4G)

This source category is not used in Luxembourg's GHG inventory.

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

Chapter 7 includes information on and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under CRF Sector 5 – Land Use, Land-use Change and Forestry – i.e. LULUCF – for the period 1990 to 2007.

7.1 Sector Overview

The territory of Luxembourg has an area of 2586 km². In 1990, 92% of that area was covered by agriculturally used areas and forests, 7% were covered by buildings and roads. The remaining areas were covered by waters (1%). In 2007 the respective areas were 86%, 13% and 1%.

Geographically Luxembourg is situated in an area with temperate maritime climate, with an annual average temperature of 11.3°C (year 2007) approximately. Luxembourg has some 89 000 ha of forests, and some 128 000 ha of agriculturally used land. Rivers, lakes and wetlands cover a surface of some 2 586 ha.

7.1.1 Emission Trends

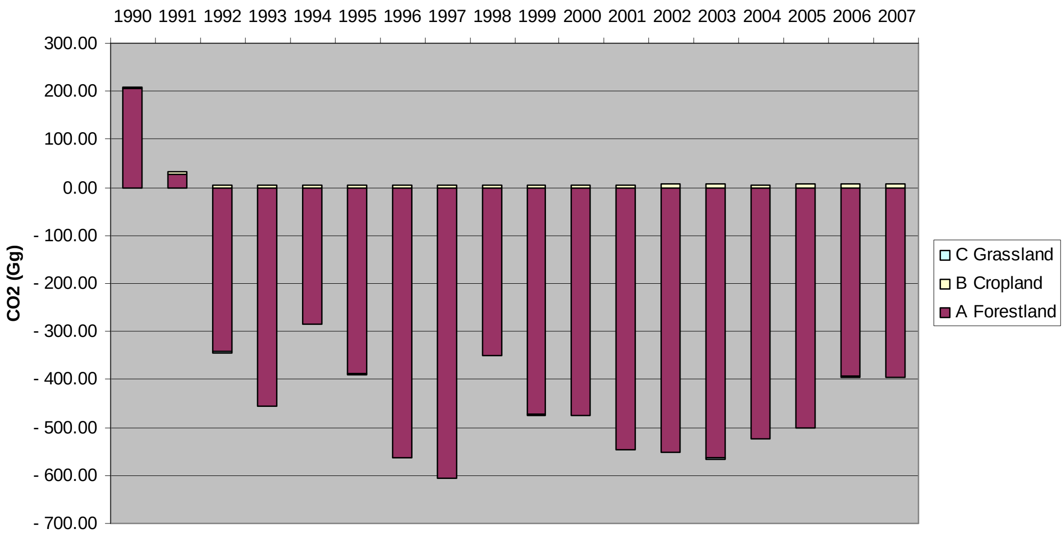
As shown in Table 7-1 and Figure 7-1, Sector *5 -Land Use, Land Use Change and Forestry* was a net sink in Luxembourg, in 2007. An important sub-category is forest land, in particular its sub-source forest land remaining forestland. This category, as well as the category grassland are net sinks for CO_2, whereas sub-category cropland is a source of CO_2 emissions. For sub-categories wetlands, settlements and other land, areas of LU and LUC have been estimated, however, emissions and removals have not yet been estimated due to a lack of data on biomass.

Table 7-1 - Emissions and Removals from Sector 5 - LULUCF

	5 - Land Use, Land Use Change & Forestry *Greenhouse gas emissions/removals (Gg CO_2 e)*						
Year	5 Total	A Forestland	B Cropland	C Grassland	D Wetlands	E Settlements	F Other land
1990	208.43	205.10	4.09	- 0.76	NE, NO	NE, NO	NE, NO
1991	31.40	27.95	4.21	- 0.76	NE, NO	NE, NO	NE, NO
1992	- 339.24	- 342.81	4.33	- 0.76	NE, NO	NE, NO	NE, NO
1993	- 450.78	- 454.46	4.45	- 0.76	NE, NO	NE, NO	NE, NO
1994	- 281.29	- 285.40	4.88	- 0.76	NE, NO	NE, NO	NE, NO
1995	- 384.87	- 388.73	4.62	- 0.76	NE, NO	NE, NO	NE, NO
1996	- 559.11	- 562.84	4.49	- 0.76	NE, NO	NE, NO	NE, NO
1997	- 600.75	- 604.96	4.97	- 0.76	NE, NO	NE, NO	NE, NO
1998	- 345.22	- 349.99	5.52	- 0.76	NE, NO	NE, NO	NE, NO
1999	- 470.05	- 473.92	4.63	- 0.76	NE, NO	NE, NO	NE, NO
2000	- 471.38	- 476.01	5.39	- 0.76	NE, NO	NE, NO	NE, NO
2001	- 542.14	- 547.17	5.79	- 0.76	NE, NO	NE, NO	NE, NO
2002	- 546.20	- 551.84	6.41	- 0.76	NE, NO	NE, NO	NE, NO
2003	- 559.07	- 564.62	6.32	- 0.76	NE, NO	NE, NO	NE, NO
2004	- 518.01	- 523.17	5.92	- 0.76	NE, NO	NE, NO	NE, NO
2005	- 493.43	- 500.07	7.41	- 0.76	NE, NO	NE, NO	NE, NO
2006	- 388.70	- 394.49	6.55	- 0.76	NE, NO	NE, NO	NE, NO
2007	- 390.65	- 396.47	6.58	- 0.76	NE, NO	NE, NO	NE, NO

In 1990 and 1991, Sector 5 was a net emission source due to the heavy windfall during the winter 1990/1991.

Figure 7-1 - Emissions and Removals in sub-categories 5A, 5B, 5C.



7.1.2 Activity Data

Before deciding which activity data would be used, an inventory of the available activity data sources for Luxembourg was made. The only datasets so far available in Luxembourg for different time periods and covering all the land uses in the whole country is the CORINE Land cover database. It's available for the reference year 1989. It has been updated in 2000 and 2007.

7.1.2.1 CORINE Land Cover

The CORINE Programme has been implemented by the European Commission from 1985 to 1990.

The CORINE Land Cover (CLC) is the largest of the CORINE databases. The CLC90 inventory and its updates are key reference data sets. They provide the basis for the development of spatial analysis.

7.1.2.1.1 <u>Level of geographical application:</u>

The CORINE land cover nomenclature comprises three levels, as set out below:

- the first level (5 items), indicates the major categories of land cover
- the second level (15 items), is for use on scales of 1:500 000 and 1: 1 000 000
- the third level (44 items), is used for projects on a scale of 1: 100 000

7.1.2.1.2 <u>Technical details:</u>

Area covered:

- 2.3 million km²,
- 12 countries,..
- from 62° N (The Faeroes) to 28° S (Canary Islands),
- from 14' W (Canary Islands) to 29° E (Kastellorizon).

Working scale: 1/100000, i.e. 1 500 standard map sheets produced using 10 different projection systems.

Area of the smallest mapping unit: 25 hectares.

Projection : Gauss Luxembourg.

7.1.2.1.3 The CORINE Land Cover Nomenclature:

The following table represents the CORINE land cover nomenclature for all the categories. Some of the categories are not occurring in Luxembourg.

Category	Description	Category	Description
1	**Artificial**	**3**	**Forests and semi-natural areas**
1.1.	Urban fabric	3.1	Forests
1.1.1.	Continuous urban fabric surfaces	3.1.1.	Broad-leaved forest
1.1.2.	Discontinuous urban fabric	3.1.2.	Coniferous forest
1.2.	Industrial, commercial	3.1.3.	Mixed forest
1.2.1.	Industrial or commercial units and transport units	3.2.	Shrub and/or herbaceous vegetation association
1.2.2.	Road and rail networks and associated land	3.2.1.	Natural grassland
1.2.3.	Port areas	3.2.2.	Moors and heathland
1.2.4.	Airports	3.2.3.	Sclerophyllous vegetation
1.3.	Mine, dump	3.2.4.	Transitional woodland shrub
1.3.1.	Mineral extraction sites and construction sites	3.3.	Open spaces with little or no vegetation
1.3.2.	Dump sites	3.3.1.	Beaches, dunes, and sand plains
1.3.3.	Construction sites	3.3.2.	Bare rock
1.4.	Artificial non-agricultural	3.3.3.	Sparsely vegetated areas
1.4.1.	Green urban areas vegetated areas	3.3.4.	Burnt areas
1.4.2.	Sport and leisure facilities	3.3.5.	Glaciers and perpetual snow
2	**Agricultural**	**4**	**Wetlands**
2.1.	Arable land	4.1.	inland wetlands
2.1.1.	Non-irrigated arable land areas	4.1.1.	Inland marshes
2.1.2.	Permanently irrigated land	4.1.2.	Peatbogs
2.1.3.	Rice fields	4.2.	Coastal wetlands
2.2.	Permanent crops	4.2.1.	Salt marshes
2.2.1.	Vineyards	4.2.2.	Salines
2.2.2.	Fruit trees and berry plantations	4.2.3.	Intertidal flats
2.2.3.	Olive groves	**5.**	**Water bodies**
2.3.	Pastures	5.1.	Inland waters
2.3.1.	Pastures	5.1.1.	Water courses
2.4.	Heterogeneous	5.1.2.	Water bodies
2.4.1.	Annual crops associated with permanent crops agricultural areas	5.2.	Marine waters
2.4.2.	Complex cultivation	5.2.1.	Coastal lagoons
2.4.3.	Land principally occupied by agriculture, with significant areas of natural vegetation	5.2.2.	Estuaries
2.4.4.	Agro-forestry areas	5.2.3.	Sea and ocean

7.1.3 Methodology

7.1.3.1 Matching the CORINE categories to the LULUCF categories

The CORINE LC categories have been assigned to the LULUCF categories according to the following matching table (Table 7-2).

Table 7-2 - Corine LC - LULUCF matching table

CORINE LC Category	LULUCF Category	CORINE LC Category	LULUCF Category
111	Settlement	222	Cropland
112	Settlement	231	Grassland
121	Settlement	241	Cropland
122	Settlement	242	Cropland
123	Settlement	243	Grassland
124	Settlement	311	Forest
131	Settlement	312	Forest
132	Settlement	313	Forest
133	Settlement	321	Grassland
141	Settlement	323	Forest
142	Settlement	324	Other Land
211	Cropland	511	Wetland
221	Cropland	512	Wetland

7.1.3.2 Surface statistics extracted from CORINE Landcover

Table 7-3 represents the land cover surfaces in ha for the different CORINE categories, for the years 1989, 2000 and 2007.

Table 7-3 - Land cover surfaces (ha) according to Corine categories

CLCODE	1989	2000	2007	CLCODE	1989	2000	2007
111	1281,4	714,3	714,3	222	90,7	98,1	98,1
112	13184,4	18060,4	18283,3	231	21203,3	37828,0	37614,1
121	1970,7	2486,5	2708,2	241	1708,1	89,3	89,3
122	136,1	362,1	539,4	242	63142,7	47470,8	47156,7
123	0,0	27,4	37,3	243	26543,9	22743,6	22725,6
124	443,4	377,3	410,6	311	34889,9	62741,9	63837,0
131	197,4	233,6	233,5	312	9462,3	11958,3	11922,0
132	696,8	630,6	392,3	313	51998,2	16877,0	17857,7
133	40,3	118,3	0,0	321	559,6	0,0	0,0
141	0,0	365,9	337,7	323	128,4	0,0	0,0
142	109,4	403,2	432,4	324	87,0	2470,9	576,6
211	28475,9	31168,3	31293,7	511	316,3	334,8	334,8
221	2143,7	1470,6	1436,2	512	393,9	681,6	681,6
				Total:	259203,8	259712,7	259712,7

7.1.3.3 Surface statistics according to LULUCF categories

Table 7-4 represents the land cover surfaces in ha for the different LULUCF categories, for the years 1989, 2000 and 2007.

Table 7-4 - Land Cover surfaces (ha) according to LULUCF categories

Category	1989	2000	2007
Cropland	95561,0	80297,2	80074,0
Forest	96478,8	91577,2	93616,7
Grassland	48306,8	60571,5	60339,7
Other Land	87,0	2470,9	576,6
Settlement	18059,9	23779,5	24089,2
Wetland	710,2	1016,4	1016,4
Total	259203,8	259712,7	259712,7

7.1.3.4 Land use change monitoring

For the land use change monitoring, the three datasets have been overlaid in a Geographical Information System (GIS). The spatial analysis function has delivered new polygons where a land use change has occurred.

Using this technique it was easy to determine which source category has moved to which destination category. Since the survey in 1989, methodological changes were carried out. For this reason the surveys 2000 and 2007 cannot fully compared to the one in 1989 and implausible LUCs would be the result. For this reason the survey of 1989 was not used, but the land uses and land use changes were estimated on basis of the surveys 2000 and 2007 and with an extrapolation into the years before.

7.1.4 Completeness

Table 7-5 gives an overview of the IPCC categories included under CRF Sector 5 and provides information on the status of emission estimates of all subcategories.

Table 7-5– Overview of subcategories of CRF Sector 5 – LULUCF: status of emission estimates for CO_2, CH_4 and N_2O

GHG source & sink category	Description	Status		
		Net CO_2	CH_4	N_2O
5A1	forest land remaining forest land	X	NE,NO	NE,NO
5A2	land converted to forest land	X	NO	NE,NO
5B1	cropland remaining cropland	X	NO	NO
5B2	land converted to cropland	X	NO	X
5C1	grassland remaining grassland	X	NO	NO
5C2	land converted to grassland	X	NO	NO
5D1	wetlands remaining wetlands	NE,NO	NO	NO
5D2	land converted to wetlands	NO	NO	NO
5E1	settlements remaining settlements	NE	NE	NE

GHG source & sink category	Description	Status		
		Net CO_2	CH_4	N_2O
5E2	land converted to settlements	NE,NO	NE	NE
5F1	other land remaining other land			
5F2	land converted to other land	NE,NO	NE	NE
5G	other	NE	NE	NE

Note: a **X** indicates that emissions from this sub-category have been estimated, the grey shaded cells are those also shaded in the CRF tables.

7.2 Forest Land (5A)

Luxembourg has some 89 000 ha of forests, covering about 34 % of the country's area. The population is well situated with an average forest area of 22 ares per person.

In Luxembourg statistical data about forests are established and updated by the Water and Forest Administration (Administration des Eaux et Forêts (AEF)) of the Environment Ministry. The forest inventory is partly based on photography from the air and on territorial measurements, partly on questionnaires filled in by the forest owners.

The forest area comprises all territories which are used for wood production, environment protection and recreation. In these areas are included land covered by trees, but also for example land covered by bushes, rocks or land no more used by agriculture.

Types of forests (IFL1 2006):

- hardwood forests (beech and oak) 40 900 ha: 46 %
- coppice forest (oak) 13 210 ha 15 %
- conifers (spruce, pin, douglas etc.) 31 645 ha 36 %
- non forested (shrubs, forest roads, quarries, clear cuttings, etc.) 2 865 ha 3 %

7.2.1 Forest Land remaining Forest Land (5A1)

7.2.1.1 Activity Data

The forest areas used in the time series from 1990 to 2007 were sized as described in section 7.1.2.

7.2.1.2 Emission Factors

The increment of growing stock biomass in m^3 per ha and year, for all tree types except for the first age class of beech and oak, was calculated using yield-tables. (Reinhard Schober, Göttingen, Ertragstafeln wichtiger Baumarten; neubearbeitet von Prof. Dr. R. Schober; J.D. Sauerländer's

Verlag, 3. neubearbeitete und erweiterte Auflage 1987, Frankfurt a. M.) The values for a medium thinning were applied and the medium quality class was chosen (class II out of four classes).

For beech, the yield-tables did not contain a value for the first age class (0-20 years). Therefore, the increment of the first age class was calculated using the following parameters: height 7m (average value) ; diameter estimated to 4 cm in 3,5 m of the total height (average value) ; 10.000 plants/ha . Thus, an increment of 87,92 m^3/ha in 20 years was obtained, which equals to an increment of 4,4 m^3/ha and year.
The value of the increment of the age 20-40 years is calculated using the values for the age of 20 years and the age for 40 years: 1,75; and 5,4 respectively ; Average: 7,15/2 = 3,575. As, there are no values for the age above 150 years in the yield-tables, these values were estimated: 8,2 m3/ha*year for the age of 170; 8,0 m3/ha*year for the age of 190.

For oak: the increment of the age 0-20 years is estimated using the following parameters: Height 7m (average value) ; diameter estimated to 4 cm in 3,5 m of the total height (average value) ; 10.000 plants/ha ; Thus, an increment of 87,92 m^3/ha in 20 years was obtained, which equals to an increment of 4,4 m^3/ha and year. The value of the increment used to calculate the increment in coppice oak-forests was estimated base on literature (M. Decker, 1981, *Der Eichenschälwald*, p. 134). The increment depends on more factors than just the age of the forest stand; other factors are the soil fertility and soil depth. These factors are unknown, an average value was estimated to 3,5 m3/ha and year based on expert judgement.

The biomass increment factor of 3,1 t C/ha and the biomass decrease factors for *5A1 - Forest Land Remaining Forest Land* were calculated using various factors:

The annual increment value: the annual increment value, calculated with yield-tables, was set to 8,57 m3/ha*y (see section 7.2.1.1). The biomass decrease due to harvest was based on:

a) Basic wood densities were calculated using the values in Table 7-6, which are based on the mean densities (absolute dry) and volume shrinkage values provided by WAGENFÜHR und SCHEIBER 1974, KOLLMANN 1982, LOHMANN 1987.

Table 7-6 - Basic wood densities.

density	%	species	average density
0,38	23	spruce	0,09
0,45	4	douglas	0,02
0,43	2	pine	0,01
0,56	3	fraxinus	0,02
0,53	4	betula	0,02
0,64	6	carpinus	0,04
0,57	28	oak	0,16
0,56	30	beech	0,17
TOTAL	**100**	**TOTAL**	**0,52**

b) The density value for "douglas fir" is the value of table 3.A.1.9-1 of the IPCC Good Practice Guidance for LULUCF (2003).

c) The Carbon content used in the calculations was the default value: 0,5 CF = carbon fraction of dry matter (default = 0,5), tonnes C (tonne d. m.)$^{-1}$.

d) The BEF1 (for increment) and BEF2 (for harvest) factors were calculated according to Table 3A.1.10 of the IPCC Good Practice Guidance for LULUCF (2003) (see Table 7-7).

Table 7-7 - BEF1 and BEF2 factors.

	%	BEF1	BEF2
broadleafs	71,0	1,20	1,4
conifers	29,0	1,15	1,3
	average BEF	1,186	1,371

e) The Root to Shoot value derives from the Table 3A.1.8 of the IPCC Good Practice Guidance for LULUCF. The (1 + R/S) factor was calculated using Table 3A.1.8 of the LUCF Sector Good Practice Guidance and is defined as 1,24. Explication: for the conifers a value of a biomass above ground >150 t/ha was chosen because the middle inventory stocks for « Conifer forest » in Luxembourg is +/- 300 m^3/ha (Forest Inventory of Luxembourg) and the specific weight of 1 m^3 of "conifer wood" is estimated to slightly more than 0,5 t/m^3. So 300 * 0,53 = 159 t/ha. For broadleaf the factor for a biomass aboveground >150 t/ha was chosen because the middle inventory stocks for "broadleaf forest" in Luxembourg is +/- 300 m^3/ha (Forest Inventory of Luxembourg) and the specific weight of 1 m^3 "broadleaf wood" is more than 0,5 t/m^3. So 300*0,6 = 180 t/ha.

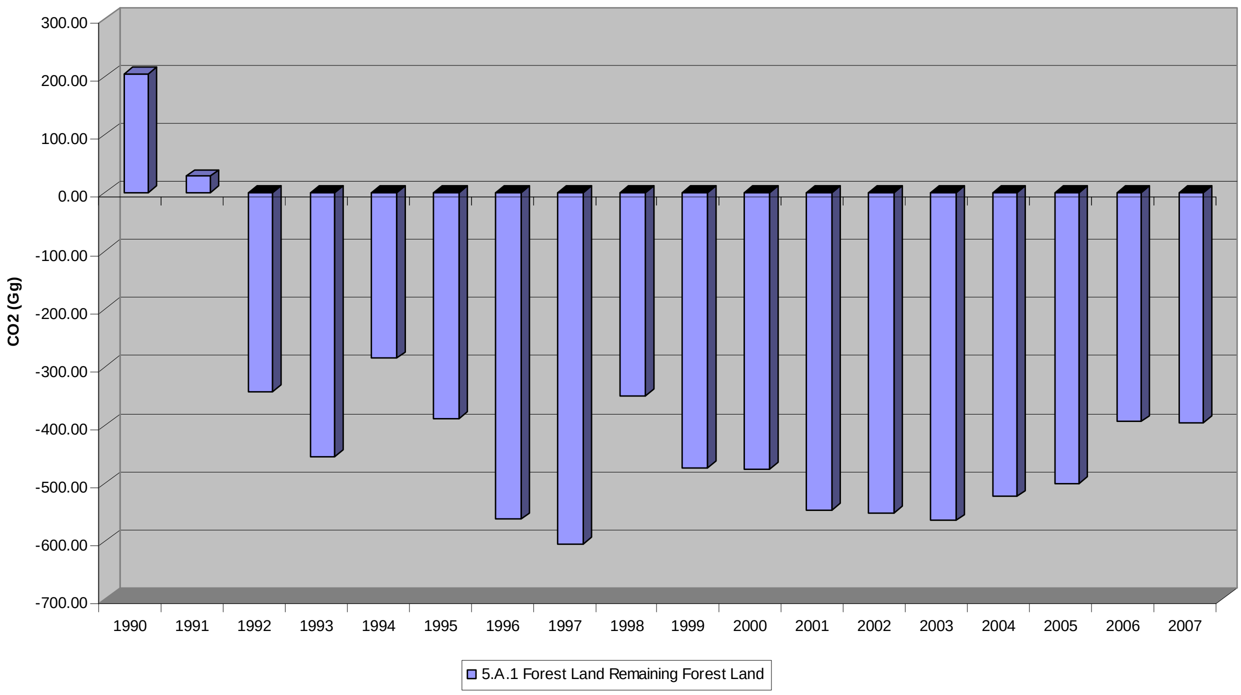
Finally, the average value for R/S is calculated as follows: (29*0,23+71*0.24)/100 = 0,24.

For the changes in soil carbon stock the IPCC GPG tier 1 approach was used (no changes in the soil Carbon stock). Changes in dead wood were not estimated so far, but will be provided in the near future when the data of the actually running NFI will be available (see chapter "planned improvements").

7.2.1.3 Results

Figure 7-2 presents the annual removal of carbon from 1990 to 2007. The values for 1990 and 1991 are above average because of the heavy windfall during the winter 1990/1991.

Figure 7-2 - Annual removal of carbon in category 5.A.1 - Forest Land remaining Forest Land



7.2.1.4 Uncertainty

The method using yield tables to calculate the increase in m^3/ha*year often underestimates the real increment; the quotation from Mr. SPIECKER confirms this. Quotation: " *In der Vergangenheit haben Ertragstafeln oft die Ertragsleistung unter den spezifischen Verhältnissen eines Waldes (Standort und Baumbestand) nicht richtig wiedergegeben. Das in den letzten Jahrzehnten insbesondere in Mitteleuropa beobachtete beschleunigte Wachstum hat dazu geführt, dass das Wachstum der Wälder häufig unterschätzt wird. Allerdings ist auch zu berücksichtigen, dass der Zuwachs von Jahrzehnt zu Jahrzehnt durchaus nennenswerten Schwankungen unterliegt. Daher sind Abschätzungen des laufenden Zuwachses für kürzere Zuwachsperioden ohne entsprechende Messungen immer mit Unsicherheiten behaftet.“ (SPIECKER, H., MIELIKÄINEN, K., KÖHL, M. and SKOVSGAARD, J. (eds.) 1996: Growth Trends in European Forests: Studies from 12 Countries. European Forest Institute Research Report Nr. 5. Springer-Verlag, 372 S.).*

7.2.2 Land Use Changes to Forest Land (5A2)

7.2.2.1 Activity Data

The activity data are described in section 7.1.2. The LUC areas are kept for 20 years in the related LUC categories before the move into the related "remaining" category.

7.2.2.2 Emission Factors

The method follows the IPCC GPG with a transition period of 20 years for LUC areas and related estimates for the increments and decreases of biomass and soil C stocks.

The biomass increment factor for *5.A.2.1 - Cropland converted to Forestland* is 1,65 t C/ha and was calculated as described under § 7.2.1.2, but only the first age class value for the annual increment was used. This factor is multiplied with the complete LUC area.

The biomass decrease factor for *5.A.2.1 - Cropland converted to Forestland* is 5,0 t C/ha and derives from Table 3.4.8 of the IPCC GPG (LULUCF 2003, Tier 1 default value). This factor is multiplied with the area of actual LUC in the respective year.

The biomass increment factor for *5.A.2.2 - Grassland converted to Forestland* is 1,65 t C/ha and was calculated as described under § 7.2.1.2, but only the first age class value for the annual increment was used. This factor is multiplied with the complete LUC area.

The biomass decrease factor for *5.A.2.2 - Grassland converted to Forestland* is 6,8 t C/ha and derives from Table 3.4.9 of the IPCC GPG (LULUCF 2003, Tier 1 default value). This factor is multiplied with the area of actual LUC in the respective year.

For the estimates of the soil C stock changes the following input values (average soil C stocks in Luxembourg) were used:

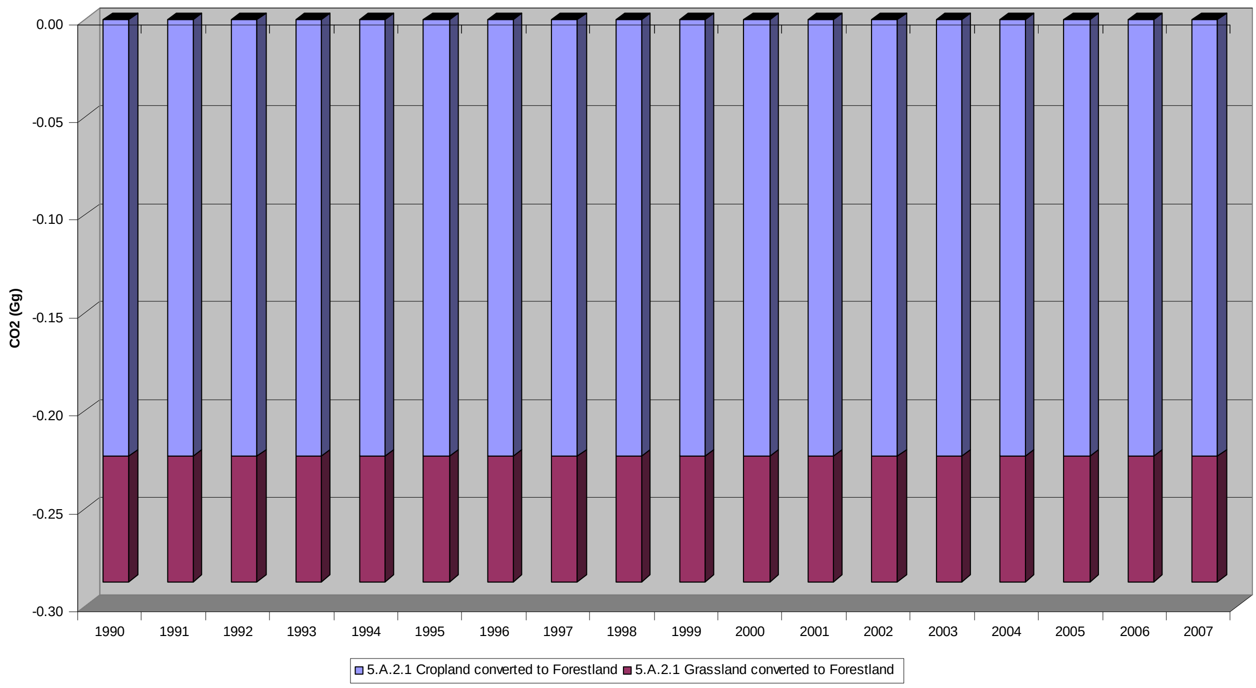
	Stock soil before LUC (t C/ha)	Stock soil after 20 years of LUC (t C/ha)	Emission factor (t C/ha*y)
Forestland	0.00	0.00	0.00
Cropland	77.00	85.00	0.40
Grassland	92.00	85.00	- 0.35

In line with the IPCC GPG, a linear soil C stock change due to the LUCs between these average soil C stocks across 20 years was estimated.

7.2.2.3 Results

Figure 7-3 shows the annual removals of CO_2 due to cropland and grassland conversion into forestland.

Figure 7-3 – Annual removals of CO_2 for IPCC Sub-category 5A2 – Land converted to Forestland



7.3 Cropland (5.B)

In this category emissions/removals from cropland management are considered.

7.3.1 Cropland remaining Cropland (5B1)

7.3.1.1 Activity Data

Cropland areas used in the time series from 1990 to 2007 were sized as described in section 7.1.2.

7.3.1.2 Emission factors for annual cropland

a) Changes of carbon stock in biomass of annual cropland remaining annual cropland:
As the biomass of annual crops is harvested every year, there is no change in carbon stock in biomass.

b) Changes of carbon stock in biomass of perennial cropland converted to annual cropland:
For the calculation of annual change in carbon stocks of living biomass of land converted to cropland the IPCC GPG 2003 LULUCF Tier 1 method equation 3.3.8 was applied:

$$\textit{Annual change in carbon stock in biomass} = \textit{annual area of converted land} * (L_{conversion} + \Delta C_{growth})$$

where :

$L_{conversion} = C_{after} - C_{before}$.

ΔC_{growth} = IPCC default value for annual crops carbon accumulation rate is 5 t C ha^{-1} yr^{-1}.

C_{before} = IPCC default value for carbon stock of woody biomass before conversion is 63 t C ha^{-1}.

C_{after} = carbon stock immediately after conversion = 0.

<u>c) Changes of carbon stock in organic soils:</u>
Organic soils are not occurring in Luxemburg.

<u>d) Changes of carbon stock in mineral soils of annual cropland remaining annual cropland:</u>
Emissions/removals were calculated using country specific values for the soil organic carbon content. The mean organic carbon content of soil per ha in the layer of 0-30 cm depth was determined for the different land uses (annual cropland, perennial cropland, grassland, forest) by using the values of the soil database of ASTA (Administration des Services Techniques de l'Agriculture, Division des Laboratories de Contrôle et d'Essais, Service de Pédologie). A weighted mean was calculated over the different pedological regions of Luxembourg. The mean organic carbon stocks per ha in mineral soils are: 77 t C/ha for annual cropland, 43 t C/ha for perennial cropland, 92 t C/ha for grassland and 85 t C/ha for forest land.

According to expert judgment, there was no change in relative stock change factors (tillage factor FMG; land use factor FLU; input factor FI) during the observation period 1990 to 2007 and these factors are set by default equal to 1. Thus there was no change in carbon stocks in annual cropland soils due to management.

<u>e) Changes of carbon stock in mineral soils of perennial cropland converted to annual cropland:</u>
According to IPCC GPG (Tier 1), annual change in carbon stock of mineral soils of perennial cropland converted to annual cropland = ΔSOC * conversion area, where :

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = 1.7\ t\ C/ha\ {}^*yr$$

SOC_0 = soil organic carbon stock in the inventory year (t C/ha) according to § c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according § c).

7.3.1.3 Emission factors for perennial cropland

<u>a) Changes of carbon stock in biomass of perennial cropland remaining perennial cropland:</u>
According to Tier 1 GPG (2003) for perennial cultures, a steady increase in biomass in the first 30 years is assumed. 3.33% of these cultures are removed and cause emissions. For older cultures the annual increase in biomass is assumed to be equal to the losses by harvesting. For calculating the carbon stock change of living biomass on perennial cropland the following formula was used:

*Annual change in carbon stock in biomass = (area of perennial cropland * carbon accumulation rate) – (area of perennial cropland before 30 years * 0.033 * biomass carbon stock at harvest)*

where:

For the carbon accumulation rate the IPCC GPG default value of 2.1 t C ha^{-1} yr^{-1} was used.

For the above ground biomass carbon stock at harvest the IPCC GPG default value of 63 t C ha^{-1} yr^{-1} was used.

b) Changes of carbon stock in biomass of annual cropland converted to perennial cropland:
For the calculation of annual change in carbon stocks of living biomass of land converted to cropland the IPCC Tier 1 method equation 3.3.8 was applied:

$$\textit{Annual change in carbon stock in biomass} = \textit{annual area of converted land} * (L_{conversion} + \Delta C_{growth})$$

where :

$L_{conversion} = C_{after} - C_{before}$

ΔC_{growth} = IPCC default value for perennial crops carbon accumulation rate is 2.1 t C ha^{-1} yr^{-1}.

C_{before} = IPCC default value for carbon stock of annual crops before conversion is 5 t C ha^{-1}.

C_{after} = carbon stock immediately after conversion = 0.

c) Changes of carbon stock in mineral soils of annual cropland converted to perennial cropland :
According to IPCC GPG (Tier 1), annual change in carbon stock of mineral soils of annual cropland converted to perennial cropland = ΔSOC * conversion area, where :

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -1.7 \ t\ C/ha * yr$$

SOC_0 = soil organic carbon stock in the inventory year (t C/ha) according to § 7.3.1.2 point c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according to § 7.3.1.2 point c).

7.3.1.4 Liming

The data concerning the quantities of limestone used in agriculture come from a survey on the quantities sold carried out among the companies providing agricultural production means to the farmers. As the numbers of these companies is very small, this survey is an exhaustive survey. This survey is carried out by ASTA.

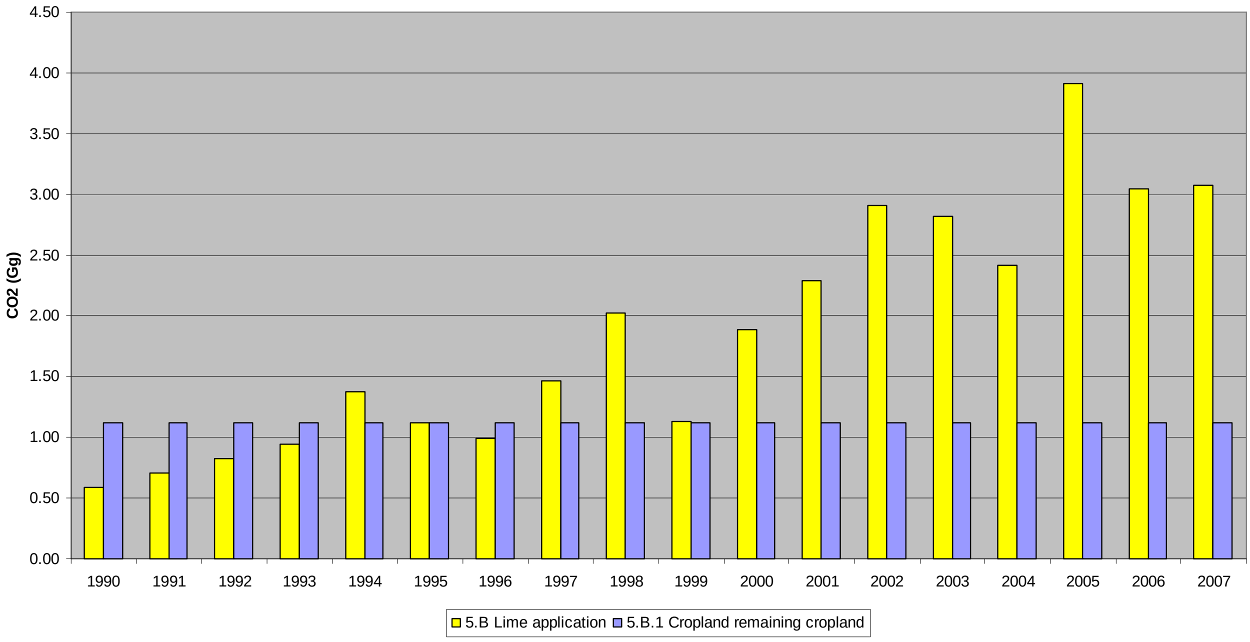
Since the beginning of the 20th century and until the 90ies of that century "Thomas slag" a by-product of the Thomas steel production process was almost the only phosphatic fertilizer used. As "Thomas slag" has a high content of CaO (45%CaO), the secondary effect of using this fertilizer is a soil amendment by increasing the pH of soils. As Thomas slag was subsidized by the Government, it was used on a very large scale so that there was no need for liming. When the production of steel, using the Thomas process, ceased in the 90ies, the Thomas slag was no longer produced and was replaced, for the soil amendment purposes, by the use of lime. This explains the growing use of lime in the 90ies.

The calculation of the CO_2 emissions due to liming is done following GPG (2003) equation 3.3.6. The overall emission factor of 0.12 is used to estimate CO_2 emissions.

7.3.1.5 Results

Figure 7-4 shows the annual emissions of CO_2 due to cropland remaining cropland and liming .

Figure 7-4 - Annual emissions of CO2 for IPCC Sub-category 5B1 - Cropland remaining Cropland and due to Lime application



7.3.2 Land Use Changes to Cropland (5B2)

7.3.2.1 Activity Data

The activity data are described in § 7.1.2 The LUC areas are kept for 20 years in the related LUC categories before the move into the related "remaining" category.

7.3.2.2 Emission factors for annual cropland

The method follows the IPCC GPG with a transition period of 20 years for LUC areas and related estimates for the increases and decreases of biomass and soil C stocks. Growth rates for annual crops (annual cropland, grassland) are accounted only once in the year of LUC, while growth rates for perennial crops (perennial cropland, forest land) are accounted for the whole period of transition. In line with the IPCC GPG, a linear soil C stock change due to the LUCs between the average soil C stocks across 20 years was estimated.

<u>a) Changes of carbon stock in biomass of forest land converted to cropland:</u>
For the calculation of annual change in carbon stocks of living biomass of grassland converted to cropland the IPCC GPG Tier 1 method equation 3.3.8 was applied:

$$\textit{Annual change in carbon stock in biomass} = \textit{annual area of converted land} * (L_{conversion} + \Delta C_{growth})$$

where :

$L_{conversion} = C_{after} – C_{before}$

ΔC_{growth} = IPCC default value for annual crops carbon accumulation rate is 5 t C ha^{-1} yr^{-1}.

C_{before} = country specific value for carbon stock of forest land biomass before conversion is 124.96 t C ha^{-1}.

C_{after} = carbon stock immediately after conversion = 0.

<u>b) Changes of carbon stock in biomass of grassland converted to annual cropland:</u>

For the calculation of annual change in carbon stocks of living biomass of grassland converted to cropland the IPCC GPG Tier 1 method equation 3.3.8 was applied:

*Annual change in carbon stock in biomass = annual area of converted land * ($L_{conversion} + \Delta C_{growth}$)*

where :

$L_{conversion} = C_{after} – C_{before}$

ΔC_{growth} = IPCC default value for annual crops carbon accumulation rate is 5 t C ha^{-1} yr^{-1}.

C_{before} = IPCC default value for carbon stock of grassland biomass before conversion is 6.8 t C ha^{-1}.

C_{after} = carbon stock immediately after conversion = 0.

<u>c) Changes of carbon stock in mineral soils of forest land converted to cropland:</u>

According to IPCC GPG (Tier 1), annual change in carbon stock of mineral soils of forest land converted to annual cropland = ΔSOC * conversion area, where :

$$\Delta SOC = (SOC_0 – SOC_{0-T})/20 = -0.4 \text{ t C/ ha *yr}$$

SOC_0 = soil organic carbon stock in the inventory year (t C/ha) according to § 7.3.1.2 point c).

SOC_{0-T} = soil organic carbon stock T years prior to the inventory (t C/ha) according to § 7.3.1.2 point c).

<u>d) Changes of carbon stock in mineral soils of grassland converted to annual cropland:</u>

According to IPCC GPG (Tier 1), annual change in carbon stock of mineral soils of grassland converted to annual cropland = ΔSOC * conversion area, where :

$$\Delta SOC = (SOC_0 – SOC_{0-T})/20 = -0.75 \text{ t C/ ha *yr.}$$

SOC_0 = soil organic carbon stock in the inventory year (t C/ha) according to § 7.3.1.2 point c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according to § 7.3.1.2 point c).

7.3.2.3 Emission factors for perennial cropland

The method follows the IPCC GPG with a transition period of 20 years for LUC areas and related estimates for the increases and decreases of biomass and soil C stocks. Growth rates for annual crops (annual cropland, grassland) are accounted only once in the year of LUC, while growth rates for perennial crops (perennial cropland, forest land) are accounted for the whole period of transition. In line with the IPCC GPG, a linear soil C stock change due to the LUCs between the average soil C stocks across 20 years was estimated.

<u>a) Changes of carbon stock in biomass of grassland converted to perennial cropland:</u>

For the calculation of annual change in carbon stocks of living biomass of grassland converted to perennial cropland the IPCC GPG Tier 1 method equation 3.3.8 was applied:

$$Annual\ change\ in\ carbon\ stock\ in\ biomass = annual\ area\ of\ converted\ land * (L_{conversion} + \Delta C_{growth})$$

where :

$L_{conversion} = C_{after} - C_{before}$

ΔC_{growth} = IPCC default value for perennial crops carbon accumulation rate is 2.1 t C ha^{-1} yr^{-1}.

C_{before} = IPCC default value for carbon stock of grassland biomass before conversion is 6.8 t C ha^{-1}.

C_{after} = carbon stock immediately after conversion = 0.

<u>b) Changes of carbon stock in mineral soils of grassland converted to perennial cropland:</u>

According to IPCC GPG (Tier 1), annual change in carbon stock of mineral soils of grassland converted to perennial cropland = ΔSOC * conversion area, where :

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -2.45\ t\ C/ha * yr.$$

SOC_0 = soil organic carbon stock in the inventory year (t C/ha) according to § 7.3.1.2 point c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according to § 7.3.1.2 point c).

7.3.2.4 N_2O emissions in soils of land converted to cropland

The annual release of N_2O due to the conversion of grassland to cropland was calculated with IPCC default value (Tier 1) using equations 3.3.14 and 3.3.15 of the IPCC GPG (2003) :

$$N_2O_{net\text{-}min}\text{-}N = EF_1 * \Delta C_{LCmineral} * 1/(C/N\ ratio)$$

where:

EF_1 = IPCC default emission factor = 0.0125 kg N_2O-N/kgN.

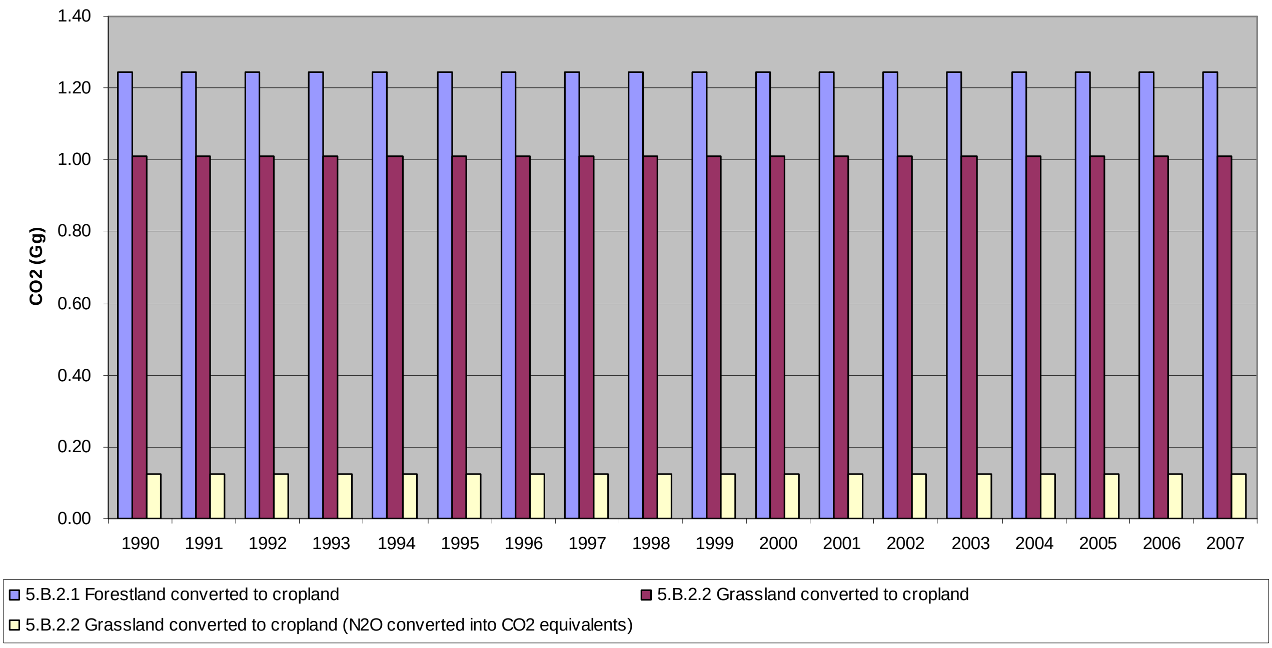
$\Delta C_{LCmineral}$ = change in carbon stock in mineral soils in grassland converted to cropland (cf § 7.3.2.2 point d) and § 0 point b) above).

C/N ratio = ratio by mass of C to N in the soil organic matter = 10/12.

7.3.2.5 Results

Figure 7-5 shows the annual removals of CO_2 due to cropland and grassland conversion into forestland.

Figure 7-5 – Annual emissions of CO_2 for IPCC Sub-category 5B2 – Land Use Cahnges to Cropland



7.4 Grassland (5C)

In this category emissions/removals from grassland management are considered.

7.4.1 Grassland remaining Grassland (5C1)

7.4.1.1 Activity Data

The activity data are described in § 7.1.2.

7.4.1.2 Emission Factors

a) Changes in carbon stock in biomass of grassland remaining grassland:
As the biomass of grassland is harvested every year, there is no long term carbon storage in biomass of grassland remaining grassland.

b) Changes in carbon stock in mineral soils of grassland remaining grassland:
The formula used to calculate the change in carbon stock in mineral soils of grassland is the same as for cropland: equation 3.3.4 of GPG (2003).

As for cropland, according to expert judgment, there was no change in relative stock change factors (tillage factor FMG; land use factor FLU; input factor FI) during the observation period 1990 to 2007 and these factors are set by default equal to 1. Thus, there was no change in carbon stocks in grassland soils due to management.

7.4.1.3 Results

There are no emissions nor removals in IPPC Sub-category *5C1 - Grassland remaining Grassland*, due to the fact that the biomass of grassland remaining grassland is harvested every year, and that there is no change in carbon stocks in grassland soils due to management (expert judgement).

7.4.2 Land Use Changes to Grassland (5C2)

7.4.2.1 Activity Data

The activity data are described in § 7.1.2. The LUC areas are kept for 20 years in the related LUC categories before the move into the related "remaining" category.

7.4.2.2 Emission Factors

The method follows the IPCC GPG with a transition period of 20 years for LUC areas and related estimates for the increases and decreases of biomass and soil C stocks. Growth rates for annual crops (annual cropland, grassland) are accounted only once in the year of LUC, while growth rates for perennial crops (perennial cropland, forest land) are accounted for the whole period of transition. In line with the IPCC GPG, a linear soil C stock change due to the LUCs between the average soil C stocks across 20 years was estimated.

<u>a) Changes in carbon stock in biomass of forest land converted to grassland:</u>
For the calculation of annual change in carbon stocks of living biomass of forest land converted to grassland the IPCC GPG Tier 1 method equation 3.3.8 was applied:

$$\textit{Annual change in carbon stock in biomass} = \textit{annual area of converted land} * (L_{conversion} + \Delta C_{growth})$$

where :

$L_{conversion} = C_{after} - C_{before}$

ΔC_{growth} = IPCC default value for annual crops carbon accumulation rate is 6.8 t C ha^{-1} yr^{-1}.

C_{before} = country specific value for carbon stock of forestland biomass before conversion is 124.96 t C ha^{-1}.

C_{after} = carbon stock immediately after conversion = 0.

<u>b) Changes in carbon stock in biomass of annual cropland converted to grassland:</u>
For the calculation of annual change in carbon stocks of living biomass of annual cropland converted to grassland the IPCC GPG Tier 1 method equation 3.3.8 was applied:

$$\textit{Annual change in carbon stock in biomass} = \textit{annual area of converted land} * (L_{conversion} + \Delta C_{growth})$$

where :

$L_{conversion} = C_{after} - C_{before}$

ΔC_{growth} = IPCC default value for grassland carbon accumulation rate is 6.8 t C ha^{-1} yr^{-1}.

C_{before} = IPCC default value for carbon stock of annual cropland biomass before conversion is 5.0 t C ha^{-1}.

C_{after} = carbon stock immediately after conversion = 0.

c) Changes in carbon stock in biomass of perennial cropland converted to grassland:

For the calculation of annual change in carbon stocks of living biomass of perennial cropland converted to grassland the IPCC GPG Tier 1 method equation 3.3.8 was applied:

$$\textit{Annual change in carbon stock in biomass} = \textit{annual area of converted land} * (L_{conversion} + \Delta C_{growth})$$

where :

$L_{conversion} = C_{after} - C_{before}$

ΔC_{growth} = IPCC default value for grassland carbon accumulation rate is 6.8 t C ha^{-1} yr^{-1}.

C_{before} = IPCC default value for carbon stock of perennial cropland biomass before conversion is 63 t C ha^{-1}.

C_{after} = carbon stock immediately after conversion = 0.

d) Changes in carbon stock in mineral soil of forest land converted to grassland:

According to IPCC GPG (Tier 1), annual change in carbon stock of mineral soils of forestland converted to grassland = ΔSOC * conversion area, where :

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = 0.35 \ t \ C/ha * yr.$$

SOC_0 = soil organic carbon stock in the inventory year (t C/ha).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha).

e) Changes in carbon stock in mineral soil of annual cropland converted to grassland:

According to IPCC GPG (Tier 1), annual change in carbon stock of mineral soils of annual cropland converted to grassland = ΔSOC * conversion area, where :

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = 0.75 \ t \ C/ha * yr.$$

SOC_0 = soil organic carbon stock in the inventory year (t C/ha) according to § 7.3.1.2 point c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according to § 7.3.1.2 point c).

f) Changes in carbon stock in mineral soil of perennial cropland converted to grassland:

According to IPCC GPG (Tier 1), annual change in carbon stock of mineral soils of perrenial cropland converted to grassland = ΔSOC * conversion area, where :

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = 2.45 \ t \ C/ha * yr.$$

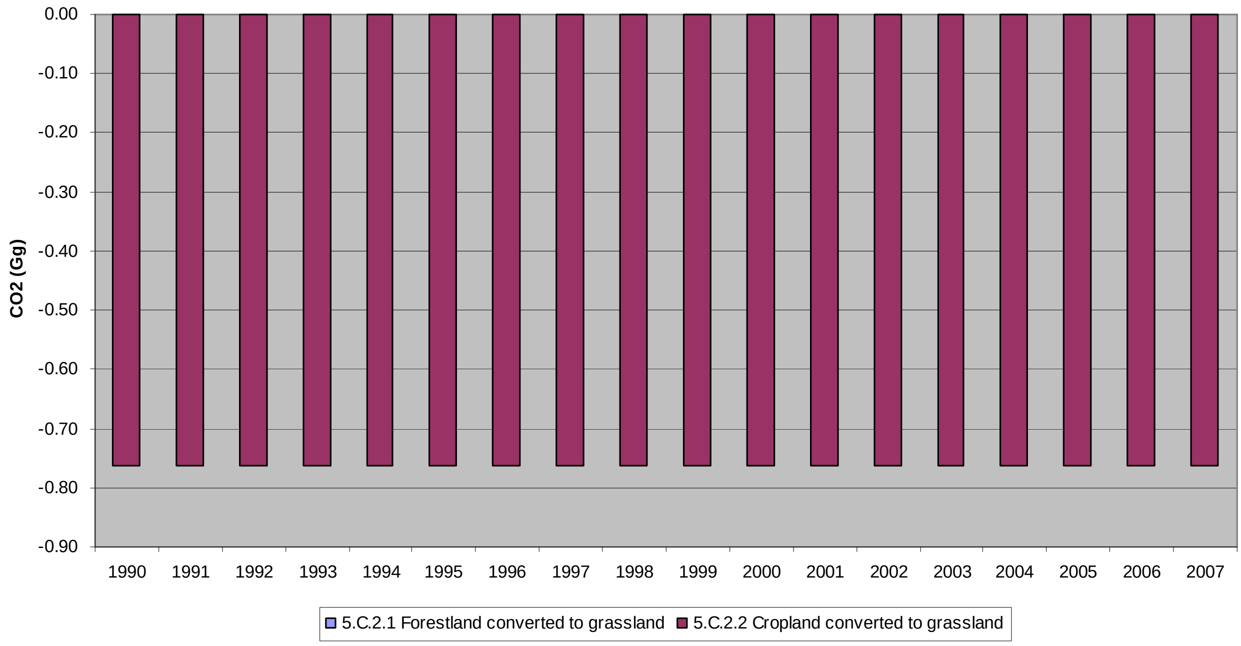
SOC_0 = soil organic carbon stock in the inventory year (t C/ha) according to § 7.3.1.2 point c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according to § 7.3.1.2 point c).

7.4.2.3 Results

Figure 7-6 shows the annual removals of CO_2 due to land converted to grassland.

Figure 7-6 - Annual removals of CO2 for IPCC Sub-category 5C2 - Land Use Changes to Grassland



7.5 Wetlands (5D)

In this category emissions/removals from wetlands are considered.

7.5.1 Activity Data

The activity data are described in § 7.1.2.

7.5.2 Wetlands remaining Wetlands (5D1)

Due to a lack of required data, this category has not yet been estimated.

7.5.3 Land Use Changes to Wetlands (5D2)

Based on expert judgment, it is assumed that no conversion occurs from forest land, cropland, grassland, settlements or other land to wetlands in Luxembourg.

7.6 Settlements (5E)

In this category emissions/removals from settlements are considered.

7.6.1 Activity Data

The activity data are described in § 7.1.2.

7.6.2 Settlements remaining Settlements (5E1)

Due to a lack of data, this category has not yet been estimated.

7.6.3 Land Use Changes to Settlements (5E2)

Based on expert judgment, it is assumed that no conversion occurs from wetlands or other land to settlements in Luxembourg. The conversion areas are mainly from forest land, cropland and grass land. However, due to a lack of required data, this category has not yet been estimated.

7.7 Other Land (5F)

In this category emissions/removals from other land are considered.

7.7.1 Activity Data

The activity data are described in § 7.1.2.

7.7.2 Other Land remaining Other Land (5F1)

Due to a lack of data, this category has not yet been estimated.

7.7.3 Land Use Changes to Other Land (5F2)

Based on expert judgment, it is assumed that no conversion occurs from forest land, cropland, grassland, or wetlands to other land in Luxembourg. The conversion areas are mainly from settlements. However, due to a lack of required data, this category has not yet been estimated.

7.8 QA/QC Verification

Consistency and completeness checks have been performed using the tools embedded in CRF Reporter.

7.9 Recalculations

Table 7-8 presents the main revisions and recalculations done since submission 2008v1.2 relevant to CRF Sector 5.

Table 7-8 – Changes in GHG inventories: submissions 2008v1.2 and 2009v1.4

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
5G	emissions and removals were reallocated to categories 5A to 5F due to new activity data	category reallocation
5A-5F	revised activity data using Corine Land Cover	revised activity data
5A-5C	revised methodologies and emission factors according to IPCC GPG LULUCF and using country specific data	revised methodology revised EFs

7.10 Planned Improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented Table 7-9 will be explored.

Table 7-9 – Planned improvements for IPCC Sector 5 – LULUCF

GHG source & sink category	Planned improvement
5A-5F	update of land use and lad use change data using more detailed data based on aerial imagery (OBS) than Corine Land Cover
5A	include data from the GSE Forest Monitoring Study[147]
5D-5F	investigate whether the required data is available for the estimation of emissions and removals of these sub-categories.

More details are given below:

LU and LUC monitoring:

Luxembourg has developed a database called "Occupation biophysique du sol (OBS)" which is compliant with CORINE LC. The dataset is based on aerial imagery and some field survey. It is available at the reference scale of 1/20000 which is much more detailed than CORINE LC.

This database extends the hierarchical nomenclature of CLC by two more levels and many more categories. At this point of time it is only available for the year 1999.

Actually an update of this database is carried out based on IKONOS Satellite imagery from the year 2008. The final version of this update should be available by autumn 2009. For the extrapola-

147 see NIR 2008, Annex IV

tion and the assessment of the land uses and land use changes into the years before 1999 a survey in 1962 using the same land use categories as OBS and based on aerial photographs for 25 % of Luxemburg will be available.

This will allow a much more detailed and accurate land use and land use change monitoring in the next submission.

Forestland:

A study for a comprehensive revision of the activity data and methodology for estimating emissions and removals in category *5A - Forestland* is commissioned and the first results are due in 2009.

This study covers the following tasks:

- support to National UNFCCC and Kyoto Protocol reporting on LULUCF activities:

  the national GHG reporting by providing statistics on land use and land use change, forest area and forest area change (afforestation, reforestation and deforestation) based on relevant maps derived using EO data and auxiliary information for the reference years 1990, 2000 and 2007;

- forest information update:

  the updating of the forest information data and basic forest typologies (provision of forest type maps and forest type change maps) especially important for areas where forest management information is not available (e.g. private forests) for the reference years 1990, 2000 and 2007;

- support to Environmental Monitoring:

  environmental monitoring towards nature conservation policy by provision of fragmentation indices based on relevant maps derived using EO data for the reference years 1990, 2000 & 2007; and

- detecting and monitoring of Forest operations and disturbances:

  monitoring of management operations, i.e. clear cutting, by provision of a clear cut map based on land cover maps of 2004 & 2007.

8 Waste (CRF Sector 6)

8.1 Sector Overview

Chapter 8 includes information on and description of methodologies used for estimating GHG emissions as well as references to activity data and emission factors reported under CRF Sector 6 – Waste for the period 1990 to 2007.

Emissions from this sector comprise emissions for the main four categories: solid waste disposal on land (6A), wastewater handling (6B) and other (compost production) (6D). For more details on categories, where emissions are not occurring and categories that are not estimated or included elsewhere, see Table 8-2.

Waste incineration (6C) related GHG emissions are allocated to IPCC Sub-category *1A1a – Fuel Combustion Activities – Energy Industries – Public Electricity and Heat Production* (see Section 3.2.4) since energy is recovered and injected in the public electricity network from waste burned in the sole incinerator of the country.

8.1.1 Emission Trends

This section briefly describes the emission trends from 1990 to 2007 for each of the IPCC Categories under CRF Sector 6. For this analysis, IPCC Category *6C – Waste Incineration* is excluded since, as indicated above, it is entirely accounted for under IPCC Sub-category *1A1a – Fuel Combustion Activities – Energy Industries – Public Electricity and Heat Production*. Consequently, CRF table 6C reports IE for this category (see Table 8-2).

As shown in Table 8-1 – and in Figure 8-1 and Figure 8-2, that provide a quick overview on waste and wastewater handling related emission trends between 1990 and 2007 and Figure 8-3 depicting the shares of each IPCC Category under CRF Sector 6 for both the years 1990 and 2007– total waste related GHG emissions have decreased by 12.9% (-33.5% for methane but +106.2% for nitrous oxide). This evolution was mainly driven by the fact that, for IPCC Category *6A – Solid Waste Disposal on Land*, methane emissions have been reduced by 47.8% between 1990 and 2007 due to:

- a decrease in the quantity of waste being landfilled, notably through the development of recycling schemes and the expansion of both the numbers of and the various waste categories collected by recycling centres;
- the aerobic pre-treatment before landfilling;
- the recent installation of methane recovery systems at waste dumping sites.

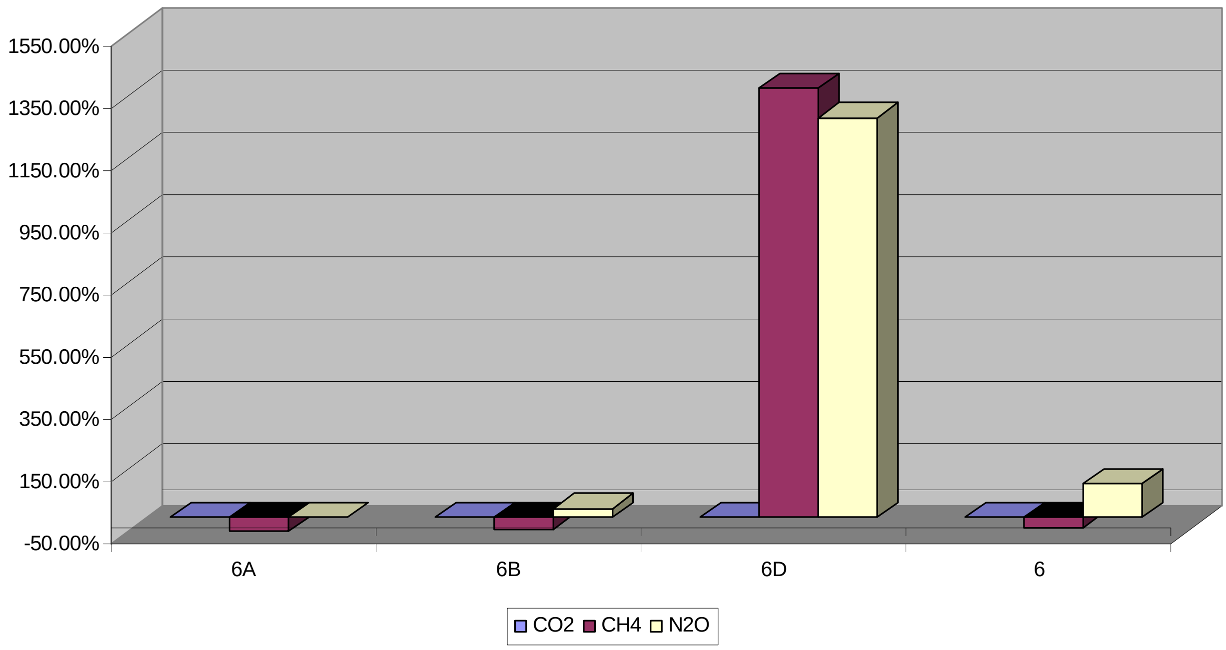
For IPCC category *6B – Wastewater Handling*, nearly identical emissions were observed in 2007 as in the base year (1990). For category *6D – Other – Compost Production*, unlike IPCC Category 6A, an increase of emissions is recorded for the years 1990 to 2007.

Wastewater treatment plant (*WWTP*) capacities expressed in population-equivalents have steadily grown since 1990 (see Section 8.3.2). This justifies, but only partly, the increasing N_2O emissions for this source category. Indeed, WWTP capacities grew by some 71.8% (Table 8-12) over the period 1990 to 2007[148], whereas nitrous oxide emissions, as shown in Table 8-1, increased by 26.2%. Therefore, technical changes, with regard to wastewater treatment, have an unquestionable role too, as the evolution of methane emissions (-39.7%) demonstrates.

With regard to compost production, this activity started on an "industrial scale" only in the early 1990s. This accelerated development, from 1993-2003[149] explains the very high, and therefore not really exploitable, percentage growths observed for both CH_4 and N_2O.

More details and explanations are also presented in the subsequent sections detailing each of the sector source categories.

Figure 8-1 – GHG emission trends in % for CRF Sector 6 – Waste: 1990-2007



148 This increase is notably explained by the significant population growth – some 26% between 1990 and 2007 - and by the increasing number of commuters who are crossing the border every working days (see Section 2.1.1.1 in Chapter 2). Percentage growths recorded for these two variables are, as well, largely above the one estimated for N_2O emissions from WWTP.

149 It stabilized since 2003 (see Section 8.5.2).

Table 8-1 - GHG emission trends in CO_2 eq for CRF Sector 6 – Waste: 1990-2007

6 - Waste

CO_2 eq emissions (Gg) by source & sink category

Year	*6A - Solid Waste Disposal on Land*				*6B - Waste Water Handling*				*6D - Other - Compost Production*				*6 - Waste*			
	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O
1990	47.87	*NA,NO*	*47.87*	*NA*	15.47	*NA*	*6.13*	*9.34*	0.00	*NO*	*NO*	*NO*	63.34	*NA,NO*	*54.00*	*9.34*
1991	46.18	*NA,NO*	*46.18*	*NA*	15.49	*NA*	*5.98*	*9.51*	0.00	*NO*	*NO*	*NO*	61.67	*NA,NO*	*52.16*	*9.51*
1992	44.56	*NA,NO*	*44.56*	*NA*	15.51	*NA*	*5.82*	*9.69*	0.00	*NO*	*NO*	*NO*	60.07	*NA,NO*	*50.38*	*9.69*
1993	43.08	*NA,NO*	*43.08*	*NA*	15.64	*NA*	*5.67*	*9.97*	1.03	*NO*	*0.49*	*0.54*	59.74	*NA,NO*	*49.24*	*10.51*
1994	41.53	*NA,NO*	*41.53*	*NA*	15.77	*NA*	*5.52*	*10.25*	1.19	*NO*	*0.57*	*0.63*	58.49	*NA,NO*	*47.62*	*10.88*
1995	40.24	*NA,NO*	*40.24*	*NA*	15.57	*NA*	*5.36*	*10.21*	1.49	*NO*	*0.71*	*0.78*	57.30	*NA,NO*	*46.31*	*10.99*
1996	39.92	*NA,NO*	*39.92*	*NA*	14.75	*NA*	*5.18*	*9.57*	1.30	*NO*	*0.62*	*0.68*	55.97	*NA,NO*	*45.71*	*10.26*
1997	38.94	*NA,NO*	*38.94*	*NA*	14.75	*NA*	*4.99*	*9.76*	2.85	*NO*	*1.35*	*1.50*	56.53	*NA,NO*	*45.28*	*11.25*
1998	37.96	*NA,NO*	*37.96*	*NA*	14.92	*NA*	*4.81*	*10.11*	4.72	*NO*	*2.24*	*2.48*	57.60	*NA,NO*	*45.00*	*12.59*
1999	36.71	*NA,NO*	*36.71*	*NA*	15.04	*NA*	*4.62*	*10.42*	4.91	*NO*	*2.33*	*2.58*	56.66	*NA,NO*	*43.66*	*13.00*
2000	36.95	*NA,NO*	*36.95*	*NA*	15.27	*NA*	*4.43*	*10.84*	9.11	*NO*	*4.46*	*4.64*	61.32	*NA,NO*	*45.84*	*15.48*
2001	31.71	*NA,NO*	*31.71*	*NA*	15.48	*NA*	*4.31*	*11.17*	8.50	*NO*	*4.17*	*4.33*	55.69	*NA,NO*	*40.19*	*15.50*
2002	26.82	*NA,NO*	*26.82*	*NA*	14.28	*NA*	*4.18*	*10.10*	10.32	*NO*	*5.10*	*5.23*	51.42	*NA,NO*	*36.09*	*15.33*
2003	26.71	*NA,NO*	*26.71*	*NA*	14.29	*NA*	*4.05*	*10.24*	13.19	*NO*	*6.47*	*6.72*	54.19	*NA,NO*	*37.23*	*16.96*
2004	25.67	*NA,NO*	*25.67*	*NA*	14.97	*NA*	*3.92*	*11.05*	12.88	*NO*	*6.32*	*6.56*	53.52	*NA,NO*	*35.91*	*17.61*
2005	25.63	*NA,NO*	*25.63*	*NA*	14.97	*NA*	*3.77*	*11.20*	13.75	*NO*	*6.75*	*7.00*	54.36	*NA,NO*	*36.15*	*18.20*
2006	25.50	*NA,NO*	*25.50*	*NA*	15.20	*NA*	*3.71*	*11.49*	15.44	*NO*	*7.62*	*7.82*	56.14	*NA,NO*	*36.84*	*19.30*
2007	24.98	*NA,NO*	*24.98*	*NA*	15.48	*NA*	*3.70*	*11.79*	14.68	*NO*	*7.21*	*7.47*	55.14	*NA,NO*	*35.89*	*19.25*
Trend 1990-2007	*-47.81%*	*NA*	*-47.81%*	*NA*	*0.11%*	*NA*	*-39.69%*	*26.24%*	*NA*	*NA*	*1378.43%*	*1283.25%*	*-12.94%*	*NA*	*-33.54%*	*106.22%*

Source: Environment Agency

Notes: CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

N_2O emissions are converted in CO_2e by multiplying the emissions by 310, i.e. the global warming potential (*GWP*) value for nitrous oxide based on the effects of GHG over a 100-year time horizon.

Figure 8-2 – GHG emission trends – indexes – for CRF Sector 6 – Waste: 1990-2007

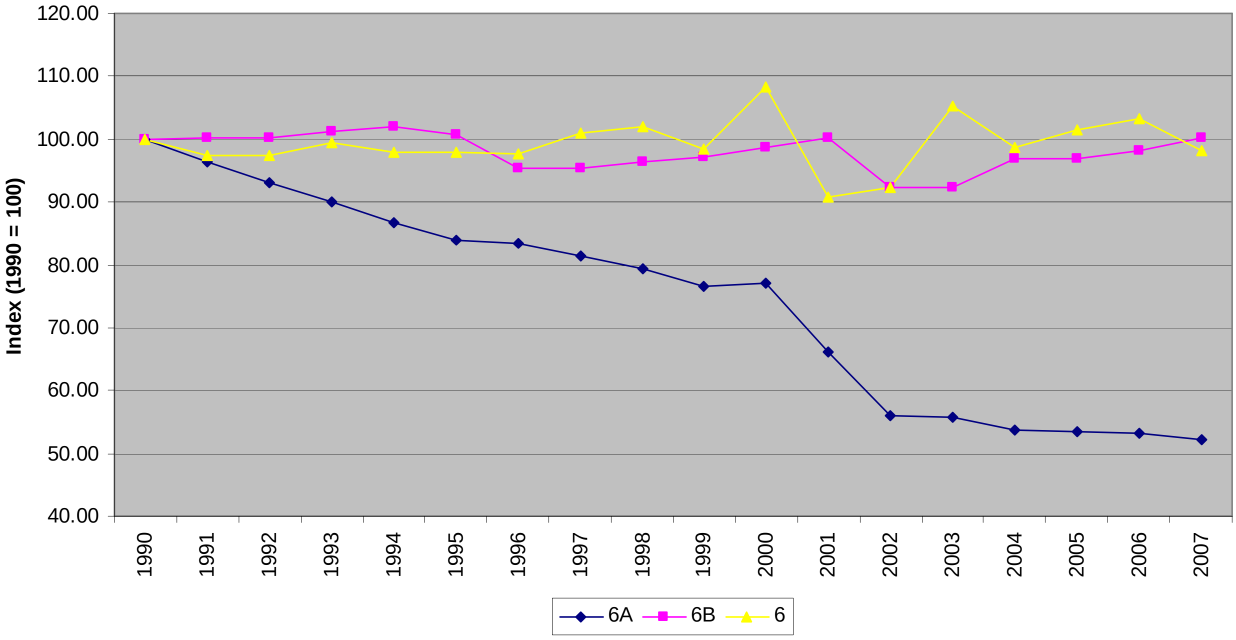
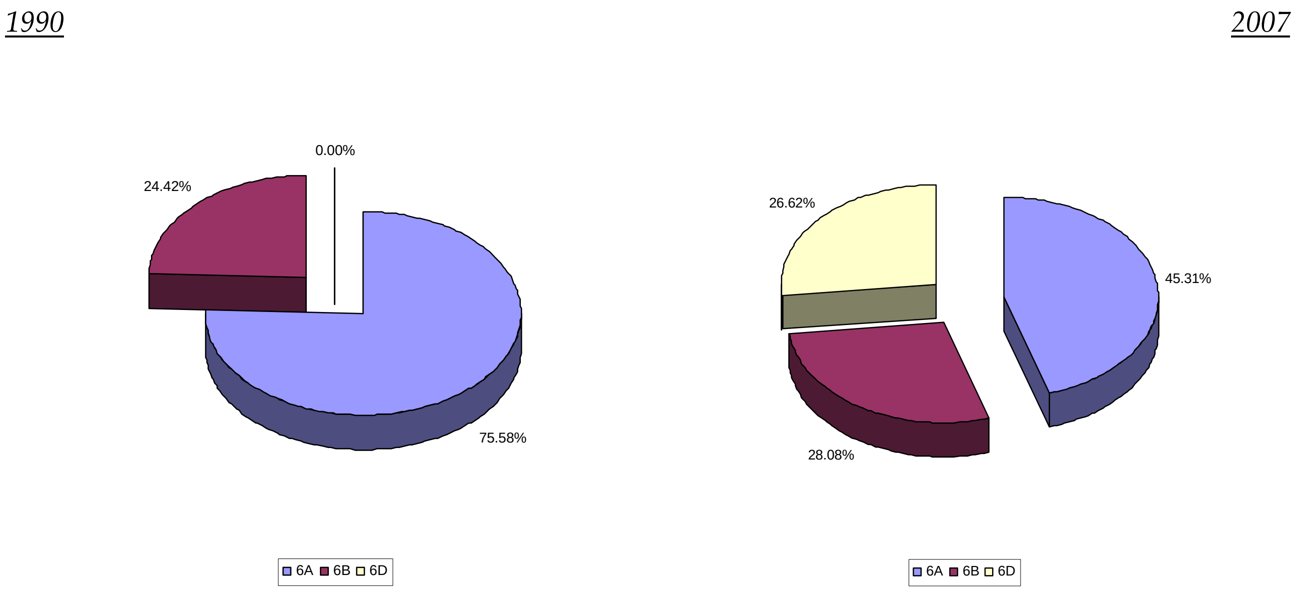


Figure 8-3 – IPCC Categories weights for CRF Sector 6 – Waste: 1990 and 2007



8.1.2 Completeness

Table 8-2 gives an overview of the IPCC categories included under CRF Sector 6 and provides information on the status of emission estimates of all subcategories.

Table 8-2 - Overview of subcategories of CRF Sector 6 – Waste: status of emission estimates for CO_2, CH_4 and N_2O

GHG source & sink category	Description	Status		
		CO_2	CH_4	N_2O
6A1	solid waste disposal on land – managed waste disposal on land	NO	X	
6A2	solid waste disposal on land – unmanaged waste disposal sites	NO	NO	
6A3	solid waste disposal on land - other	NA	NA	
6B1	wastewater handling – industrial wastewater		NA	X
6B2	wastewater handling – domestic & commercial wastewater		X	X
6B3	wastewater handling – other		NA	NA
6C	waste incineration	IE *	IE *	IE *
6D	other – compost production	NO	NO (1990-1992) X (1993-2007)	NO (1990-1992) X (1993-2007)

Note: **X** indicates that emissions from this sub-category have been estimated, the grey shaded cells are those also shaded in the CRF tables.

* = waste incineration is recorded under CRF Sub-category 1A1a since electricity is produced from incinerated municipal waste residues.

8.1.3 Recalculations

Table 8-3 presents the main revisions and recalculations done after the ICR of October 2008 relevant to CRF Sector 6.

Table 8-3 - Changes in GHG inventory between submissions 2008v1.2 and 2009v1.4

GHG source & sink category	Revisions 2008v1.2 ➔ 2009v1.4	Type of revision
6A1	- Incorporation of activity data from SIDA dumping site (closed down in January 1994) and emission estimation according to IPCC Tier 2 methodology. - Emission estimation from the closed industrial waste landfill (Ronnebierg) according to on site measurements ("Bericht zu Deponienachsorge (2000-2007)")	- refinement
6B1	Wastewater handling: N_2O emission estimation of industrial waste water (was NE in submission 2008v1.2)	- new source category
6D	Composting : corrected global warming potential	- refinement

8.2 Solid Waste Disposal on Land (6A)

This section describes the estimation of methane emissions resulting from solid waste disposal on land (*SWDL*). In 2007, this source category was responsible for 69.6% of waste treatment methane related emissions – excluding waste incineration – and for 5.5% of the total methane emissions estimated for Luxembourg (10.3% in 1990). It represented 0.2% of the total GHG emissions (excluding LULUCF) (0.4% in 1990). The emissions, from the closed landfill site for industrial waste according to data from the annual analyse reports since 2000, have been included in this category. No CO_2, nor N_2O emissions are occurring in this category.

8.2.1 Key source

None of the source categories under SWDL is a key source.

8.2.2 Source category description

IPCC Category 6A covers waste disposal on land – or landfilled waste – whether generated by households or enterprises. For the moment, Luxembourg's GHG inventory covers only municipal waste disposal on land. Municipal waste consists of waste collected from households as well as refuses similar to households waste generated by small industrial enterprises, retail shops and services (private or institutional). In other words, municipal waste corresponds to the totality of waste collected by municipalities.[150]

Municipal waste is partly landfilled – i.e. solid waste to be accounted for under IPCC Category 6A –, partly incinerated – i.e. solid waste to be accounted for under IPCC Category 1A1a as energy is recovered from incineration – and partly recycled or recovered. For the latter, door to door collections of selected refuses (paper and cardboard, packaging (plastic bottles, cans & Tetra-Pack®), garden waste, etc.), recycling centres and/or on-street specific waste containers where selected waste can be dumped, exist.

In Luxembourg, the collection of municipal waste falls within the competence of municipal waste management associations. These associations are:

- SIDEC[151] = association for the management of household and similar to household waste for the municipalities of the regions Diekirch, Ettelbruck and Colmar-Berg;
- SIDOR[152] = association for the management of household and similar to household waste for the municipalities of the districts Luxembourg, Esch-sur-Alzette and Capellen;
- SIGRE[153] = association for the management of household and similar to household waste for the municipalities of the regions Grevenmacher, Remich and Echternach;
- SIDA[154] = association for the management of household and similar to household waste for the municipalities of the region Wiltz and other regions of the north of the country.

All these associations existed in 1990 and managed their own dumping or incineration site. In 1994, however, SIDA was merged with SIDEC and its dumping site closed down. Hence, nowadays, there are two controlled landfill sites (one managed by SIDEC and one managed by SIGRE) and

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150 For details on municipal waste collection, see:
http://www.environnement.public.lu/dechets/statistiques_indicateurs/LUXUS_Daten/index.html (in German)
http://www.environnement.public.lu/dechets/statistiques_indicateurs/index.html, line "*Activité des parcs à conteneurs (recycling centres)*" (in French).

151 *Syndicat Intercommunal pour la gestion des Déchets from households en provenance des ménages et des déchets assimilables des communes de la région de Diekirch, Ettelbruck et Colmar-Berg*.

152 *Syndicat Intercommunal pour la gestion des déchets en provenance des ménages et des déchets assimilables des communes des cantons de Luxembourg, d'Esch-sur-Alzette et de Capellen*.

153 *Syndicat Intercommunal pour la collecte, l'évacuation et l'élimination des ordures provenant des communes de la région de Grevenmacher, Remich et Echternach*.

154 *Syndicat de Communes pour la collecte, l'évacuation et l'élimination des ordures provenant des communes de la région de Wiltz et du nord du pays*.

one incinerator (managed by SIDOR) for the whole country of Luxembourg. As underlined above, the activities and emissions related to the SIDOR incinerator are dealt with under IPCC Sub-category 1A1a – Public Electricity and Heat Production.

At the SIGRE site, a methane recovery system is operated since 2000, and, since 2002, at the SIDEC site. The aerobic pre-treatment in heaps at SIGRE is made since 1993. The biological treatment in tunnels at SIDEC is fully operational since 2008.

Table 8-4 summarizes the situation for each waste management association.

Table 8-4 – Municipal solid waste management in Luxembourg

Association	Waste elimination scheme	Operating years with regard to the GHG inventory
SIDEC	landfill	1990-2007
SIDOR	incineration	1990-2007
SIGRE	landfill	1990-2007
SIDA	landfill	1990-1993

Source: Environment Agency.

To summarize:

- IPCC Category 6A covers methane emissions from managed waste disposal on land. No CO_2 emissions derived from non-biological or inorganic waste sources have been identified so far;
- only managed waste disposal on land is relevant for Luxembourg. There are no unmanaged or other waste disposal sites (➔ IPCC Category 6A = IPCC Sub-category 6A1);
- municipal waste from households or similar to households waste are accounted for in the inventory. The emissions of the closed industrial waste disposal on land site (Ronnebierg) are estimated for the period 2000 to 2007 .[155]

8.2.3 Methodological issues

The Revised 1996 IPCC Guidelines outline two methods to estimate CH_4 emissions from solid waste disposal sites, the default method (Tier 1) and the First Order Decay (*FOD*) method (Tier 2).

The main difference between the two methods is that the FOD approach produces a time-dependent emission profile that better reflects the true pattern of the degradation process over time, whereas the default method is based on the assumption that all potential CH_4 is released in the year the waste is disposed of.

155 Today, there are no landfill sites for purely industrial waste in Luxembourg. However, one site existed in the past and it has been closed down in the early 1990s (Ronnebierg site).

It is good practice to use the FOD method, if possible, because it more accurately reflects emission trends. The use of the FOD method requires current, as well as historic, data on waste quantities, composition and disposal practices for several decades. It is good practice to estimate this historical data, if unavailable, when waste disposal on land is a key source category or if there have been significant changes in waste management practices.

The IPCC Guidelines do not provide default values or methods for the estimation of some key parameters needed to use the FOD method. These data are very dependent on country-specific conditions, and currently there are not enough data available to give reliable default values or methods for them.

Nevertheless, a Tier 2 method has been used for estimating SWDL related methane emissions. It relies on a detailed study on the methane generation from managed municipal waste disposal on land that has been completed in 2006 for the Environment Agency [Strauss, 2006].

8.2.3.1 Activity data

Table 8-5 summarizes the quantities of waste that have been landfilled in Luxembourg. This data was prepared by the Environment Agency and is officially published by STATEC.

The relatively high figures for waste generation rate per capita is explained by the fact that, every working day, more than 140 000 commuters (i.e. around a quarter of the resident population) are crossing Luxembourg's borders to come to work (see Section 2.1.1.1 in Chapter 2). They, of course, generate important quantities of waste that are then divided by the resident population when estimating per capita figures.

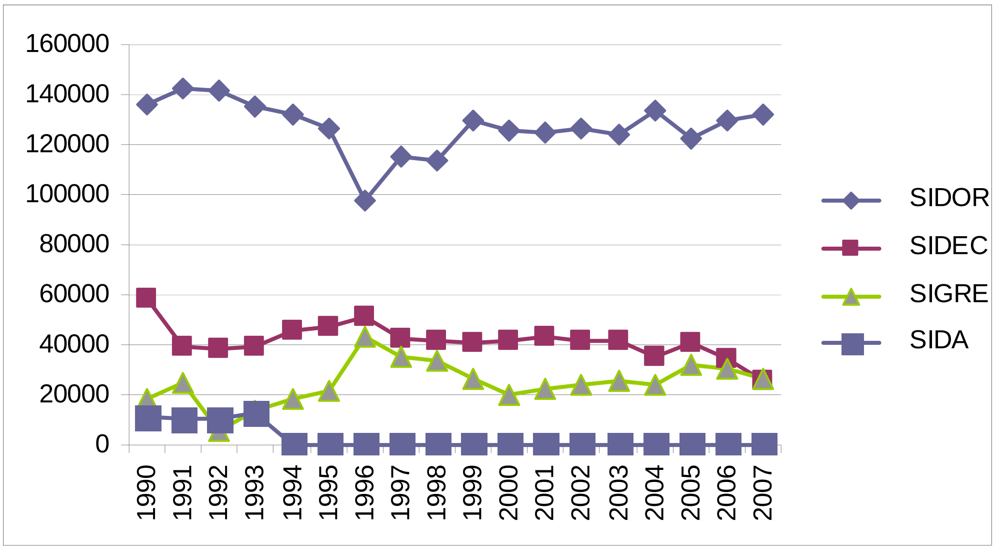
Table 8-5 - Solid waste disposed on land (1990 - 2007)

6A - Solid Waste Disposal on Land *Activity Data - Trend by landfill site*							
Year	Total MSW *tonnes*	SIDEC *tonnes*	SIGRE *tonnes*	SIDA *tonnes*	Ronnebierg *tonnes*	Population *#*	SWDL/capita *kg/hab.*
1990	87 634	*58 234*	*18 400*	*11 000*	*NO*	*384 400*	*227.98*
1991	71 540	*36 340*	*24 600*	*10 600*	*NO*	*389 600*	*183.62*
1992	53 672	*38 111*	*5 461*	*10 100*	*NO*	*394 800*	*135.95*
1993	66 029	*39 259*	*13 712*	*13 058*	*NO*	*400 200*	*164.99*
1994	64 074	*45 526*	*18 548*	*NO*	*NO*	*405 700*	*157.93*
1995	68 670	*47 309*	*21 361*	*NO*	*NO*	*411 600*	*166.84*
1996	94 064	*51 021*	*43 043*	*NO*	*NO*	*416 900*	*225.63*
1997	77 023	*42 019*	*35 004*	*NO*	*NO*	*422 100*	*182.48*
1998	75 737	*41 898*	*33 839*	*NO*	*NO*	*427 400*	*177.20*
1999	67 117	*40 547*	*26 570*	*NO*	*NO*	*433 600*	*154.79*
2000	61 728	*41 600*	*20 128*	*NO*	*NO*	*439 000*	*140.61*
2001	65 118	*43 022*	*22 096*	*NO*	*NO*	*444 000*	*146.66*
2002	65 952	*41 780*	*24 172*	*NO*	*NO*	*448 300*	*147.12*
2003	67 327	*41 453*	*25 874*	*NO*	*NO*	*455 000*	*147.97*
2004	59 459	*35 535*	*23 924*	*NO*	*NO*	*461 200*	*128.92*
2005	72 738	*40 491*	*32 247*	*NO*	*NO*	*469 100*	*155.06*
2006	64 528	*34 362*	*30 166*	*NO*	*NO*	*476 200*	*135.51*
2007	52 268	*25 839*	*26 429*	*NO*	*NO*	*483 800*	*108.04*
Trend 1990-2007	*-40.36%*	*-55.63%*	*43.64%*	*NA*	*NA*	*25.86%*	*-52.61%*

Sources: STATEC, *Statistical Yearbook*, Table B.1100: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=1058
STATEC, *Statistical Yearbook*, Table A.3300: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=1036

The sharp increase of solid waste disposed at the SIGRE site and to a smaller extend at the SIDEC site in the year 1996 can be explained by a sharp decrease of waste incinerated at the SIDOR incineration site (shut-down for 3 months) due to a fire.[156] This strong relationship between waste incineration and SWDL is illustrated in Figure 8-4 below.

Figure 8-4 - Relationship between waste incineration and waste disposal on land.



8.2.3.2 Emission factors

Emission factors (EFs) for SWDL related methane emissions are actually IEFs obtained by applying the Tier 2 FOD method.

As indicated in the 2000 IPCC-GPG, "*The FOD method can be expressed equivalently by equation 5.1 and equation 5.2 below. Equation 5.1 is based on the derivative of the general FOD equation (see p 6.10, Revised 1996 IPCC Guidelines) with t replaced by t – x, representing a normalisation factor that corrects for the fact that the evaluation for a single year is a discrete time estimate rather than a continuous time estimate*".[157] These equations are:

➔ equation 5.1 of the 2000 IPCC-GPG:

$$CH_4 \text{ generated in year } t\ (Gg/yr) = \sum_x [(A * k * MSW_T(x) * MSW_F(x) * L_0(x)) * e^{-k(t-x)}]$$

which gives, when adding up the obtained results for all years (x):

➔ equation 5.2 of the 2000 IPCC-GPG:

156 De Journal, N.200, p.7, "SIDOR: Feiern in der Zeit des Umbruchs"

157 2000 IPCC-GPG, page 5.6.

$$CH_4 \text{ emitted in year } t \text{ (Gg/yr)} = [CH_4 \text{ generated in year } t - R(t)] * (1 - OX)$$

Table 8-6 recapitulates the various activity data, coefficients and parameters used to estimate SWDL methane emission using the Tier 2 FOD method.

Table 8-6 – Activity data, coefficients and parameters used for IPCC Category 6A – SWDL

Parameter	Description	Expressed as	Type and source of value
CH_4	methane emissions generated in year t	Gg/year	calculated by the Environment Agency (see Table 8-10)
x	initial year to t	-	-
t	year of inventory	-	14
A	normalisation factor which corrects the addition	$A = \frac{(1 - e^{-k})}{k}$	0.97565
k	methane generation rate constant[158]	$k = \frac{\ln 2}{t_{1/2}}$	0.5
$MSW_T(x)$	total municipal solid waste (*MSW*) generated in year x	Gg/year	AD (see Table 8-5)
$MSW_F(x)$	fraction of MSW disposed at solid waste disposal sites (*SWDS*) in year x	fraction	calculated by the Environment Agency (see Table 8-7 to Table 8-9)
$L_0(x)$	methane generation potential	$L_0(x) = MCF(x) \bullet DOC(x) \bullet DOC_F \bullet F \bullet \frac{16}{12}$ Gg CH_4/Gg waste	parameter (see 2000 IPCC-GPG, p. 5.6)
MCF(x)	methane correction factor in year x	fraction	1.0 (see table 5.1 – 2000 IPCC-GPG)
DOC (x)	degradable organic carbon (*DOC*) in year x	$DOC = (0.4 \bullet A) + (0.17 \bullet B) + (0.15 \bullet C) + (0.3 \bullet D)$ fraction in Gg C/Gg waste	parameter calculated by the Environment Agency (see Tables 8-8 to 8-10 and equation 5.4 – 2000 IPCC-GPG)
DOCF	fraction of DOC dissimilated	fraction	0.5 (see 2000 IPCC-GPG, p. 5.9)
F	fraction by volume of CH_4 in landfill gas	fraction	0.5 (see 2000 IPCC-GPG, p. 5.10)
16 / 12	conversion from C to CH_4	fraction	-
R	methane recovery	m^3 gaz/h	calculated by the Environment Agency (see Tables 8-8 to 8-10)
OX	oxidation factor	fraction	0.1 (see 2000 IPCC-GPG, p. 5.10)

Table 8-7 to Table 8-9 detail the values estimated for some of the parameters presented in Table 8-6: DOC, some fractions of MSW and methane recovery on SWDS for each of the 3 SWDS.

Table 8-7– Parameters: DOC, fractions and R – SIDEC: 1990-2007

Year of waste disposal	Degradable Organic Carbon (*DOC*) *%*	fraction x of MSW that is paper and textiles *A*	fraction y of MSW that is garden waste *B*	fraction w of MSW that is food waste *C*	fraction z of MSW that is wood or straw *D*	recovery (R) *m^3 gaz/h*
1990	14.61%	0.2190	0.0728	0.2912	0.0080	NO
1991	14.61%	0.2190	0.0728	0.2912	0.0080	NO
1992	14.61%	0.2190	0.0728	0.2912	0.0080	NO
1993	14.61%	0.2190	0.0728	0.2912	0.0080	NO
1994	14.61%	0.2190	0.0728	0.2912	0.0080	NO

158 If no data on types of waste are available, a k value of 0.05 (a half life of about 14 years) is suggested as a default value (see 2000 IPCC-GPG, page 5.10).

Year of waste disposal	Degradable Organic Carbon (*DOC*) %	fraction x of MSW that is paper and textiles *A*	fraction y of MSW that is garden waste *B*	fraction w of MSW that is food waste *C*	fraction z of MSW that is wood or straw *D*	recovery (R) *m^3 gaz/h*
1995	14.61%	0.2190	0.0728	0.2912	0.0080	NO
1996	14.61%	0.2190	0.0728	0.2912	0.0080	NO
1997	14.61%	0.2190	0.0728	0.2912	0.0080	NO
1998	14.61%	0.2190	0.0728	0.2912	0.0080	NO
1999	14.61%	0.2190	0.0728	0.2912	0.0080	NO
2000	14.66%	0.2110	0.0736	0.2576	0.0368	NO
2001	14.66%	0.2110	0.0736	0.2576	0.0368	NO
2002	14.66%	0.2110	0.0736	0.2576	0.0368	85
2003	14.66%	0.2110	0.0736	0.2576	0.0368	85
2004	15.83%	0.2772	0.0333	0.2609	0.0089	85
2005	15.83%	0.2772	0.0333	0.2609	0.0089	85
2006	15.83%	0.2772	0.0333	0.2609	0.0089	85
2007	15.83%	0.2772	0.0333	0.2609	0.0089	85

Source: Environment Agency.

Table 8-8 – Parameters: DOC, fractions and R – SIGRE: 1990-2007

Year of waste disposal	Degradable Organic Carbon (*DOC*) %	fraction x of MSW that is paper and textiles *A*	fraction y of MSW that is garden waste *B*	fraction w of MSW that is food waste *C*	fraction z of MSW that is wood or straw *D*	recovery (R) *m^3 gaz/h*
1990	14.61%	0.2190	0.0728	0.2912	0.0080	NO
1991	14.61%	0.2190	0.0728	0.2912	0.0080	NO
1992	11.33%	0.2190	0.0728	0.0728	0.0080	NO
1993	11.33%	0.2190	0.0728	0.0728	0.0080	NO
1994	11.33%	0.2190	0.0728	0.0728	0.0080	NO
1995	11.33%	0.2190	0.0728	0.0728	0.0080	NO
1996	11.33%	0.2190	0.0728	0.0728	0.0080	NO
1997	11.33%	0.2190	0.0728	0.0728	0.0080	NO
1998	11.33%	0.2190	0.0728	0.0728	0.0080	NO
1999	11.33%	0.2190	0.0728	0.0728	0.0080	NO
2000	11.76%	0.2110	0.0736	0.0644	0.0368	NO
2001	11.76%	0.2110	0.0736	0.0644	0.0368	70
2002	11.76%	0.2110	0.0736	0.0644	0.0368	50
2003	11.76%	0.2110	0.0736	0.0644	0.0368	30
2004	13.53%	0.2873	0.0417	0.0669	0.0108	30
2005	13.53%	0.2873	0.0417	0.0669	0.0108	30
2006	13.53%	0.2873	0.0417	0.0669	0.0108	30
2007	13.53%	0.2873	0.0417	0.0669	0.0108	30

Source: Environment Agency.

Table 8-9 – Parameters: DOC, fractions and R – SIDA: 1990-2007

Year of waste disposal	Degradable Organic Carbon (*DOC*) %	fraction x of MSW that is paper and textiles *A*	fraction y of MSW that is garden waste *B*	fraction w of MSW that is food waste *C*	fraction z of MSW that is wood or straw *D*	recovery (R) *m³ gaz/h*
1990	14.61%	0.219	0.0728	0.2912	0.008	NO
1991	14.61%	0.219	0.0728	0.2912	0.008	NO
1992	14.61%	0.219	0.0728	0.2912	0.008	NO
1993	14.61%	0.219	0.0728	0.2912	0.008	NO
1994	14.61%	0.219	0.0728	0.2912	0.008	NO
1995	14.61%	0.219	0.0728	0.2912	0.008	NO
1996	14.61%	0.219	0.0728	0.2912	0.008	NO
1997	14.61%	0.219	0.0728	0.2912	0.008	NO
1998	14.61%	0.219	0.0728	0.2912	0.008	NO
1999	14.61%	0.219	0.0728	0.2912	0.008	NO
2000	14.66%	0.211	0.0736	0.2576	0.0368	NO
2001	14.66%	0.211	0.0736	0.2576	0.0368	NO
2002	14.66%	0.211	0.0736	0.2576	0.0368	NO
2003	14.66%	0.211	0.0736	0.2576	0.0368	NO
2004	15.83%	0.2772	0.0333	0.2609	0.0089	NO
2005	15.83%	0.2772	0.0333	0.2609	0.0089	NO
2006	15.83%	0.2772	0.0333	0.2609	0.0089	NO
2007	15.83%	0.2772	0.0333	0.2609	0.0089	NO

Source: Environment Agency.

Table 8-10 details methane emissions generated by each of the solid waste disposal sites (including the closed down industrial disposal site - Ronnebierg), as well the implied emission factors derived from the Tier 2 methodology.

Table 8-10 - CH_4 emissions generated in year t: summary 1990-2007

6A - Solid Waste Disposal on Land											
	CH_4 - Emissions						*CH_4 - Recovery*				
Year	Total *Gg*	SIDEC *tonnes*	SIGRE *tonnes*	SIDA *tonnes*	Ronnebierg *tonnes*	IEF *kg/t MSW*	Total *Gg*	SIDEC *tonnes*	SIGRE *tonnes*	SIDA *tonnes*	Ronnebierg *tonnes*
1990	2.280	*1 000*	*380*	*900*	*NE*	*26.012*	NO	*0.000*	*0.000*	*NO*	*NO*
1991	2.199	*986*	*377*	*836*	*NE*	*30.739*	NO	*0.000*	*0.000*	*NO*	*NO*
1992	2.122	*977*	*370*	*775*	*NE*	*39.536*	NO	*0.000*	*0.000*	*NO*	*NO*
1993	2.051	*970*	*358*	*723*	*NE*	*31.068*	NO	*0.000*	*0.000*	*NO*	*NO*
1994	1.978	*977*	*355*	*646*	*NE*	*30.866*	NO	*0.000*	*0.000*	*NO*	*NO*
1995	1.916	*988*	*356*	*572*	*NE*	*27.903*	NO	*0.000*	*0.000*	*NO*	*NO*
1996	1.901	*1 006*	*393*	*502*	*NE*	*20.208*	NO	*0.000*	*0.000*	*NO*	*NO*
1997	1.854	*1 004*	*415*	*435*	*NE*	*24.072*	NO	*0.000*	*0.000*	*NO*	*NO*
1998	1.807	*1 002*	*434*	*372*	*NE*	*23.864*	NO	*0.000*	*0.000*	*NO*	*NO*
1999	1.748	*997*	*440*	*312*	*NE*	*26.047*	NO	*0.000*	*0.000*	*NO*	*NO*
2000	1.759	*995*	*436*	*254*	*74*	*28.501*	NO	*0.000*	*0.000*	*NO*	*NO*
2001	1.510	*996*	*255*	*200*	*59*	*23.188*	0.201	*0.000*	*200.712*	*NO*	*NO*
2002	1.277	*775*	*310*	*148*	*44*	*19.364*	0.387	*243.721*	*143.365*	*NO*	*NO*
2003	1.272	*772*	*368*	*98*	*33*	*18.889*	0.330	*243.721*	*86.019*	*NO*	*NO*
2004	1.222	*764*	*377*	*51*	*30*	*20.556*	0.330	*243.721*	*86.019*	*NO*	*NO*
2005	1.220	*751*	*401*	*38*	*31*	*16.779*	0.330	*243.721*	*86.019*	*NO*	*NO*
2006	1.214	*746*	*413*	*25*	*31*	*18.818*	0.330	*243.721*	*86.019*	*NO*	*NO*
2007	1.190	*720*	*437*	*14*	*19*	*22.761*	0.330	*243.721*	*86.019*	*NO*	*NO*
Trend 1990-2007	*-47.81%*	*-27.95%*	*14.77%*	*NA*	*NA*	*-12.50%*	*NA*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency

8.2.4 Recalculations

See Table 8-3 in Section 8.1.3.

8.2.5 Category specific QA/QC procedures

No category specific QA/QC procedures have been completed, only the tools embedded in CRF Reporter have been used.

8.2.6 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 8-11 will be explored.

Table 8-11 – Planned improvements for IPCC Category 6A – SWDL

GHG source & sink category	Planned improvement
6A - SWDL	Calculation of emissions from waste deposits since 1950 using the 2006 IPPC spreadsheet model
6A –SWDL	Review of the data as the Stauss study does contain non compliant data, using real data from gas recuperations, updated waste compositions in accordance to pre-treatment of waste before landfilling,

8.3 Wastewater Handling (6B)

This section describes the estimation of methane and nitrous oxide emissions resulting from wastewater handling (*WWH*). In 2007, this source category was responsible for 28.1% of the total GHG emissions from the waste sector – excluding waste incineration – and it represented 0.001% of the total GHG emissions in CO_2e (excluding LULUCF). For each of the two gases reported, in 2007:

- CH_4 represented 10.3% of waste treatment methane related emissions – excluding waste incineration – and 0.82% of the total methane emissions estimated for Luxembourg;
- N_2O represented 61.2% of waste treatment nitrous oxide related emissions – excluding waste incineration – and almost 2.24% of the total nitrous oxide emissions estimated for Luxembourg.

8.3.1 Key source

None of the source categories under WWH is a key source.

8.3.2 Source category description

IPCC Category 6B covers wastewater and related sludge handling, whether these have been generated by households or by industrial enterprises. For the moment, Luxembourg's GHG inventory covers domestic, commercial (Sub-category 6B2) and industrial (Sub-category 6B1) WWH, excluding sludge.

In addition, it is assumed that domestic and commercial WWH corresponds to municipal wastewater treatment carried out in wastewater treatment plants (*WWTPs*).

Table 8-12 shows the theoretical load that can be treated in municipal WWTPs since 1990. It also indicates the percentage of that load that is treated using aerobic procedures, i.e. in WWTPs applying a biological treatment to wastewater.

Table 8-12 – Municipal WWTP capacities and aerobic procedures: 1990-2007

Year	Load treated in municipal WWTP *1000 population-equivalents*	aerobic procedures *%*
1990	591.6	84%
1991	594.0	85%
1992	596.5	86%
1993	600.0	87%
1994	605.8	88%
1995	631.6	89%
1996	782.4	91%
1997	788.4	92%
1998	793.9	92%
1999	799.4	93%
2000	806.9	94%
2001	811.8	94%
2002	816.7	94%
2003	818.7	94%
2004	820.7	95%
2005	820.0	95%
2006	1012.0	95%
2007	1016.0	97%
Trend 1990-2007	*71.80%*	*NA*

Sources : Le Portail des Statistiques au Luxembourg, Statistical Yearbook
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=417&IF_Language=fra&MainTheme=1&FldrName=3&RFPath=47
data extracted on 2 April 2009 (subject to changes since that date)

Finally, CO_2 emissions from municipal WWTP are not included in Luxembourg's GHG inventory for the reason that carbon emissions derive from biomass/biogenic raw materials.

To summarize:

- IPCC Category 6B1 covers nitrous oxide emissions from wastewater treatment in industry, thus, IPCC Category 6B = IPCC Sub-category 6B1; emissions related to methane are not applicable ;
- IPCC Category 6B2 covers methane and nitrous oxide emissions from wastewater treatment in residential and commercial sectors and septic tanks. No CO_2 emissions deriving from non-biological or inorganic WWH residuals have been identified so far ;

- Emissions related to the sludge residues of domestic and commercial WWH are not estimated yet. However, sewage sludge spreading has been accounted for in the agriculture sector (see Section 6.5.3 in Chapter 6), thus, IPCC Category 6B = IPCC Sub-category 6B2, excluding sludge.

8.3.3 Methodological issues – methane emissions

Municipal wastewater treatment in Luxembourg uses mainly aerobic processes (see Table 8-12) like activated sludge or biofiltration. As a result, no or negligible methane emissions are produced, since such emissions only occur under anaerobic conditions. In these plants, sludge stabilisation is carried out in order to prevent uncontrolled putrefaction. In facilities with a treatment capacity smaller than 30.000 population-equivalents (p.e.) such stabilisation is usually carried out aerobically, with oxygen and energy consumption, while for facilities with a treatment capacity larger then 30.000 p.e., the stabilisation is normally carried out anaerobically with production of methane gas. The gas produced is usually used for energy recovery in combined heat/power generating systems or may be flared.

Treatment of human sewage from inhabitants connected to small mechanical treatment facilities or septic tanks represents an exception. The percentage of organic loads discharged to these small treatment units has been reduced consequently since 1990. In this emission inventory, methane emissions from these small anaerobic sludge treatments has been taken in account as there is no gas reuse and therefore methane emissions have been assumed. The methodology for these septic tanks is based on the IPCC method in which the relevant population (individual septic tanks) or population equivalents (for the small mechanical treatment plants) is multiplied by the average organic load per person.

The 2006 IPCC default value of 0,6 kg CH_4/kg BOD is used. Each habitant produces 60 g BOD/day, and a MCF of 0,27 is assumed (STEINLECHNER et al. 1994). According to the national expert judgment and based on the study of Steinlechner et al. (1994), the MCF has been adapted to the national situation in Austria which is also applicable for Luxembourg. The MCF defines the portion of methane producing capacity (B0) that degrades anaerobically and may vary between 0,0 (completely aerobic) to 1,0 (completely anaerobic) according to the IPCC 2006 Guidelines. When the sludge treatment process is anaerobic, the temperature has a great influence. During the winter time, the temperature degreases to 10°C in the sludge digester part of the WWTP so that the biological activity is very reduced and the MCF = 0,1. During the rest of the year the temperature in the sludge part is closer to 20°C which is still low for an optimal biological activity and therefore the MCF factor is 0,35 according to Steinlechner. As the mechanical wastewater treatment plants are based on the same technical process as the septic tanks, the MCF factor used for both categories is the same and is calculated as follows:

$$MCF = 2/3 * 0{,}35 + 1/3 * 0{,}1 = 0{,}27$$

Calculation of the organic load:

*BODsep [kg/year] = inhabitants connected to septic tanks * 60 g BOD (person/day) * 365 (days) / 1000*

*BODmec [kg/year] = inhab. connected to mechanical WWTP * 60 g BOD (person/day) * 365 (days) / 1000*

Calculation of the methane emissions:

CH_4 *sep [t/year] = BODsep * B0 * MCF / 1000 ; where : sep = septic tanks*

CH_4 *mec [t/year] = BODmec * B0 * MCF / 1000*

where :

mec = mechanical treatment plants

B0 = 0,6 kg CH_4/ kg BOD 2006 IPCC Good Practice Guidance (page 6.12)

60 g BOD/person par day: 2006 IPCC Good Practise Guidance (page 6.14) and European Directive 91/271/CEE on the treatment of urbane wastewater, article 2.6

MCF: Methane Conversion Factor (STEINLECHNER et al. 1994) (0,35*2/3 + 0,1*1/3= 0,27)

The number of inhabitants connected to a septic tank (sep) is determined annually by the Ministry of Interior Affairs - Water Management Administration through an inventory. The number of inhabitant from agglomerations connected to a septic tank or to a mechanical treatment plants is based on the last national detailed population inventories, as these census take place every ten years, and the last one in 2004, the evaluation is based on an extrapolation for the years 2005-2007. The next census will be take place in 2009, so that for the next submission a recalculation can be done for this period.

Total methane emission from wastewater handling:

CH_4 *tot =* CH_4 *sep +* CH_4 *mec [t/year)]*

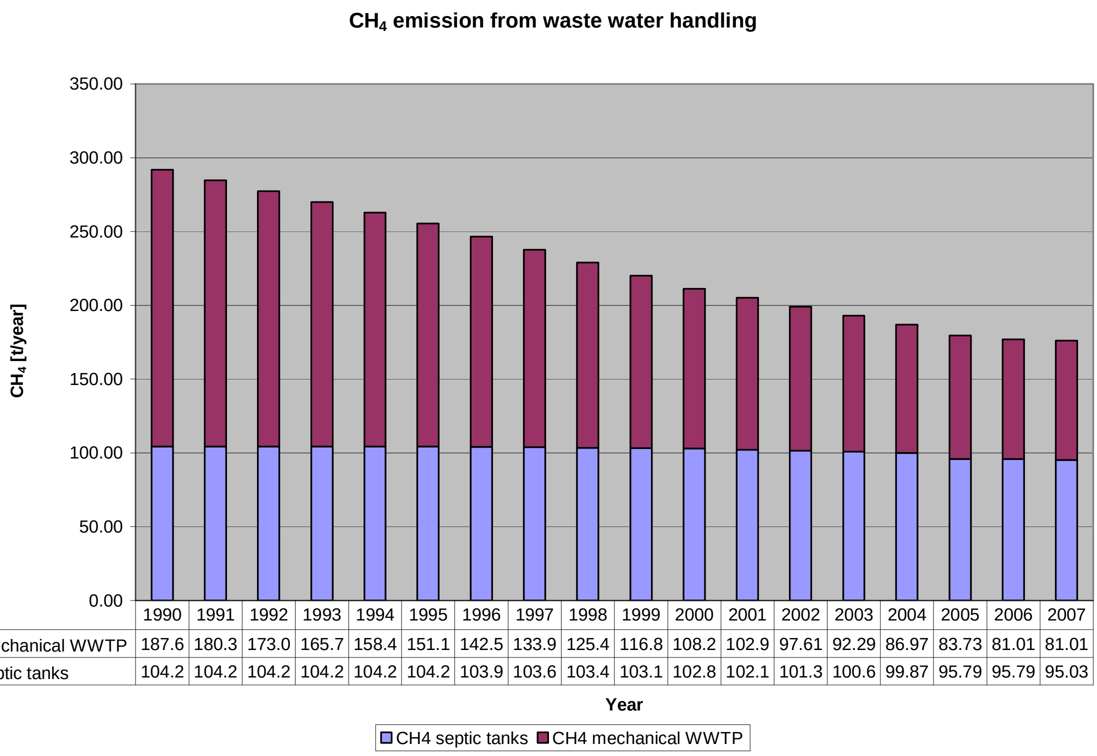
The estimated emissions obtained following the method described above are presented in Table 8-13 and Figure 8-5.

Table 8-13 – CH_4 emission trends for IPCC Sub-category 6B2 – Domestic & Commercial WWH: 1990-2007

CH_4 emissions (tonnes) 6B2 - Domestic & Commercial WWH			
Year	Mechanical	Septic Tanks	Total
1990	187.68	104.20	*291.88*
1991	180.38	104.20	*284.58*
1992	173.07	104.20	*277.27*
1993	165.77	104.20	*269.97*
1994	158.46	104.20	*262.66*
1995	151.16	104.20	*255.36*
1996	142.57	103.94	*246.51*
1997	133.99	103.67	*237.67*
1998	125.41	103.41	*228.82*
1999	116.83	103.15	*219.97*
2000	108.24	102.88	*211.13*
2001	102.93	102.13	*205.06*
2002	97.61	101.38	*198.98*
2003	92.29	100.62	*192.91*
2004	86.97	99.87	*186.84*
2005	83.73	95.79	*179.52*
2006	81.01	95.79	*176.80*
2007	81.01	95.03	*176.04*
Trend 1990-2007	-56.84%	-8,80%	*-39.69%*

Source: Water Agency.

Figure 8-5 – CH_4 emission trends for IPCC Sub-category 6B2 – Domestic & Commercial WWH: 1990-2007



Source: Water Agency.

Methane emissions from industrial wastewater treatment

Industrial wastewater treatment and sewage sludge treatment is carried out under aerobic conditions (activated sludge process). As for the municipal facilities there are no methane emissions.

8.3.4 Methodological issues – nitrous oxide

8.3.4.1 Nitrous oxide emissions from municipal wastewater

Pursuant to the 2006 IPCC Guidelines, nitrous oxide emissions from household wastewater can be evaluated in taking into account the average per-capita protein intake. The IPCC default values are used in each case for the nitrous oxide emission factor per kg of nitrogen in wastewater and for the nitrogen fraction in protein.

N_2O emissions from urban wastewater handling are calculated by distinguishing wastewater arising from population:

1. not connected to a biological wastewater treatment plant (WWTP)
2. connected to a WWTP without denitrification
3. connected to a WWTP with denitrification

The N_2O emissions resulting from population not connected to a WWTP were calculated according the 2006 IPCC default approach. For the nitrogen calculation not only the inhabitants of the country but also the daily commuters has been taken in account. As they spent only the time of the working time they calculated only with there half load of nitrogen. The number of inhabitants and the commuters are provided by the STATEC.

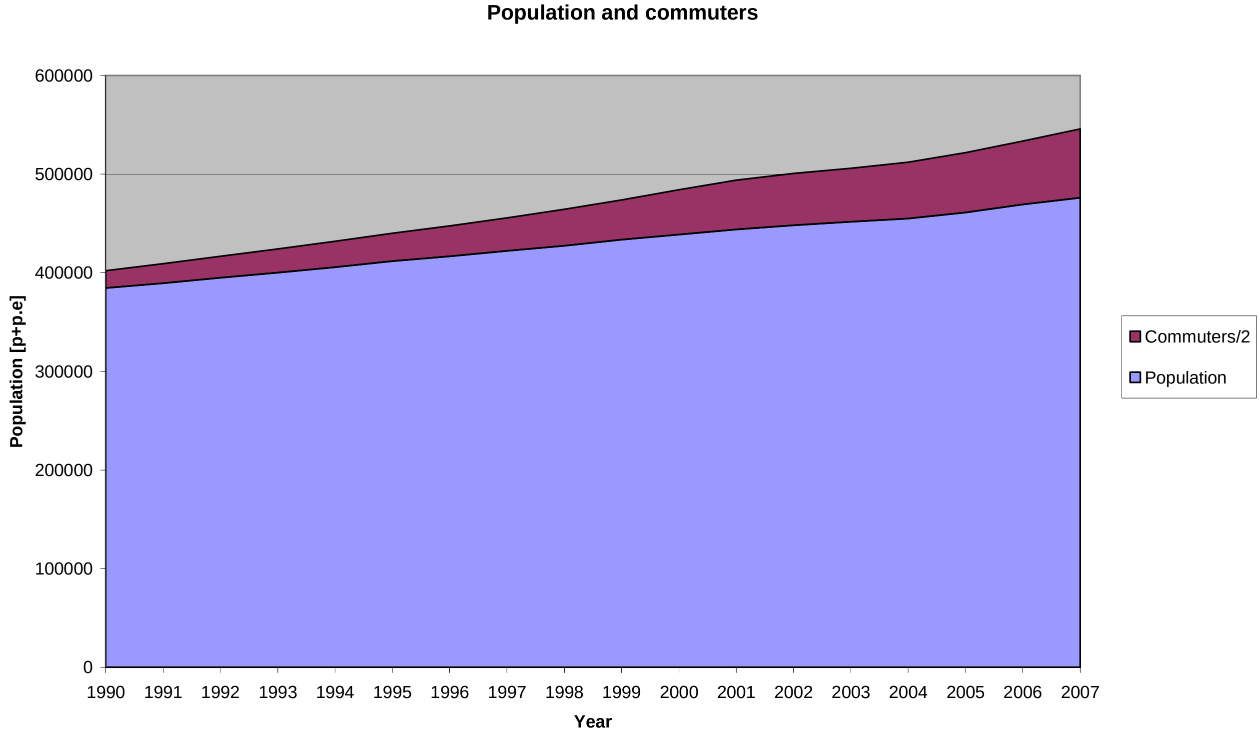
Figure 8-6 illustrates the population and cross-border commuters growth between 1990 and 2007. The latter is divided by 2 in the figure below (so that only a half load of nitrogen is counted for by commuting individual).

Denitrification is a treatment requirement in Luxembourg for Urban Waste Water Treatment Plants based on the European Directive 91/271/CEE concerning urban waste water treatment. WWTP with an organic design capacity larger than 10 000 population-equivalents (p.e.) have to meet the minimum reduction rate of 75% of total nitrogen. The objective of denitrification is to reduce the risk of eutrophication of surface waters.

For the current evaluation of the N_2O emissions the methodology of the 2006 IPCC Guidelines has been applied with a default value 3,2 g N_2O per capita per year (for biological wastewater treatment plant with denitrification processes) as well a factor of Find-com of 1,25 based on data in Metcalf & Eddy (2003) and expert judgment.

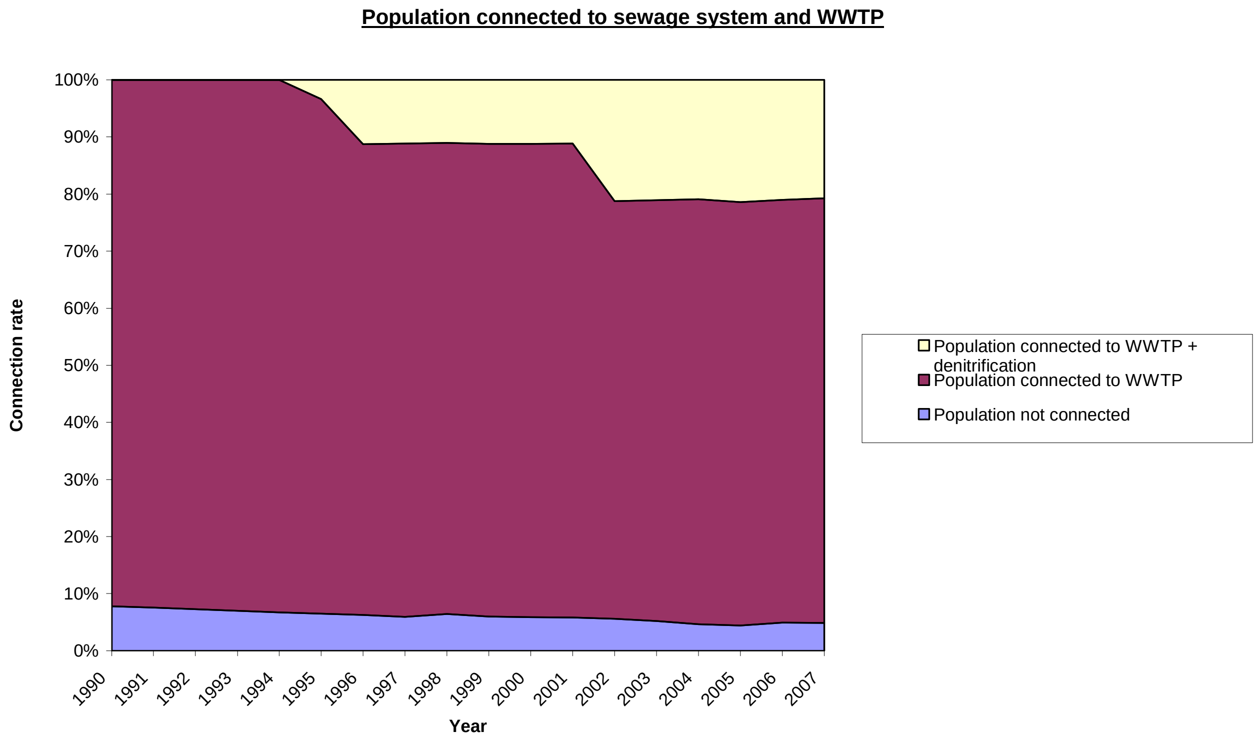
Figure 8-7 provides an overview of the population of Luxembourg connected to WWTPs (with or without denitrification) or not.

Figure 8-6 – Resident population and cross-border commuters: 1990-2007



Sources: Le Portail des Statistiques au Luxembourg, Statistical Yearbook
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=417&IF_Language=fra&MainTheme=1&FldrName=3&RFPath=47
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=360&IF_Language=fra&MainTheme=2&FldrName=5&RFPath=37
data extracted on 2 April 2009 (subject to changes since that date)

Figure 8-7 – Population connected to sewage system and biological WWTP: 1990-2007



Source: Water Agency.

Determination of N_2O from waste water not connected to a biological WWTP (2006 IPCC Guidelines)

$$N_2O\ nc\ [t/year] = N\ effluent * F\ ind\text{-}com * EF\ effluent / 1000 * 44/28$$

where :

nc = not connected

N effluent = P* Protein * F NPR

with : P = inhabitants (p.e.) not connected

Protein = protein intake per person (kg/year) (http://www.fao.org)

EF effluent = Emission Factor 0,005 (2006 IPCC Guidelines default value, page 6.25)

F ind-com = fraction of industrial and commercial co-discharged protein (default = 1.25, based on data in Metcalf & Eddy (2003) and expert judgment ; IPCC Guidelines, page 6.26)

F NPR = 0,16 kg N/kg protein (2006 IPCC Guidelines, page 6.25)

44/28 = 1,57: conversion of N_2O-N to N_2O (44/28, N_2O/N))

Determination of N_2O from waste water connected to a biological WWTP without denitrification

$$N_2Owwtp\ [t/year] = N\ effluent / 1000 * \%\ FRAC\ denitri * 0{,}01 * F\ ind\text{-}com * 44/28$$

where :

wwtp = wastewater treatment plant

N effluent = P * Protein * F NPR

with: P = population connected

Protein = protein intake per person (kg/year) (http://www.fao.org)

F NPR = 0,16 kg N/kg protein (2006 IPCC Guidelines, page 6.25)

% FRAC denitri = 35 % denitrification rate (% of wastewater which is denitrificated)

0,01: 1% of the denitrificated N is emitted as N_2O (ORTHOFER et al. 1995)

F ind-com = fraction of industrial and commercial co-discharged protein (default = 1,25, based on data in Metcalf & Eddy (2003) and expert judgment, IPCC Guidelines, page 6.26)

44/28 = 1,57, conversion of N_2O-N to N_2O (44/28, N_2O/N)

Determination of N_2O from waste water connected to a biological WWTP with denitrification

$$N_2Owwtp\text{-}de = P * F\ ind\text{-}com * EF\ plant / 1.000.000 \qquad [t/year]$$

where:

wwtp-de = wastewater treatment plant with denitrification

P = inhabitants connected

F ind-com = fraction of industrial and commercial co-discharged protein (default = 1,25, based on data in Metcalf & Eddy (2003) and expert judgment ; IPCC Guidelines, page 6.26)

EF plant = emission factor, 3,2 g N_2O / person / year

Determination of N_2O total emission from waste water handling

N_2Omun tot [t/year] = N_2O not connected + N_2O connected to WWTP without denitrification + N_2O connected to WWTP with denitrification

where:

mun = municipal wastewater

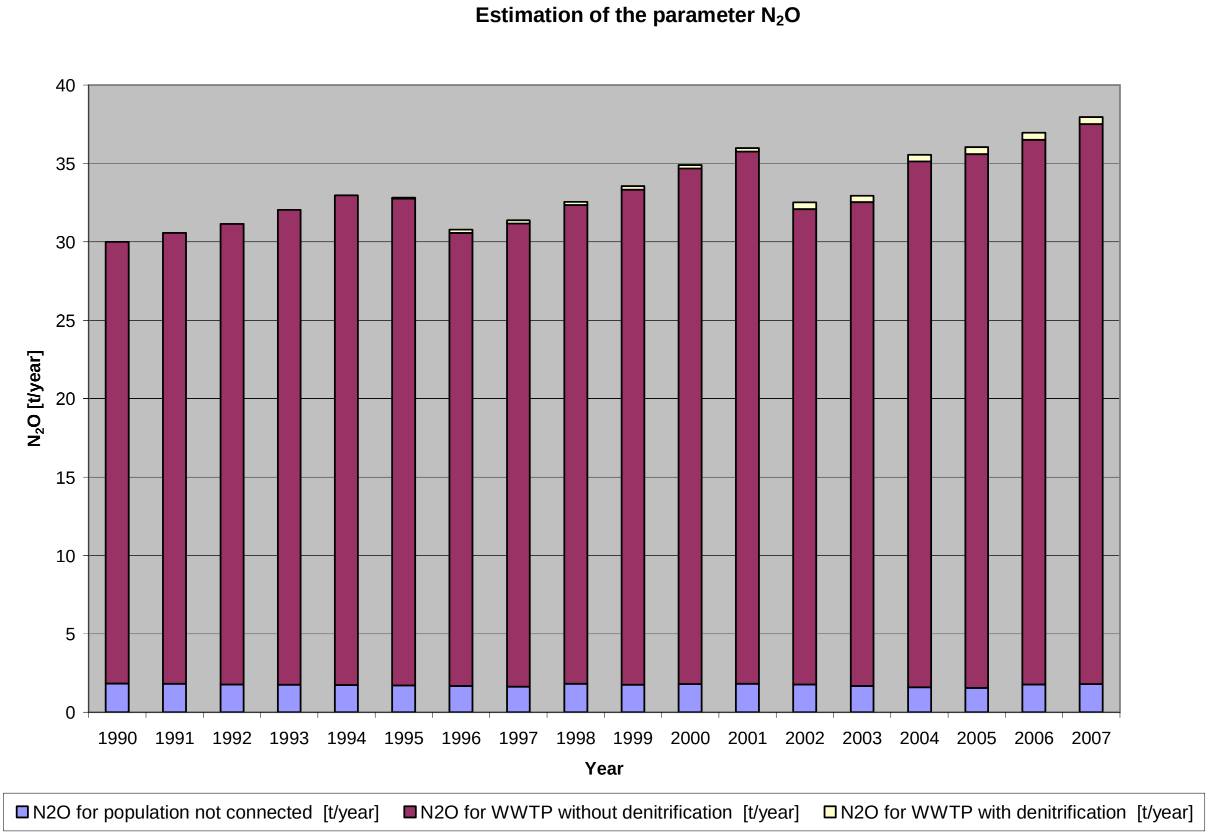
The estimated emissions obtained following the method described above are presented in Table 8-14 and Figure 8-8.

Table 8-14 – N_2Oemission trends for IPCC Sub-category 6B2 – Domestic & Commercial WWH: 1990-2007

	N_2O emissions (tonnes) 6B2 - Domestic & Commercial WWH			
Year	N_2O nc	N_2O wwtp	N_2O wwtp-de	Total
1990	1.83	28.17	NO	*30.00*
1991	1.80	28.77	NO	*30.57*
1992	1.77	29.37	NO	*31.14*
1993	1.75	30.28	NO	*32.03*
1994	1.73	31.21	NO	*32.95*
1995	1.72	31.04	NO	*32.76*
1996	1.68	28.89	NO	*30.57*
1997	1.62	29.54	0.20	*31.36*
1998	1.83	30.52	0.21	*32.55*
1999	1.75	31.58	0.21	*33.54*
2000	1.80	32.88	0.22	*34.90*
2001	1.83	33.92	0.22	*35.97*
2002	1.78	30.30	0.43	*32.51*
2003	1.67	30.85	0.43	*32.95*
2004	1.60	33.53	0.43	*35.55*
2005	1.55	34.04	0.45	*36.04*
2006	1.78	34.72	0.45	*36.95*
2007	1.79	35.71	0.45	*37.95*
Trend 1990-2007	3.83%	26.77%	650%	*26.5%*

Source: Water Agency.

Figure 8-8 – N_2O emission trends for IPCC Sub-category 6B2 – Domestic & Commercial WWH: 1990-2007



Source: Water Agency.

Nitrous oxide emissions from industrial WWTP

N_2O emissions from industrial wastewater handling are issued from only one chemical plant that produces plastics and which releases N to aquatic environments. This industrial WWTP is equipped with a biological treatment with denitrification. N_2O emissions are based on the measured inflow data in the wastewater treatment plant (WWTP). The data available since the year 2002 are the flow as well as the mean total nitrogen concentration in the WWTP.

The determination of N_2O from wastewater connected to an industrial wastewater treatment plant with denitrification is calculated as follows:

$$N_2O\ ind = N\ cc\ [mg/l] * Inflow\ [m3/a] /1000 * \%\ FRAC\ denitri * 0{,}01 *44/28 \quad [t/year]$$

where :

ind = industrial

N cc = N concentration in mg/l (measured data)

Inflow = flow in m3/a (measured data)

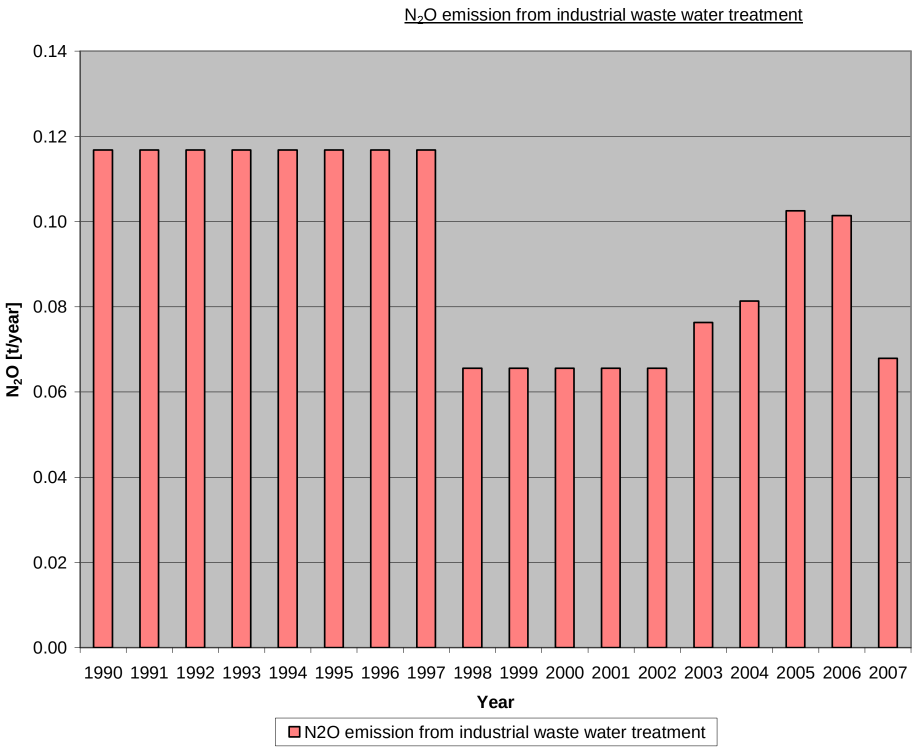
% FRAC denitri = 70% denitrification rate in % (% of wastewater which is denitrificated)

0,01 = 1% of the denitrificated N is emitted as N_2O (ORTHOFER et al. 1995)

44/28 = 1.57, conversion of N_2O-N to N_2O (44/28, N_2O/N)

The estimated emissions obtained following the method described above are presented in Figure 8-9.

Figure 8-9 – N_2O emission trends for IPCC Sub-category 6B1 – Industrial wastewater WWH: 1990-2007



Source: Water Agency.

Determination of N concentration:

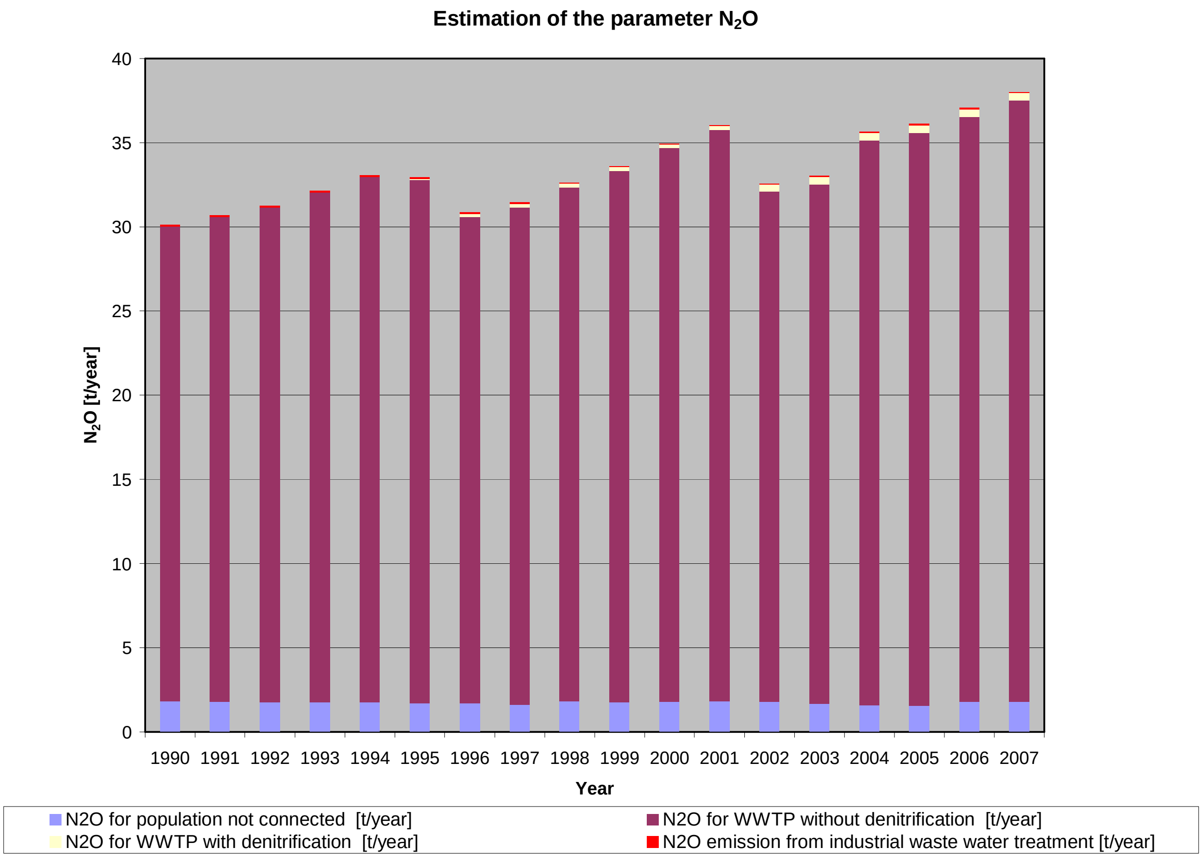
Year 1990 - 1997	Year 1998 - 2002	Year 2002 – 2007
N concentration extrapolated by expert judgment of water management administration	N concentration extrapolated by expert judgment of water management administration. In 1998 theWWTP has been upgraded allowing also denitrification	N concentration issues from analyses

8.3.4.2 Determination of the total nitrous oxide emissions

$$N_2O\ tot = N_2Omun\ tot + N_2Oind$$

The estimated emissions obtained following the formula described above are presented in Figure 8-10 and Table 8-15.

Figure 8-10 - N_2O emission trends for IPCC Sub-category 6B1 and Sub-category 6B2 WWH: 1990-2007



Source: Water Agency.

Table 8-15 – N_2O emission trends for IPCC Sub-category 6B1 and Sub-category 6B2 WWH: 1990-2007

N_2O emissions (tonnes) 6B1 and 6B2 - Domestic & Commercial and Industrial WWH					
Year	N_2O nc	N_2O wwtp	N_2O wwtp-de	N_2O ind	Total
1990	1.83	28.17	NO	0.12	*30.12*
1991	1.80	28.77	NO	0.12	*30.69*
1992	1.77	29.37	NO	0.12	*31.26*
1993	1.75	30.28	NO	0.12	*32.15*
1994	1.73	31.21	NO	0.12	*33.07*
1995	1.72	31.04	0.06	0.12	*32.93*
1996	1.68	28.89	0.20	0.12	*30.89*
1997	1.62	29.54	0.20	0.12	*31.48*
1998	1.83	30.52	0.21	0.07	*32.62*
1999	1.75	31.58	0.21	0.07	*33.61*
2000	1.80	32.88	0.22	0.07	*34.96*
2001	1.83	33.92	0.22	0.07	*36.04*
2002	1.78	30.30	0.43	0.07	*32.57*
2003	1.67	30.85	0.43	0.08	*33.02*
2004	1.60	33.53	0.43	0.08	*35.64*
2005	1.55	34.04	0.45	0.10	*36.14*
2006	1.78	34.72	0.45	0.10	*37.05*
2007	1.79	35.71	0.45	0.07	*38.02*
Trend 1990-2007	3.83%	26.77%	650%	-41.67%	*26.23*

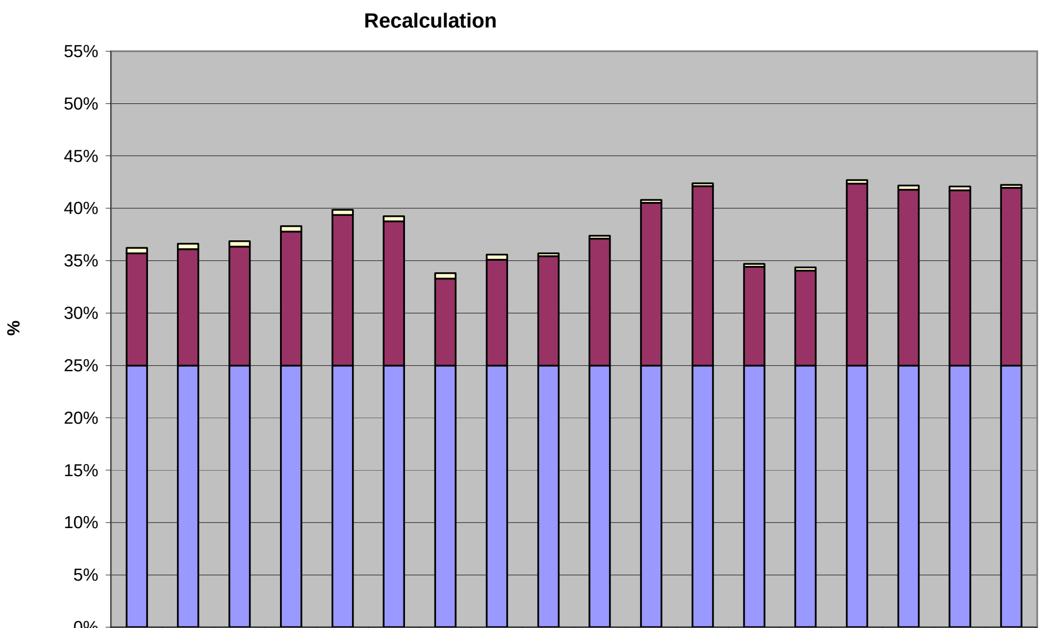
Source: Water Agency.

8.3.5 Recalculations

The following recalculations have been made since submission2008v1.2:

- For the previous evaluation of the N_2O emissions the methodology of the revised IPCC Guidelines of 1996 has been considered. But, according with the review expert we decide to take in account the new approach mentioned in the new 2006 IPCC Guidelines with a default value 3,2 g N_2O per capita per year (for biological wastewater treatment plant with denitrification processes) as well a factor of Find-com of 1,25 (for biological wastewater treatment plant with or without denitrification processes) based on data in Metcalf & Eddy (2003) and expert judgment;
- The protein intake value per day per person has been adapted according to the FAO statistics, so that a current value from 102 g protein/person/day in 1990 to 118 g protein/person/day in 2006 has been taken (as concluded during the ICR 2008, reference: www.fao.org);
- The addition of N_2O emission from industrial sector has been taken in account in the new data report (according with the review expert during ICR 2008).

Figure 8-11 – Recalculations for IPCC Sub-category 6B1 and Sub-category 6B2 WWH: 1990-2007



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Additional industrial emission	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.3%
Adapatation of protein intake value	10.7%	11.1%	11.3%	12.8%	14.4%	13.8%	8.3%	10.1%	10.4%	12.1%	15.5%	17.1%	9.4%	9.0%	17.4%	16.8%	16.7%	17.0%
Additional fraction F Ind-Com	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%

Source: Water Agency.

The total increase, in percentage, of N_2O emission, due to the recalculation and in comparison with the value of the last NIR, is showed in the following table:

Table 8-16 – Recalculations for IPCC Sub-category 6B1 and Sub-category 6B2 WWH: 1990-2007

Recalculations Sub-category 6B1 and Sub-category 6B2 WWH			
Year	2009v1.4	2008v1.2	Delta
1990	30.12	22.11	*36.2%*
1991	30.69	22.46	*36.6%*
1992	31.26	22.84	*36.9%*
1993	32.15	23.25	*38.3%*
1994	33.07	23.64	*39.8%*
1995	32.93	23.65	*39.2%*
1996	30.89	23.08	*33.8%*
1997	31.48	23.22	*35.6%*
1998	32.62	24.04	*35.7%*
1999	33.61	24.47	*37.4%*
2000	34.96	24.83	*40.8%*
2001	36.04	25.31	*42.4%*
2002	32.57	24.18	*34.7%*
2003	33.02	24.58	*34.4%*
2004	35.64	24.97	*42.7%*
2005	36.14	25.42	*42.2%*
2006	37.05	26.08	*42.1%*
2007	38.02	26.73	*42.2%*
Trend 1990-2007	26.23%	20.90%	*16.58%*

Source: Water Agency.

8.3.6 Category specific QA/QC procedures

QA/QC procedures have been completed for the following category:

1) Activity data:

- population and commuters from the STATEC (national data inventory of Luxemburg);
- number and size of WWTP from national inventory from the Water Management Administration;
- measured data for the denitrification efficiency;

2) Parameters and emission factor:

- references are indicated, waste expert (QA);

3) Emissions:

- references are indicated, waste expert (QA).

8.3.7 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 8-17 will be explored.

Table 8-17 – Planned improvements for IPCC Category 6B – WWH

GHG source & sink category	Planned improvement
6B2 – Domestic & Commercial WWH – N_2O	List of WWTPs which produce methane gas for energy reuse in combined heat/power generating systems
6B2 – Domestic & Commercial WWH – CH_4	The number of inhabitants which are connected or not connected to WWTPs will be updated
6B2 – Domestic & Commercial WWH	analyse whether it would be possible and/or necessary to estimate emissions from sewage sludge (knowing that sewage sludge spreading is accounted for in IPCC Category 4D).

8.3.8 Uncertainties

- Wastewater quantity: 10 % not connected to wastewater treatment plants
- Emission factor for N_2O: 50% (IPCC 2006 - Guidelines)
- Emission factor for CH_4: 50% (Treatment of uncertainties for national estimates of GHG Emission, Charles D., 1998, referenced by Wilfried Winiwarter)

8.4 Waste Incineration (6C)

This category is presented under IPCC Sub-category *1A1a – Fuel Combustion Activities – Energy Industries – Public Electricity and Heat Production* (see Section 0 in Chapter 3) because in the sole incinerator of the country (SIDOR site), energy from waste burning is recovered and injected in the electric public network.

8.5 Other Waste – Compost Production (6D)

This section describes the estimation of methane and nitrous oxide emissions generated by compost production. In 2007, this source category was responsible for a bit less than 26.6% of the total GHG emissions from the waste sector – excluding waste incineration – and it represented 0.001% of the total GHG emissions in CO_2e (excluding LULUCF). For each of the two gases reported, in 2007:

- CH_4 represented 20.1% of waste treatment methane related emissions – excluding waste incineration – and 1.6% of the total methane emissions estimated for Luxembourg;
- N_2O represented 38.8% of waste treatment nitrous oxide related emissions – excluding waste incineration – and almost 1.4% of the total nitrous oxide emissions estimated for Luxembourg.

8.5.1 Key source

Compost production is not a key source.

8.5.2 Source category description

Under IPCC Category *6D – Other*, Luxembourg reports CH_4 and N_2O emissions from compost production. This activity actually started up on a systematic "industrial scale" in the early 1990s: emissions are reported from the year 1993 onward. Table 8-18 shows that CH_4 and N_2O emissions generated by compost production increased a lot over time as a result of the increasing amount of waste composted.

Table 8-18 – CH_4 & N_2O emission trends for IPCC Category *6D – Other – Compost Production:* 1990-2007

	Emissions (Gg) 6D – Other - Compost Production		
Year	CH_4	N_2O	Total in CO_2e
1990	NO	NO	NO
1991	NO	NO	NO
1992	NO	NO	NO
1993	0.023	0.002	1.027
1994	0.027	0.002	1.194
1995	0.034	0.003	1.486
1996	0.029	0.002	1.302
1997	0.064	0.005	2.847
1998	0.107	0.008	4.723
1999	0.111	0.008	4.908
2000	0.149 + *0.064*	0.011 + *0.004*	6.579 + *2.526*
2001	0.136 + *0.062*	0.010 + *0.004*	6.034 + *2.471*
2002	0.154 + *0.089*	0.012 + *0.005*	6.801 + *3.524*
2003	0.213 + *0.095*	0.016 + *0.006*	9.436 + *3.758*
2004	0.207 + *0.094*	0.016 + *0.006*	9.149 + *3.734*
2005	0.219 + *0.102*	0.016 + *0.006*	9.7.03 + *4.050*
2006	0.229 + *0.134*	0.017 + *0.008*	10.132 + *5.307*
2007	0.233 + *0.111*	0.017 + *0.007*	10.301 + *4.376*

Source: Environment Agency.

Note: the added emissions (*italic*) from 2000 onwards are those of the pilot project Soil-Concept.

8.5.3 Methodological issues

The IPCC Tier 1 method has been applied to estimate both methane and nitrous oxide emissions from compost production. Default EFs have been used.

8.5.3.1 Activity data

Activity data are taken:

- from STATEC Statistical Yearbook, Table A.3312 (these data are actually prepared by the Waste Division of the Environment Agency);
- from Soil-Concept annual reports transmitted to the Waste Division of the Environment Agency.

These activity data are presented in Table 8-19.

Table 8-19 – Composting activities: 1994-2007

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	tonnes wet												
Total	8 398	7 354	16 083	26 685	27 729	37 169	34 088	38 424	53 310	51 692	54 817	57 242	58 196
kg/habitant	*60.2*	*49.5*	*106.8*	*100.2*	*101.6*	*133.2*	*120.8*	*134.1*	*138.2*	*133.2*	*122.3*	*125.0*	*125.2*
Minette-Kompost Monder-cange *(1)*	4 534	3 767	11 773	17 345	20 520	24 146	23 234	25 421	24 462	27 514	28 746	28.743	30 173
kg/habitant	*37.8*	*30.9*	*95.4*	*114.1*	*130.8*	*151.7*	*144.2*	*154.2*	*146.7*	*163.6*	*167.7*	*164.0*	*172.1*
SICA Mamer	3 326	3 587	4 310	3 171	3 758	4 903	4 747	4 730	4 650	4 899	5 278	5 061	5185
kg/habitant	*170.1*	*133.5*	*158.7*	*115.6*	*135.2*	*176.0*	*170.1*	*167.5*	*164.5*	*172.2*	*181.8*	*170.4*	*174.6*
SIDEC Fridhaff *(3)*				6 169	3 451	8 120	5 416	5 920	6 116	6 564	6 510	6 238	6092
SIDEC Angelsberg *(4)*							691	2 353	2 174	2 534	2 651	2 670	2702
kg/habitant				*70.9*	*39.1*	*88.3*	*65.6*	*88.7*	*87.9*	*95.3*	*93.3*	*88.6*	*87.5*
Commune de Hespé-range									611.4	742	786	743	786
kg/habitant									*50.4*	*59.2*	*59.9*	*54.9*	*58.1*
Ville de Luxem-bourg/ Reckenthal									15 297	9 439	8 083	11 108	9733
kg/habitant									*181.5*	*113.2*	*97.5*	*122.8*	*107.6*
SIGRE Muertendall *(5)*											2 763	2679	3525
kg/habitant											*51.4*	*48.5*	*63.8*
Pétange *(2)*	538												
tonnes dry													
Soil-Concept *(6)*						6379.8	6238.9	8898.1	9488.5	9429.8	10228.1	13401.5	11050.7

Source: Environment Agency.

Notes:

(1) new installation since may 1997

(2) installation closed in 1996

(3) new installation running from 1998 onwards

(4) new installation running from 2001 onwards

(5) new installation running from 2005 onwards

(6) Soil-Concept pilot project started in 2000 (tonnes of 100% dry matter)

The Soil-Concept pilot project

This project aims at reducing direct spreading of sludge on agricultural lands thanks to the spreading of compost which is less harmful for the environment (see http://www.soil-concept.lu/). Though most of the compost produced in the Soil-Concept installation is then used in agriculture, horticulture and viticulture, it seems logical to record associated emissions in IPCC Category 6D since these are "process" and not "spreading" emissions. Nevertheless, it is planned to analyse further the impact of sludge spreading and compost application on agriculture GHG emissions in order to refine these first estimates.

8.5.3.2 Emission factors

EFs for compost production are actually default EFs for CH_4 and N_2O emissions from biological treatment of waste taken from the 2006 IPCC Guidelines: see Table 8-20.

Table 8-20 – Default EFs for CH_4 and N_2O emissions from biological treatment of waste

Type of biological treatment	CH_4 EF *g CH_4/kg waste treated*	N_2O EF *g N_2O/kg waste treated*	Comment
	on a wet basis		Assumptions on the waste treated: 25-50% DOC in dry matter, 2% N in dry matter, moisture content 60%. EF for dry waste are estimated from those for wet waste assuming a moisture content of 60% in wet waste.
Composting excluding Soil-Concept project	4	0.3	
	(0.03 - 8)	(0.06 - 0.6)	
Soil-Concept project	*on a dry basis*		
	10	0.6	
	(0.08-20)	(0.2-1.6)	

CH_4 and N_2O emissions of biological treatment are estimated using the default method given in the following equations:

$$CH_4 emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3} - R$$

$$N_2O emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3}$$

where:

CH_4 emissions = total CH_4 emissions in inventory year [Gg CH_4]

N_2O emissions = total N_2O emissions in inventory year, [Gg N_2O]

M_i = mass of organic waste treated by biological treatment type i [Gg]

EF_i = emission factor for biological treatment type i (see Table 8-23)

I = composting or anaerobic digestion

R = total amount of CH_4 recovered in inventory year [Gg CH_4][159]

8.5.4 Recalculations

See Table 8-3 in Section 8.1.3.

8.5.5 Category specific QA/QC procedures

No category specific QA/QC procedures have been completed, only the tools embedded in CRF Reporter have been used.

[159] So far, emission estimates for composting are not taking CH_4 recovery into account.

8.5.6 Planned improvements

Taking into account the potential contribution of identified improvements in the total GHG emissions and the corresponding resources needed to make these improvements effective, developments presented in Table 8-21 will be explored.

Table 8-21 – Planned improvements for IPCC Category 6D – Other

GHG source & sink category	Planned improvement
6D – Other	Include aerobic pre-treatment of municipal waste before landfilling at SIDEC

8.6 Selected references

- Administration de l'Environnement (AEV) - Division des Déchets (2005), *Restabfallanalyse 2004/05 im Großherzogtum Luxemburg, Band 1: Kompendium*, Luxembourg.
- Administration de l'Environnement (AEV) - Division des Déchets (2002), *Restabfallanalyse 2001 im SIDOR*, Luxembourg.
- Administration de l'Environnement (AEV) - Division des Déchets (2002), *Waste analysis 1992/1994*, Luxembourg.
- Daniel Strauss, *Détermination des émissions atmosphériques de méthane du secteur des déchets, du secteur agricole et de la distribution de gaz naturel au Grand-Duché de Luxembourg : analyse des méthodes de calcul - calcul d'incertitudes, Rapport de Stage pour l'Administration de l'Environnement*, Luxembourg, 2006.

9 Recalculations and Improvements

This chapter quantifies the changes in emissions for all six GHG compared to the previous official submission to the UNFCCC Secretariat, i.e. submission 2008v1.2. Recalculations are quantified for total GHG emissions for all years and gas specific emissions for 1990 and 2006.

Recalculations of previously submitted inventory data are performed following the 2000 IPCC-GPG, Chapter 7 "Methodological Choice and Recalculation" with the unique purpose to improve the GHG inventory.

9.1 Explanations and Justifications for Recalculations

Compiling an emission inventory includes data collection, data transfer and data processing. Data has to be collected from different sources, for instance national statistics, plant operators, studies, personal information or other publications. The provided data must be transferred from different data formats and units into a unique electronic format to be processed further. The calculation of emissions, by applying methodologies on the collected data, and the final computing of time series into a predefined format (CRF) are further steps in the preparation of the final submission. Finally, the submission must be delivered in due time. Even though the implemented QA/QC system should prevent or at least minimize potential errors, it will remain necessary to make some revisions (called recalculations) under the following circumstances:

- an emission source was not considered in the previous inventory;
- a source/data supplier has delivered new data. The causes might be that previous data were preliminary data or that methodology has been improved/modified;
- occurrence of errors in data transfer or processing: wrong data, unit-conversion, software errors, etc;
- methodological changes: a new methodology must be applied to fulfil the reporting obligations because of one of the following reasons:
  - to decrease uncertainties;
  - an emission source becomes a key source;
  - consistent input data needed for applying the methodology is no longer accessible;
  - input data for more detailed methodology is now available;
  - the methodology is no longer appropriate.

For detailed information on recalculations and their justifications, please consult the tables, showing revisions between submissions 2008v1.2 and 2009v1.4, in each recalculation sub-section of Chapters 3 to 8.

9.2 Implication for Emission Levels

The analysis is made by comparing our two last official submissions to the UNFCCC Secretariat, i.e. submissions 2008v1.2 and 2009v1.4. After the ICR that took place in October 2008, Luxembourg's inventory experienced dramatic improvements in some sectors and categories. Hence, the total GHG estimates for the year 1990 in submission 2009v1.4 differ from those reported in submission 2008v1.2, as well as those that have been used to calculate Luxembourg's assigned amount as specified in paragraph 116 of the Report of the review of the initial report of Luxembourg (doc. FCCC/IRR/2007/LUX of 14 December 2007).[160]

Table 9-1 presents the recalculation differences between submission 2008v1.2 and 2009v1.4 for each of the 6 GHG (a positive value indicates that submission 2009v1.4 estimate is higher).

Table 9-1 – Recalculation differences between submissions 2008v1.2 and 2009v1.4 (excl. LULUCF): 1990 and 2006

GHG	1990 (base year)	2006
	recalculation difference (%)	
CO_2	-0.68%	1.14%
CH_4	1.30%	-1.66%
N_2O	1.73%	-22.44%
F-gases	0.00%	0.00%
Total	-0.52%	-0.14%

Source: Ministry of the Environment and Environment Agency.

Differences for the 3 main GHG – CO_2, CH_4 and N_2O – are largely explained by the important recalculations conducted in CRF Sector 1. For CO_2, significant changes also happened in CRF Sector 3 – however, with around 20 Gg CO_2e, in 2007, this sector represented only 0.2% of the total CO_2 emissions (excluding LULUCF). For CH_4, besides the changes operated in CRF Sector 1, major recalculations took place in both IPCC Categories 6A and 6B. Finally, with regard to N_2O, on top of CRF Sector 1 improvements, IPCC Category 6B has been revised with the inclusion of industrial wastewater treatment related emissions in the inventory.

For more detailed explanations, please refer to the relevant sections in each of the CRF Sectors Chapters 3 to 8).

Table 9-2 shows the recalculation effect for all years.

160 See http://unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php

Table 9-2 – Recalculation differences between submissions 2008v1.2 and 2009v1.4 for total GHG emissions (excl. LULUCF): 1990-2006

Year	National Total GHG Emissions excluding LULUCF		
	Submission 2008v1.2 *Gg CO_2e*	Submission 2009v1.4 *Gg CO_2e*	Recalculation difference *%*
1990	13186,51	13117,79	-0,52%
1991	13489,55	13608,40	0,88%
1992	13356,75	13373,44	0,12%
1993	13601,50	13496,11	-0,77%
1994	12765,21	12622,52	-1,12%
1995	10334,81	10389,96	0,53%
1996	10428,89	10457,57	0,28%
1997	9793,68	9841,83	0,49%
1998	9054,81	9016,93	-0,42%
1999	9674,04	9420,67	-2,62%
2000	10184,97	9971,14	-2,10%
2001	10476,50	10280,11	-1,87%
2002	11305,50	11338,01	0,29%
2003	11665,12	11774,37	0,94%
2004	13402,55	13285,95	-0,87%
2005	13290,61	13390,71	0,75%
2006	13222.16	13304.02	-0.14%
Trend 1990-2006	*1.03%*	*1.42%*	*NA*

Source: Ministry of the Environment and Environment Agency.

9.3 Implications for Emissions Trend

As shown in Table 9-2, the recalculation between the two submissions 2008v1.2 and 2009v1.4 led to a modification in the total GHG (excluding LULUCF) emissions trend from 1.03% to 1.42%. However, the upward trend between the base year and the latest common inventory year has not been modified radically by the recalculations: it is still a little positive, just a bit more for the latest inventory submission.

9.4 Planned Improvements

Since the overall goal is to produce emission inventories which are fully consistent with the UNFCCC reporting guidelines and the IPCC Guidelines, an improvement programme has being established to help meeting this goal, so to avoid any adjustments under the Kyoto Protocol. The implementation of an improvement programme is driven by the results of the various review processes, as e.g. the review under the European Union Monitoring Mechanism and the review under the UNFCCC and/or under the Kyoto Protocol. These reviews showed the necessity to plan improvements sector by sector and this is why an overview of the main source specific planned improvements identified in the respective sections and sub-sections of Chapters 3 to 8 is presented below in Table 9-3. This table also lists some of the cross-cutting improvements Luxembourg commits itself to put in place.

The Environment Agency acting as the "Single National Entity with overall responsibility for the GHG Inventory" will be responsible for the management of the improvement programme and in line with the QA/QC procedures and the Quality Policy.

Nevertheless, due to limited resources in Luxembourg – small country, hence small administrations – prioritising resources for inventory improvement is a key point. Therefore, **those improvements for which the additional effort would be warranted by increased accuracy and/or for which key sources are considered will be prioritised**. Indeed, as indicated in the 2000 IPCC-GPG "*it would not be a good use of limited resources to spend large amounts of time exhaustively collecting data and expert judgements for a source category that has little effect on* (overall GHG total) *and uncertainty*".[161]

Table 9-3 – Main planned improvements

Issue GHG source & sink category	Planned improvement
Cross-cutting improvements	
Uncertainties	whenever a method used for the estimation of emissions/removals of a key category is not consistent with the requirements of the 2000 IPCC-GPG, the method will have to be improved in order to reduce uncertainty, which is considered in the emission inventory improvement programme.
Notation Key NE	it is planned that source or sink categories currently indicated as NE are, if possible, either estimated or allocated to NO.
Indirect GHG	generate better emission estimates for indirect GHG – NO_x, CO, NMVOCs – and SO_2.

Issue GHG source & sink category	Planned improvement
Source categories improvements	
1A1a - Public Electricity and Heat Production	waste incineration: revise N_2O EF of MSW.
1A1a - Public Electricity and Heat Production	waste incineration: revise interpolation of MSW composition between waste analysis years.
1A1a - Public Electricity and Heat Production	Investigate whether it would be feasible to obtain country specific NCV and EF for gas oil.
1A1a - Public Electricity and Heat Production	Further consultations with Ministry of Economic Affairs and STATEC regarding energy balance.
1A2 – Manufacturing Industries and Construction	Investigate whether it would be feasible to obtain country specific NCV and EF for gas oil, diesel oil and gasoline.
1A2 – Manufacturing Industries and Construction	Further consultations with Ministry of Economic Affairs and STATEC regarding energy balance.
1A2b – Non-Ferrous Metals	include other non-ferrous activities if relevant (copper processing and production from copper scrap)

161 The text into bracket is an addition by Luxembourg.

Issue GHG source & sink category	Planned improvement
Source categories improvements	
	which is now included in 1A2f.
1A3a – Civil Aviation	refine the share between domestic and international flights (90/10) for aviation gasoline that is based, for the moment, on expert judgement.
1A3b – Road Transport	investigate whether it would be feasible to obtain country specific NCV and EF for gasoline and diesel oil.
1A3b – Road Transportation	update some of the country specific parameters used in the COPERT IV model, especially concerning the vehicle split for heavy duty vehicles.
1A3b – Road Transportation	lubricants: 50% of carbon that is not stored will be allocated in this sub-category.
1A3d – Navigation	reallocate gasoline emissions produced by leisure shipping activities from 1A3b.
1A4 – Other Sectors	collect information helping to refine the fuel consumption split between the commercial/institutional sector, the residential sector and the agriculture/forestry/fisheries sector.
1A4 – Other Sectors	investigate whether it would be possible to move away from default EFs to country specific ones, at least for gas oil, diesel oil and gasoline.
1A5 – Other	investigate whether the consumption data reported by the official statistics has been correctly understood, and correctly allocated.
1A5 – Other	investigate whether it would be possible to move away from default EFs to country specific ones, at least for gas oil and diesel oil.
1.B.2.v Distribution of oil products	Only refined oil products are distributed in Luxembourg. Activity data on these has been collected; however, no EFs are available in the IPCC guidelines. Therefore, EFs from neighbouring countries might be chosen instead. Further investigations are needed.
2A1 – Cement Production	streamlining with the new 2006 IPCC Guidelines and the new 2007 ETS Guidelines.
2A5 – Asphalt Roofing	investigate further whether this category is effectively NA or NO in Luxembourg.
2A6 – Road Paving with Asphalt	investigate further whether this category is effectively NA or NO in Luxembourg.
2A7 – Other – Glass Production	streamlining with the new 2006 IPCC Guidelines and the new 2007 ETS Guidelines.
2C1 – Iron and Steel Production	application of the mass balance approach according to the ETS guidelines.
2F – Consumption of Halocarbons & SF_6	complete re-evaluation including the results of a new study.
3D1 – N_2O from Anaesthesia	investigate the possibility of acquiring data on the consumption of anaesthesia products in Luxembourg.
3D2 - N_2O from fire extinguishers	correct CRF tables and change NE to NA, because no N_2O is used in fire extinguishers in Europe.
4A – Enteric Fermentation	analyse whether it would be possible to replace some default parameter values – such as GE – by national values.
4A1 – Cattle: net energy for activity	refine the calculation for this parameter taking into account the time spent by animals in stalls and on pastures.
4A3 – Sheep: live-weight	national statistics allow for a breakdown of sheep between lambs and mature animals, hence allow for calculating a more precise live-weight for this animal category since estimated weights are known for both lambs and mature animals.
4A4 - Goats	completing the time series for the years prior to 1997 (through the estimation of the number of animals).
4A8 – Swine	national statistics allow for a breakdown of swine in various sub-categories for which more precise parameter values could be applied.
4A9 – Poultry – Chickens	national statistics allow for a breakdown of chickens in various sub-categories for which more precise parameter values could be applied.
4A10 – Other	completing the time serie for the years prior to 1997 (through the estimation of the number of animals) and investigate whether it would be worth, straightforward and not time/resources consuming to include the missing farm animals (ostriches, “productive animals”).
4B – Manure Management - AWMS	analysing whether it would be feasible to refine AWMS per livestock category and through the reporting years.
4B – Manure Management – Other AWMS: Anaerobic Digester	analyze if it would be possible to use formula 1 under table 4.10 of the 2000 IPCC-GPG (p. 4.36) in order to refine/produce a reliable emission estimate for manure used in anaerobic digesters.
4B – Manure Management - Nex	analyzing whether it would be feasible to refine Nex per livestock category and through the reporting years.
4B4 - Goats	completing the time serie for the years prior to 1997 (through the estimation of the number of ani-

Issue GHG source & sink category	Planned improvement
Source categories improvements	
	mals).
4B8 – Swine	national statistics allow for a breakdown of swine in various sub-categories for which more precise parameter values could be applied.
4B9 – Poultry – Chickens	national statistics allow for a breakdown of chickens in various sub-categories for which more precise parameter values could be applied.
4B10 – Other	completing the time serie for the years prior to 1997 (through the estimation of the number of animals) and investigate whether it would be worth, straightforward and not time/resources consuming to include the missing farm animals (ostriches, "productive animals").
4D – Agricultural Soils	analyze whether it would be possible to replace some default parameters, coefficients or EFs by national values.
4D13 & 4D14 – Agricultural Soils – N-fixing Crops & Crop Residue	refine the various crop categories: allocation, possible correction, etc. especially with regard to the non N-fixing & the fixing crops as well with regard to forage crops contribution to emissions.
4D16 – Agricultural Soils – Other – Sewage Sludge Spreading	analyze further the impact of sludge spreading and compost application on agriculture GHG emissions in order to refine first estimates presented in the inventory.
4D3 – Indirect Emissions from Agricultural Soils	Reviewing the ammonia balance so to refine first estimates for this source sub-category.
4F – Field Burning of Agricultural Residues	refine the various crop categories: allocation, possible correction, etc. especially with regard to the non N-fixing & the fixing crops as well with regard to forage crops contribution to emissions.
5A-5F	update of land use and lad use change data using more detailed data based on aerial imagery (OBS) than Corine Land Cover
5A	include data from the GSE Forest Monitoring Study
5D-5F	investigate whether the required data is available for the estimation of emissions and removals of these sub-categories.
6A - SWDL	Calculation of emissions from waste deposits since 1950 using the 2006 IPPC spreadsheet model
6A –SWDL	Review of the data as the Stauss study does contain non compliant data, using real data from gas recuperations, updated waste compositions in accordance to pre-treatment of waste before landfilling,
6B2 – Domestic & Commercial WWH – N_2O	List of WWTPs which produce methane gas for energy reuse in combined heat/power generating systems
6B2 – Domestic & Commercial WWH – CH_4	The number of inhabitants which are connected or not connected to WWTPs will be updated
6B2 – Domestic & Commercial WWH	analyse whether it would be possible and/or necessary to estimate emissions from sewage sludge (knowing that sewage sludge spreading is accounted for in IPCC Category 4D).
6D – Other	Include aerobic pre-treatment of municipal waste before landfilling at SIDEC

Annex I – Regulation to set-up a NIS in Luxembourg (adopted by the Government during its session of 20th of July 2007)

Text in French.

Règlement grand-ducal du 1er août 2007 relatif à la mise en place d'un Système d'Inventaire National des émissions de gaz à effet de serre dans le cadre de la Convention-cadre des Nations Unies sur le Changement Climatique

Nous Henri, Grand-Duc de Luxembourg, Duc de Nassau,

Vu l'article 5 de la loi modifiée du 27 novembre 1980 ayant pour objet la création d'une Administration de l'environnement ;

Vu la loi du 4 mars 1994 portant approbation de la Convention-cadre des Nations Unies sur le Changement Climatique (ci-après dénommée *CCNUCC*), faite à New York, le 9 mai 1992 ;

Vu la loi du 29 novembre 2001 portant approbation du Protocole de Kyoto à la CCNUCC, fait à Kyoto, le 11 décembre 1997 ;

Vu la Décision n° 280/2004/CE du Parlement européen et du Conseil du 11 février 2004 relative au mécanisme pour surveiller les émissions de gaz à effet de serre dans la Communauté et mettre en œuvre le Protocole de Kyoto ;

Vu la Décision de la Commission du 10 février 2005 fixant les modalités d'exécution de la décision n° 280/2004/CE du Parlement européen et du Conseil relative à un mécanisme pour surveiller les émissions de gaz à effet de serre dans la Communauté et mettre en œuvre le Protocole de Kyoto (2005/166/CE) ;

Vu les accords dits de « Marrakech », et plus particulièrement la Décision 20/CP.7 de la Conférence des Parties de la CCNUCC portant sur la définition d'un cadre directeur des systèmes nationaux permettant d'estimer les émissions anthropiques par les sources et les absorptions anthropiques par les puits des gaz à effet de serre tel que prévu par l'article 5, paragraphe 1, du Protocole de Kyoto ;

Vu la fiche financière ;

Les avis de la Chambre de commerce, de la Chambre des métiers, de la Chambre des employés privés et de la Chambre des fonctionnaires et employés publics ayant été demandés ;

Vu l'article 2(1) de la loi modifiée du 12 juillet 1996 portant réforme du Conseil d'Etat et considérant qu'il y a urgence ;

Sur le rapport de Notre Ministre de l'Environnement et après délibération du Conseil de Gouvernement ;

Arrêtons:

Art. 1er: Objet

Le présent règlement a pour objet la mise en place d'un Système d'Inventaire National (ci-après dénommé *SIN*) tel que requis par l'article 5, paragraphe 1, du Protocole de Kyoto et l'article 4, paragraphe 4, de la Décision n° 280/2004/CE du Parlement européen et du Conseil du 11 février 2004. Il détermine également les modalités de fonctionnement du SIN dans le but de produire des inventaires annuels relatifs aux émissions de gaz à effet de serre conformes aux standards de qualité, aux formats et aux délais requis.

Art. 2: Annexe

Fait partie intégrante du présent règlement :

- Annexe I : Tableau des compétences sectorielles pour l'établissement de l'inventaire et rôles dévolus.

Art. 3: Entité nationale unique

Aux fins de l'établissement des inventaires et des rapports afférents, l'Administration de l'environnement est désignée Entité nationale unique.

Celle-ci a notamment pour missions :

- la gestion globale du SIN, y compris son développement, son fonctionnement, son suivi ainsi que l'engagement de toutes les mesures requises afin d'assurer son fonctionnement continu ;
- le suivi des règles pour l'établissement des inventaires édictées par le Groupe d'experts Intergouvernemental sur l'Evolution du Climat (*GIEC*) et adoptées par les instances de la CCNUC : « lignes directrices révisées pour les inventaires nationaux de gaz à effet de serre » et « guide des bonnes pratiques et de gestion des incertitudes dans les inventaires nationaux de gaz à effet de serre » ;
- d'informer les différents experts sectoriels concernés de tout changement dans les règles édictées par le GIEC et d'évaluer, avec ces experts sectoriels, l'impact de ces changements sur les méthodes de calcul et les estimations des émissions de gaz à effet de serre ;
- l'assistance aux experts sectoriels dans leur mission et leur formation ;
- la définition d'un échéancier pour la transmission des différents éléments requis pour l'établissement de l'inventaire et des rapports afférents, ainsi que le respect de cet échéancier ;
- la mise en place d'un système cohérent de documentation et d'archivage des différentes informations en relation avec le SIN ;
- le respect des procédures de contrôle et d'assurance qualité ;
- de définir et d'approuver, ensemble avec les experts sectoriels, les méthodes appropriées pour l'acquisition des données de base, pour procéder au choix et au calcul des facteurs d'émission, pour évaluer l'incertitude liée aux estimations des émissions et pour effectuer le contrôle et l'assurance de la qualité des estimations des émissions ;

- de compiler l'ensemble des données requises pour l'inventaire et les rapports afférents à l'aide d'outils informatiques propres et/ou distribués par le Secrétariat de la CCNUCC ;
- l'analyse et la définition des sources d'émissions essentielles ;
- la transmission au Ministère de l'Environnement du rapport annuel sur l'inventaire national conforme aux lignes directrices éditées par la CCNUCC, ainsi que des tableaux associés à ce rapport dans le format requis par la CCNUCC ;
- la rédaction et la mise à jour du rapport de mise en œuvre du SIN ;
- de soulever tous les problèmes pouvant survenir au sein du SIN et qui auraient comme conséquence un retard dans la transmission des inventaires et du rapport annuel sur l'inventaire national.

Art. 4: Calculs des émissions

Les émissions proprement dites sont calculées par des experts sectoriels à désigner pour les différents secteurs de l'inventaire.

Les experts sectoriels ont notamment les missions suivantes :

- choix des méthodes appropriées pour le calcul des émissions, notamment sur base des règles édictées par le GIEC ;
- établissement des données d'activités et des facteurs d'émissions nécessaires aux calculs des émissions ;
- calcul des émissions proprement dites ;
- recalcul des émissions passées lorsque ceci s'avère nécessaire (affinements ou changements de méthodes, prise en compte de nouvelles sources d'information, corrections d'erreurs) ;
- assurance de la qualité des données et contrôle de cette qualité ;
- préparation des éléments du rapport annuel sur l'inventaire national ;
- transmission à l'Entité nationale unique des données dans les formats requis et des éléments du rapport annuel sur l'inventaire national.

Art. 5: Mise à disposition des données

Les données nécessaires pour les calculs des émissions sont fournies aux experts sectoriels par les institutions reprises à l'annexe I tout en respectant les standards de qualité, les formats et les délais établis par l'Entité nationale unique.

Il s'agit notamment de données résultant de statistiques, d'inventaires ou d'autres sources de données établies par ces instances.

Art. 6: Désignation d'agents au sein de l'Administration de l'environnement

Au sein de l'Administration de l'environnement, le directeur désigne les agents suivants :

a) un agent chargé de la gestion de l'Entité nationale unique ;

b) les experts sectoriel ;

c) un agent qui doit assurer le contrôle de la qualité des inventaires. Cet agent a notamment pour missions d'élaborer et de mettre en œuvre le plan d'assurance et de contrôle de la qualité, y compris la définition des objectifs de qualité, la coordination des procédures de contrôle et d'assurance de la qualité, la coordination des processus régissant les vérifications des examens par des experts ainsi que les mises à jour et la maintenance des documents et des systèmes d'archivage selon les normes convenues ;

d) les agents en charge de fournir aux experts sectoriels les données conformément à l'article 5 du présent règlement.

Art. 7 : Désignation d'agents au sein d'institutions autres que l'Administration de l'environnement

Pour les secteurs de l'inventaire hors du champ de compétence de l'Administration de l'environnement, des agents sont désignés au sein des institutions respectives par le Ministre de l'Environnement sur proposition du Ministre de tutelle de l'institution concernée.

Ces agents sont nommés soit experts sectoriels, soit agents chargés de fournir les données nécessaires pour les calculs des émissions.

Les institutions concernées et les missions respectives sont reprises à l'annexe I du présent Règlement.

Art. 8: Transmission des inventaires et des rapports afférents

L'Administration de l'environnement transmet l'inventaire annuel et le rapport annuel sur l'inventaire national au Ministère de l'Environnement qui, en sa qualité de Point Focal sur le Changement Climatique, les transmet au Secrétariat de la CCNUCC et à la Commission européenne.

Art. 9: Entrée en vigueur

Le présent règlement entre en vigueur le jour de sa publication au Mémorial.

Art. 10: Exécution

Notre Ministre de l'Environnement est chargé de l'exécution du présent règlement qui sera publié au Mémorial.

Annexe I

Tableau des compétences sectorielles pour l'établissement de l'inventaire et rôles dévolus

Secteurs de l'inventaire	Institutions compétentes	Rôles dévolus pour la réalisation de l'inventaire
énergie : bilans énergétiques détaillés (vecteurs, production, consommation, importations, exportations, transformation)	Ministère de l'Economie et du Commerce Extérieur, STATEC	mise à disposition de données de base
	Administration de l'Environnement	expert sectoriel
transports	Ministère de l'Economie et du Commerce Extérieur, Ministère du Transport, SNCT, Administration des Douanes et Accises	mise à disposition de données de base
	Administration de l'Environnement	expert sectoriel
procédés industriels	Administration de l'Environnement	mise à disposition de données de base, expert sectoriel
utilisation de solvants et d'autres produits	Administration de l'Environnement	mise à disposition de données de base, expert sectoriel
agriculture	Service d'Economie rurale, Administration des Services Techniques de l'Agriculture	mise à disposition de données de base, experts sectoriels
utilisation des sols, changements d'affectation des sols et forêts	Ministère de l'Environnement, Administration des Eaux & Forêts	mise à disposition de données de base, experts sectoriels
déchets, épuration des eaux	Administration de l'Environnement, Administration de la Gestion de l'Eau	mise à disposition de données de base, experts sectoriels

Annex II - Table for methodologies, data sources and emission factors used by Luxembourg for submission 2009v1.4

The table on the next page corresponds to the table presented in Annex I of Community Decision 2005/166/EC. This table is an expansion of table Summary 3 of the CRF.

Table I -1: Community summary report for methods, activity data and emission factors used (Energy)

GREENHOUSE GAS SOURCE AND SINK	CO_2				CH_4				N_2O			
CATEGORIES	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)
1. Energy												
A. Fuel Combustion												
1. Energy Industries												
a. Public Electricity and Heat Production		T1 T2	NS PS IS	CS D		T1	NS PS IS	D		T1	NS PS IS	D
b. Petroleum Refining		NA	NO	NA		NA	NO	NA		NA	NO	NA
c. Manufacture of Solid Fuels and Other Energy Industries		NA	NO	NA		NA	NO	NA		NA	NO	NA
2. Manufacturing Industries and Construction												
a. Iron and Steel		T1 T2	NS PS IS	CS D PS		T1	NS PS IS	D		T1	NS PS IS	D
b. Non-Ferrous Metals		T1 T2	NS PS	CS D		T1	NS PS	D		T1	NS PS	D
c. Chemicals		T1 T2	NS PS	CS D		T1	NS PS	D		T1	NS PS	D
d. Pulp, Paper and Print		NA	NO	NA		NA	NO	NA		NA	NO	NA
e. Food Processing, Beverages and Tobacco		T1 T2	NS PS	CS D		T1	NS PS	D		T1	NS PS	D
f. Other *(as specified in table 1.A(a)s2)*		T1 T2	NS PS IS	CS D PS		T1	NS PS IS	D		T1	NS PS IS	D
3. Transport												
a. Civil Aviation		T1	NS PS	D		T1	NS PS	D		T1	NS PS	D
b. Road Transportation		COPERT IV	NS	D OTH		COPERT IV	NS	D OTH		COPERT IV	NS	D OTH
c. Railways		T1	NS PS	D		T1	NS PS	D		T1	NS PS	D
d. Navigation		T1	PS	D		T1	PS	D		T1	PS	D
e. Other Transportation *(as specified in table 1.A(a)s3)*		NA	NA	NA		NA	NA	NA		NA	NA	NA
4. Other Sectors												
a. Commercial/Institutional		T1 T2	NS IS	CS D		T1	NS IS	D		T1	NS IS	D
b. Residential		T1 T2	NS IS	CS D		T1	NS IS	D		T1	NS IS	D
c. Agriculture/Forestry/Fisheries		T1	NS IS	D		T1	NS IS	D		T1	NS IS	D
5. Other												
a. Stationary		T1	NS IS	D		T1	NS IS	D		T1	NS IS	D
b. Mobile		T1	NS IS	D		T1	NS IS	D		T1	NS IS	D
B. Fugitive Emissions from Fuels												
1. Solid Fuels												
a. Coal Mining		NA	NO	NA		NA	NO	NA		NA	NO	NA
b. Solid Fuel Transformation		NA	NO	NA		NA	NO	NA		NA	NO	NA
c. Other *(as specified in table 1.B.1)*		NA	NO	NA		NA	NO	NA		NA	NO	NA
2. Oil and Natural Gas												
a. Oil		NA	NE	NA		NA	NE	NA		NA	NE	NA
b. Natural Gas		T1	NS	D		T1	NS	D			NS	
c. Venting and Flaring		NA	NO	NA		NA	NO	NA		NA	NO	NA
d. Other *(as specified in table 1.B.2)*		NA	NA	NA		NA	NA	NA		NA	NA	NA

Table I -2: Community summary report for methods, activity data and emission factors used (industrial processes)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Key source (1)	CO_2 Method applied (2)	CO_2 Activity data (3)	CO_2 Emission factor (4)	CH_4 Key source (1)	CH_4 Method applied (2)	CH_4 Activity data (3)	CH_4 Emission factor (4)	N_2O Key source (1)	N_2O Method applied (2)	N_2O Activity data (3)	N_2O Emission factor (4)
2. Industrial Processes												
A. Mineral Products		CS T2	PS	CS PS		NA	NO	NA		NA	NO	NA
1. Cement Production		T2	PS	CS PS								
2. Lime Production		NA	NO	NA								
3. Limestone and Dolomite Use		NA	IE	NA								
4. Soda Ash Production and Use		NA	IE	NA								
5. Asphalt Roofing		NA	NO	NA								
6. Road Paving with Asphalt		NA	NO	NA								
7. Other *(as specified in table 2(I)A-G)*		CS	PS	PS		NA	NO	NA		NA	NO	NA
B. Chemical Industry		NA	NO	NA		NA	NO	NA		NA	NO	NA
1. Ammonia Production		NA	NO	NA		NA	NO	NA		NA	NO	NA
2. Nitric Acid Production										NA	NO	NA
3. Adipic Acid Production		NA	NO	NA						NA	NO	NA
4. Carbide Production		NA	NO	NA		NA	NO	NA				
5. Other *(as specified in table 2(I)A-G)*		NA	NO	NA		NA	NO	NA		NA	NO	NA
C. Metal Production		CS T2	NS PS	CS		NA	NO	NA		NA	NO	NA
1. Iron and Steel Production		CS T2	NS PS	CS		NA	NO	NA				
2. Ferroalloys Production		NA	NO	NA		NA	NO	NA				
3. Aluminium Production		NA	NO	NA		NA	NO	NA				
4. SF_6 Used in Aluminium and Magnesium Foundries												
5. Other *(as specified in table 2(I)A-G)*		NA	NO	NA		NA	NO	NA		NA	NO	NA
D. Other Production		NA	NO	NA								
1. Pulp and Paper												
2. Food and Drink		NA	NO	NA								
E. Production of Halocarbons and SF_6												
1. By-product Emissions												
2. Fugitive Emissions												
3. Other *(as specified in table 2(II)*												
F. Consumption of Halocarbons and SF_6												
1. Refrigeration and Air Conditioning Equipment												
2. Foam Blowing												
3. Fire Extinguishers												
4. Aerosols/ Metered Dose Inhalers												
5. Solvents												
6. Other applications using ODS substitutes												
7. Semiconductor Manufacture												
8. Electrical Equipment												
9. Other *(as specified in table 2(II)*												
G. Other		NA	NO	NA		NA	NO	NA		NA	NO	NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	HFCs Key source (1)	HFCs Method applied (2)	HFCs Activity data (3)	HFCs Emission factor (4)	PFCs Key source (1)	PFCs Method applied (2)	PFCs Activity data (3)	PFCs Emission factor (4)	SF_6 Key source (1)	SF_6 Method applied (2)	SF_6 Activity data (3)	SF_6 Emission factor (4)
2. Industrial Processes												
A. Mineral Products												
1. Cement Production												
2. Lime Production												
3. Limestone and Dolomite Use												
4. Soda Ash Production and Use												
5. Asphalt Roofing												
6. Road Paving with Asphalt												
7. Other *(as specified in table 2(I)A-G)*												
B. Chemical Industry		NA	NO	NA		NA	NO	NA		NA	NO	NA
1. Ammonia Production		NA	NO	NA		NA	NO	NA		NA	NO	NA
2. Nitric Acid Production		NA	NO	NA		NA	NO	NA		NA	NO	NA
3. Adipic Acid Production		NA	NO	NA		NA	NO	NA		NA	NO	NA
4. Carbide Production		NA	NO	NA		NA	NO	NA		NA	NO	NA
5. Other *(as specified in table 2(I)A-G)*		NA	NO	NA		NA	NO	NA		NA	NO	NA
C. Metal Production						NA	NO	NA		NA	NO	NA
1. Iron and Steel Production						NA	NO	NA		NA	NO	NA
2. Ferroalloys Production						NA	NO	NA		NA	NO	NA
3. Aluminium Production						NA	NO	NA		NA	NO	NA
4. SF_6 Used in Aluminium and Magnesium Foundries										NA	NO	NA
5. Other *(as specified in table 2(I)A-G)*						NA	NO	NA		NA	NO	NA
D. Other Production												
1. Pulp and Paper												
2. Food and Drink												
E. Production of Halocarbons and SF_6		NA	NO	NA		NA	NO	NA		NA	NO	NA
1. By-product Emissions		NA	NO	NA		NA	NO	NA		NA	NO	NA
2. Fugitive Emissions		NA	NO	NA		NA	NO	NA		NA	NO	NA
3. Other *(as specified in table 2(II)*		NA	NO	NA		NA	NO	NA		NA	NO	NA
F. Consumption of Halocarbons and SF_6		CS	Q	CS		NA	NO	NA		CS	Q	CS
1. Refrigeration and Air Conditioning Equipment		CS	Q	CS		NA	NO	NA		NA	NO	NA
2. Foam Blowing		CS	NS	CS		NA	NO	NA		NA	NO	NA
3. Fire Extinguishers		NA	NO	NA		NA	NO	NA		NA	NO	NA
4. Aerosols/ Metered Dose Inhalers		CS	Q	CS		NA	NO	NA		NA	NO	NA
5. Solvents		NA	NO	NA		NA	NO	NA		NA	NO	NA
6. Other applications using ODS substitutes		NA	NO	NA		NA	NO	NA		NA	NO	NA
7. Semiconductor Manufacture		NA	NO	NA		NA	NO	NA		NA	NO	NA
8. Electrical Equipment		NA	NO	NA		NA	NO	NA		CS	Q	CS
9. Other *(as specified in table 2(II)*		NA	NO	NA		NA	NO	NA		CS	Q	CS
G. Other		NA	NO	NA		NA	NO	NA		NA	NO	NA

Table I -3: Community summary report for methods, activity data and emission factors used (solvent and other product use, agriculture)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Key source (1)	CO_2 Method applied (2)	CO_2 Activity data (3)	CO_2 Emission factor (4)	CH_4 Key source (1)	CH_4 Method applied (2)	CH_4 Activity data (3)	CH_4 Emission factor (4)	N_2O Key source (1)	N_2O Method applied (2)	N_2O Activity data (3)	N_2O Emission factor (4)
3. Solvent and Other Product Use												
A. Paint Application		M	NS	M								
B. Degreasing and Dry Cleaning		M	NS	M						NA	NE	NA
C. Chemical Products, Manufacture and Processing												
D. Other		M	NS	M						CS	NS	CS
4. Agriculture												
A. Enteric Fermentation						T1 T2	NS	CS D				
1. Cattle						T2	NS	CS				
2. Buffalo						NA	NO	NA				
3. Sheep						T1	NS	D				
4. Other						T1	NS	D				
B. Manure Management						T1 T2	NS	CS D		T1	EJ	D
1. Cattle						T2	NS	CS		T1	EJ	D
2. Buffalo						NA	NO	NA		NA	NO	NA
3. Sheep						T1	NS	D		T1	EJ	D
4. Other						T1	NS	D		T1	EJ	D
8. Swine						T1	NS	D		T1	EJ	D
13. Solid Storage and Dry Lot										T1	EJ	D
C. Rice Cultivation						NA	NO	NA				
D. Agricultural Soils						NA	NO	NA		T1 T1a T1b	EJ NS	D
1. Direct Soil Emissions						NA	NA	NA		T1a T1b	EJ NS	D
2. Pasture, range and paddock manure										T1	EJ	D
3. Indirect Emissions						NA	NA	NA		T1b	EJ NS	D
4. Other *(as specified in table 4.D)*						NA	NO	NA		NA	NO	NA
E. Prescribed Burning of Savannas						NA	NO	NA		NA	NO	NA
F. Field Burning of Agricultural Residues						NA	NO	NA		NA	NO	NA
G. Other						NA	NO	NA		NA	NO	NA

Table I -4: Community summary report for methods, activity data and emission factors used (land-use change and forestry, waste, other)

GREENHOUSE GAS SOURCE AND SINK	CO_2				CH_4				N_2O			
CATEGORIES	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)
5. Land-Use, Land-Use Change and Forestry												
A. Forest Land		T1 T2	Q	CS D		NA	NE	NA		NA	NE	NA
1. Forest Land remaining Forest Lands		T2	Q	CS		NA	NE	NA		NA	NE	NA
2. Land converted to Forest Lands		T1	Q	CS D		NA	NO	NA		NA	NE	NA
B. Cropland		T1	Q	CS D		NA	NO	NA		T1	Q	D
1. Cropland remaining Cropland		T1	Q	CS D		NA	NO	NA		NA	NO	NA
2. Land converted to Cropland		T1	Q	CS D		NA	NO	NA		T1	Q	D
C. Grassland		T1	Q	D		NA	NO	NA		NA	NO	NA
1. Grassland remaining Grassland		NA	NO	NA		NA	NO	NA		NA	NO	NA
2. Land converted to Grassland		T1	Q	D		NA	NO	NA		NA	NO	NA
D. Wetlands		NA	NE	NA		NA	NO	NA		NA	NO	NA
1. Wetlands remaining Wetlands		NA	NE	NA		NA	NO	NA		NA	NO	NA
2. Land converted to Wetlands		NA	NO	NA		NA	NO	NA		NA	NO	NA
E. Settlements		NA	NE	NA		NA	NE	NA		NA	NE	NA
1. Settlements remaining Settlements		NA	NE	NA		NA	NE	NA		NA	NE	NA
2. Land converted to Settlements		NA	NE	NA		NA	NE	NA		NA	NE	NA
F. Other Land		NA	NE	NA		NA	NE	NA		NA	NE	NA
1. Other Land remaining Other Land						NA	NE	NA		NA	NE	NA
2. Land converted to Other Land		NA	NE	NA		NA	NE	NA		NA	NE	NA
G. Other (please specify)		NA	NE	NA		NA	NE	NA		NA	NE	NA
Harvested Wood Products		NA	NE	NA		NA	NE	NA		NA	NE	NA
6. Waste												
A. Solid Waste Disposal on Land		NA	NO	NA		T2	NS	D				
1. Managed Waste Disposal on Land		NA	NO	NA		T2	NS	D				
2. Unmanaged Waste Disposal Sites		NA	NO	NA		NA	NO	NA				
3. Other *(as specified in table 6.A)*		NA	NA	NA		NA	NA	NA				
B. Wastewater Handling						T1	NS	D		T1	NS	D PS
1. Industrial Wastewater						NA	NE	NA		T1	PS	PS
2. Domestic and Commercial Wastewater						T1	NS	CS		T1	NS	D
3. Other *(as specified in table 6.B)*						NA	NA	NA		NA	NA	NA
C. Waste Incineration		T2	NS Q	D		T1	NS Q	D		T1	NS Q	D
D. Other		NA	NO	NA		T1	NS PS	D		T1	NS PS	D
7. Other (as specified in Summary 1.A)												
Memo Items: (8)												
International Bunkers		T1	NS	D		T1	NS	D		T1	NS	D
Aviation		T1	NS	D		T1	NS	D		T1	NS	D
Marine		T1	NS	D		T1	NS	D		T1	NS	D
CO_2 Emissions from Biomass		T1	NS PS	D OTH								

Legend for tables I -1 to I -4

(1) Key sources of the Community. To be completed by Commission/EEA with results from key category analysis from previous inventory submission.

(2) Use the following notation keys to specify the method applied:

D (IPCC default),	**T1a, T1b, T1c** (IPCC Tier 1a, Tier 1b and Tier 1c, respectively),	**C** (CORINAIR),	**COPERT X** (Copert Model X = Version)
RA (Reference Approach),	**T2** (IPCC Tier 2),	**CS** (Country Specific).	
T1 (IPCC Tier 1),	**T3** (IPCC Tier 3),	**M** (Model)	

If using more than one method within one source category, enumerate the relevant methods. Explanations regarding country-specific methods or any modifications to the default IPCC methods, as well as information regarding the use of
Different methods per source category where more than one method is indicated, should be provided in the documentation box.

(3) Use the following notation keys to specify the sources of activity data used :

NS (national statistics),	**IS** (International statistics),	**AS** (associations, business organizations)
RS (regional statistics),	**PS** (Plant Specific data).	**Q** (specific questionnaires, surveys)

If keys above are not appropriate for national circumstances, use additional keys and explain those in the documentation box.
Where a mix of AD sources has been used, use different notations in one and the same cells with further explanations in the documentation box.

(4) Use the following notation keys to specify the emission factor used:

D (IPCC default),	**CS** (Country Specific),
C (CORINAIR),	**PS** (Plant Specific).

Where a mix of emission factors has been used, use different notations in one and the same cells with further explanations in the documentation box.

Documentation box:
* The full information on methodological issues, such as methods, activity data and emission factors used, can be found in the relevant sector sections of chapter 5 of the NIR. If any additional information is needed to understand the content of this table, use this documentation box to provide references to the relevant section of the NIR where further details can be found.
* Where a mix of methods/ emission factors has been used within one source category, use this documentation box to specify those methods/emission factors for the various sub-sources where they have been applied (see also footnotes 2 to 4 to this table).

1.A.1.a - CO2 - method	a T1 method has been applied for liquid fuels, a T2 method for solid & gaseous & other fuels. The latter covers municipal solid waste incineration with energy recovery. For biomass, a T2 method has been applied for the years 1990 & 1991, then, from 1992 onwards, a mix of T1 & T2 methods were applied according to the bio-fuel.
1.A.1.a - CO2 - EF	CS EFs have been used for solid and gaseous fuels.
1.A.1.a - all gases - AD	for liquid fuels: PS for steel industry up to 1997 (power plant runned by the steel industry and stopped when Luxembourg's steel industry move from blast furnaces to electrical arc furnaces was completed); NS & PS for all other plants; for solid fuels: PS for steel industry up to 1997 (see above). 1.A.1.a - solid fuels = NO from 1998 onwards since the last blast furnaces stopped its activities in September 1997 and since Luxembourg has no thermal power plant using solid fuels; for gaseous fuels: PS for steel industry up to 1997 (see above) ; NS & PS for all other plants (including Twinerg); for other fuels: covers municipal solid waste incineration with energy recovery. AD are a mix of NS (waste treated every year by the incinerator) and of Q data (analysis of the incinerated waste composition for the years 1992-94, 2001 and 2004-05).
1.A.2.a - CO2 - method	a T1 method has been applied for liquid fuels, a T2 method for gaseous fuels and a mix of T1 & T2 methods for solid fuels.
1.A.2.a - CO2 - EF	CS EFs have been used for gaseous fuels and a mix of CS & PS EFs for solid fuels.
1.A.2.a - all gases - AD	a combination of PS data (bottom-up) and NS & IS (top-down) was used.
1.A.2.b - CO2 - method	a T1 method has been applied for liquid fuels, a T2 method for gaseous fuels.
1.A.2.b - CO2 - EF	CS EFs have been used for gaseous fuels.
1.A.2.b - all gases - AD	a combination of PS data (bottom-up) and NS & IS (top-down) was used.
1.A.2.c - CO2 - method	a T1 method has been applied for liquid fuels, a T2 method for gaseous fuels.
1.A.2.c - CO2 - EF	CS EFs have been used for gaseous fuels.
1.A.2.c - all gases - AD	a combination of PS data (bottom-up) and NS (top-down) was used.
1.A.2.e - CO2 - method	a T1 method has been applied for liquid fuels, a T2 method for gaseous fuels.
1.A.2.e - CO2 - EF	CS EFs have been used for gaseous fuels.
1.A.2.e - all gases - AD	a combination of PS data (bottom-up) and NS (top-down) was used.
1.A.2.f - CO2 - method	a T1 method has been applied for all fuels except gaseous fuels for which a T2 method has been used.
1.A.2.f - CO2 - EF	CS EFs have been used for gaseous fuels and PS EFs have been used for other fuels (shredded tyres, fluff & sewage sludge)
1.A.2.f - all gases - AD	a combination of PS data (bottom-up) and NS & IS (top-down) was used.
1.A.3.b - road transportation - method	for COPERT IV one should read that COPERT IV method has been applied on NS for the vehicle fleet in Luxembourg. Then, the amount of fuel calculated via COPERT IV is deduced from the total amount of fuel sold in Luxembourg, the difference being 'fuel exports'. The latter is estimated using a T1 method with IEF calculated on the basis of domestic consumption, since not enough information on the type of transit vehicles fueling in Luxembourg is available.
1.A.3.b - road transportation - EF	for biomass (2004-2007 only), use of the EF suggested by the European Commission, hence the OTH notation key.
1.A.3.d - all gases - AD	consumption data from shipping activities was obtained directly from the operators, hence PS
1.A.4.a - all gases - method	a T1 method has been applied for liquid & solid fuels and for biomass, a T2 method for gaseous fuels.
1.A.4.a - all gases - EF	CS EFs have been used for gaseous fuels.
1.A.4.b - all gases - method	a T1 method has been applied for liquid & solid fuels and for biomass, a T2 method for gaseous fuels.
1.A.4.b - all gases - EF	CS EFs have been used for gaseous fuels.
1.A.4.c - all gases - AD	a combination of NS and IS was used.
1.A.5.a - all gases - AD	a combination of NS and IS was used.
1.A.5.b - all gases - AD	a combination of NS and IS was used.
2.A.1 - CO2 - EF	CS EF based on PS CaO content in clinkers provided every 5 years by the sole cement manufacturer operating in Luxembourg.
2.C.1 - CO2 - AD	NS for iron production (blast furnaces operating from 1990 to 1997) and steel production (basic oxygen furnace operating from 1990 to 1997). PS for sinter production (1990 to 1997) and steel production from electrical arc furnace (from 1993 onwards).
2.C.1 - CO2 - method	CS for every type of production and for every year, except T2 for blast furnaces and basic oxygen furnace in 1990 and T2 for electrical arc furnace (from 2004 onwards).
2.F.1 - HFCs - AD	based on a study realized end 1999 by the Environment Agency and the Centre des Ressources des Technologies pour l'Environnement (CRTE) and inter- and extrapolated using CS methods.
2.F.4 - HFCs - AD	based on a study realized end 1999 by the Environment Agency and the Centre des Ressources des Technologies pour l'Environnement (CRTE) and inter- and extrapolated using CS methods.
2.F.8 - SF6 - AD	based on a study realized end 1999 by the Environment Agency and the Centre des Ressources des Technologies pour l'Environnement (CRTE) and inter- and extrapolated using CS methods.
2.F.9 - SF6 - AD	based on a study realized end 1999 by the Environment Agency and the Centre des Ressources des Technologies pour l'Environnement (CRTE) and inter- and extrapolated using CS methods.
4.A.1 - CH4 - AD	the various AD needed to calculate CH4 emissions for cattle are coming from NS except for the Digestible Energy (DE) parameter for which we have used the German values.
4.B.1 - CH4 - AD	the various AD needed to calculate CH4 emissions for cattle are coming from NS except for the Digestible Energy (DE) parameter for which we have used the German values.
4.B.1/3/4/8/13 - N2O - AD	nitrogen excretion values per AWMS are deriving from an expert judgement (EJ).
4.D.1 - N2O - method	T1a for CRF categories 4.D.1.1/4 and T1b for CRF categories 4.D.1.2/3/6.
4.D.1 - N2O - AD	experts judgements (EJ) for nitrogen excretion values per AWMS (CRF category 4.D.1.2) and for sewage sludge production & spreading (CRF category 4.D.1.6).
4.D.2 - N2O - AD	nitrogen excretion values per AWMS are deriving from an expert judgement (EJ).
4.D.3 - N2O - AD	nitrogen excretion values per AWMS and sewage sludge production & spreading are deriving from experts judgements (EJ).
5 - CO2 & N2O - AD	land use and land use change data was obtained from the Corine Land Cover databas, hence Q.
6.C - all gases - AD	mix of NS (waste treated every year by the incinerator) and of Q data (analysis of the incinerated waste composition for the years 1992-94, 2001 and 2004-05). These data are reported under 1.A.1.a - other fuels.
6.D - CH4 & N2O - AD	mix of NS (for all the public recycling centers) and of PS data (Soil-Concept project).
CO2 emissions from biomass - AD	a combination of PS and NS, IS was used for 1.A.3.b, 1.A.4.a, 1.A.4.b & 1.A.4.c.