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DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère du Développement durable
et des Infrastructures

Administration de l'environnement

Luxembourg's National Inventory Report 1990-2009

Submission under the United Nations Framework
Convention on Climate Change
and under the Kyoto Protocol

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Tables & Figures

Executive Summary

ES.1. Background information on greenhouse gas inventories, climate change and supplementary information required under Article 7 paragraph 1, of the Kyoto Protocol

ES.1.1. Background information on climate change

Climate as such is the totality of all atmospheric conditions at a particular location. It undergoes natural variability. Since industrialisation started some 150 years ago, mankind has been influencing the climate via the emission of greenhouse gases. In 1994, by setting up the United Nations Framework Convention on Climate Change (UNFCCC), the nations of the world came together to start a process to prevent dangerous effects of climate change. However, the Convention did not include binding commitments. To go this step further the Kyoto Protocol was adopted in 1997, it sets binding targets for 37 industrialized countries.

ES.1.2. Background information on greenhouse gas inventories

In order to evaluate the trend of greenhouse gas emissions and the progress in achieving the reduction target, it is necessary to regularly compile an emissions inventory. The compilation of these inventories follows rules as set up by the UNFCCC and the Kyoto Protocol.

ES.1.3. Background information on supplementary information under Article 7, paragraph 1, of the Kyoto Protocol

Supplementary information to the annually submitted information under the UNFCCC is necessary to determine compliance with the regulations of the Kyoto Protocol. This is in particular (i) information on emissions and removals from the elements of the land use, land use change and forestry (LULUCF) sector that are relevant to the Kyoto Protocol, and (ii) information on the national registry which is responsible for accounting of the emission and removal units of each Party.

ES.2. Summary of National Emission and Removal Related Trends and Emission and Removals from KP-LULUCF activities

ES.2.1. Green House Gas Inventory

In 2009, Luxembourg's green house gas emissions amounted to a total of 11.68 million tonnes calculated in CO_2 equivalents (CO_2e) – excluding land-use, land-use change and forestry (*LULUCF*). Carbon dioxide (CO_2) was the main source of greenhouse gases (GHG) in Luxembourg (Table 0-1).

This source counted for 91.6% of the total GHG emissions (excluding LULUCF) total. The second source of GHG was nitrous oxide (*N_2O*) with about 3.9% of the total emissions excluding LULUCF. Methane (*CH_4*) was the third source with 3.8%. Fluorinated gases (*F-gases*) only accounted for 0.63% of the total emissions excluding LULUCF, with hydrofluorocarbons (*HFCs*) representing 0.56%, sulphur hexafluoride (*SF_6*) representing 0.06% and perfluorocarbons (*PFCs*) representing 0.002% of the national total (excl. LULUCF).

In 2009, total GHG emissions amounted to 11.68 Mio. t CO_2e, which is a decrease of 4.7% compared to 2008 and 8.9% below their base year level [1]. For the different GHG, trends over the period 1990-2009 (and 2008-2009) were as follows:

- CO_2: .... -9.78% (-5.03%)
- CH_4: .... -4.04% -0.06%)
- N_2O: ....-4.67% (-2.33%)
- F-gases: ....+400.26% (+4.11%)

Carbon dioxide emissions, over the period 1990-2009, are characterised by a V-shape evolution driven by changes in the sources of emissions: declining emissions in industrial, increasing emissions from transport and natural gas fired power plants. The last emission peak was attained in 2005 and, since then, the emissions seem to be continuously decreasing again.

Methane emissions have declined over the period due to the conjunction of reduced methane emissions in agriculture (-0.1%) and in waste management (-40.4%) and with growing emissions in energy use (+31.1%), 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 from combustion activities and the waste sector that could not be balanced by declining emissions from the agriculture and solvent and other product use sectors.

Finally, with regard to F-gases, HFCs emissions were almost 4 times higher in 2009 than in the base year, whereas SF_6 emissions showed a 5 fold increase between 1990 and 2009.

ES.2.2. KP-LULUCF activities

In 2009, Article 3.3 activities were a net source in Luxembourg: Net CO_2 emissions amounted to 63.36 Gg.

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1 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 2-10).

Removals from afforestation/reforestation amounted to 78.0 Gg CO_2. About 2/3 of these gains were caused by the C stock increases in living biomass, 1/3 was due increases in soil and litter at the aforestation/reforestation (*AR*) areas.

In the same year, emissions from deforestation amounted to 141.4 Gg CO_2. About 90% were due to biomass losses, and 10% due to C stock losses in litter and soil.

Due to the nature and permanence of aforestation/reforestation and deforestation (*ARD*) areas, there is from 1990 on a steady increase in ARD areas and related to that a steady increase of removals and emissions, respectively, at these areas.

ES.3. Overview of Source and Sink Category Emission Estimates and Trends, including KP-LULUCF activities

ES.3.1. Green House Gas Inventory

Table 0-2 splits up total GHG emissions of Luxembourg for the seven CRF sectors to be included in the inventories. In 2009, the energy sector accounted for almost 88.0% of the total GHG emissions, excluding LULUCF. Two sectors represented between 5% and 6% of the total emissions, excluding LULUCF: industrial processes (5.5%) and agriculture (5.8%). The remaining sectors[2] (solvent and other product use (0.14%), waste[3] (0.57%)) were not even reaching 1% of the total GHG emitted in Luxembourg.

For the different sectors, trends over the period 1990-2009 (and 2008-2009) were as follows:

- Energy: ....-0.58% (-4.7%)
- Industrial Processes: ....-60.4% (-9.1%)
- Solvent and Other Product Use: ....-33.0% (-5.22%)
- Agriculture: ....-9.6% (+0.67%)
- LULUCF:..-185.2% +8.85%)
- Waste: ....-25.5% (-5.00%)

Emission reductions observed in all sectors could just balance the growth of energy use and production related emissions whose contribution to total GHG emissions, excluding LULUCF, ranged from 81% to 89% over the period 1990 to 2009. Within the energy sector, the fastest growing sub-

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2 The sector "other" is not reported for Luxembourg.

3 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).

sectors were energy industries (1A1) (due to the operational start of the Twinerg gas turbine in 2001) and transportation (1A3): +3159% and +130%, respectively between 1990 and 2009 (+14.6% and -7.8 from 2008 to 2009) with, as a result, a share in the total energy related GHG emissions rising from 0.34% to 11.3% and 25.6% to 59.4%, respectively. For the other sub-sectors, the observed trends between 1990 and 2009 are -81.6% for manufacturing industries (1A2), +39.8% for the other sectors (1A4), and +158.7% for fugitive emissions from fuels (1B).[4]

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 87% since 1990. Compared to 2008, emissions from industrial processes decreased by 9.1% which is mainly due to the economic crisis wich began in the second half of 2008.

Trends in agriculture were also favourable between 1990 and 2009: declining GHG emissions were observed for agricultural soils (4D: -15.2%), whereas enteric fermentation and manure management decreased by 5.8% and 1.0%, respectively.

In the waste sector, the main source of GHG was solid waste disposal on land (6A), but its weight decreased over the period 1990-2009 due to the combination of reduced amounts of landfilled waste and of increased emissions arising from composting activities (6D). GHG emission reduction for solid waste disposal on land (-50% between 1990 and 2009) still drove a reduction for the overall waste sector despite rising emissions from composting. Wastewater handling emissions (6B) decreased by 6.9% over the same period.

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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 CO_2 from 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.

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

ES.3.2. KP-LULUCF activities

In 2009, Article 3.3 activities were a net source in Luxembourg: Net CO_2 emissions amounted to 63.36 Gg.

Removals from afforestation/reforestation amounted to 78.0 Gg CO_2. About 2/3 of these gains were caused by the C stock increases in living biomass, 1/3 was due increases in soil and litter at the AR areas.

In the same year, emissions from deforestation amounted to 141.4 Gg CO_2. About 90% were due to biomass losses, and 10% due to C stock losses in litter and soil.

Due to the nature and permanence of ARD areas, there is from 1990 on a steady increase in ARD areas and related to that a steady increase of removals and emissions, respectively, at these areas.

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: 1990-2009

Gg (1000 t.) CO_2 e	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2	11870.82	12391.62	12169.15	12290.15	11471.84	9132.40	9180.32	8479.89	7596.75	8002.17	8771.36	9301.27	10059.83	10517.07	11881.84	12154.36	12030.71	11425.30	11277.25	10710.06
	92.54%	92.70%	92.54%	92.66%	92.28%	90.39%	90.31%	89.66%	88.61%	89.00%	89.81%	90.52%	91.09%	91.56%	92.11%	92.41%	92.42%	92.16%	91.99%	91.66%
CH_4 (1)	467.13	478.70	469.11	471.97	466.55	474.75	478.73	473.72	472.68	480.29	471.58	471.47	472.13	462.27	456.18	455.29	450.74	445.94	448.54	448.26
	3.64%	3.58%	3.57%	3.56%	3.75%	4.70%	4.71%	5.01%	5.51%	5.34%	4.83%	4.59%	4.27%	4.02%	3.54%	3.46%	3.46%	3.60%	3.66%	3.84%
N_2O (2)	474.84	482.11	497.76	486.75	476.74	479.38	488.00	485.07	482.19	483.01	492.49	465.25	466.77	455.52	507.99	484.32	473.66	458.94	463.48	452.67
	3.70%	3.61%	3.78%	3.67%	3.84%	4.74%	4.80%	5.13%	5.62%	5.37%	5.04%	4.53%	4.23%	3.97%	3.94%	3.68%	3.64%	3.70%	3.78%	3.87%
HFCs (3)	13.54	13.54	13.54	13.83	14.32	15.62	16.02	17.32	20.14	24.12	28.79	34.38	42.09	47.00	49.40	53.23	57.15	61.33	63.68	65.78
	0.11%	0.10%	0.10%	0.10%	0.12%	0.15%	0.16%	0.18%	0.23%	0.27%	0.29%	0.33%	0.38%	0.41%	0.38%	0.40%	0.44%	0.49%	0.52%	0.56%
PFCs (3)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.01	0.01	0.01	0.02	0.11	0.15	0.17	0.21	0.24	0.22
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SF_6 (3)	1.13	1.21	1.29	1.37	1.46	1.55	1.71	1.87	1.97	2.05	2.15	2.82	3.37	4.09	4.60	5.04	5.71	6.15	6.57	7.40
	0.01%	0.01%	0.01%	0.01%	0.01%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.03%	0.03%	0.04%	0.04%	0.04%	0.04%	0.05%	0.05%	0.06%
Total GHG excluding LULUCF	12827.46	13367.18	13150.85	13264.08	12430.92	10103.70	10164.79	9457.88	8573.72	8991.63	9766.38	10275.20	11044.20	11485.97	12900.12	13152.40	13018.13	12397.88	12259.77	11684.38
	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%	100.00%	100.00%

Source: Environment Agency
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. HFCs, PFCs and SF_6 expressed in CO_2 equivalents using 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: 1990-2009

Gg (1000 t.) CO_2 e	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	10344.59	10952.79	10812.56	10961.55	10240.41	8257.42	8367.61	7780.81	7059.81	7428.35	8186.68	8775.84	9528.23	10064.17	11405.66	11684.01	11501.69	10884.07	10796.40	10284.96
	80.64%	81.94%	82.22%	82.64%	82.38%	81.73%	82.32%	82.27%	82.34%	82.61%	83.83%	85.41%	86.27%	87.62%	88.42%	88.84%	88.35%	87.79%	88.06%	88.02%
2. Industrial Processes	1623.03	1545.26	1475.28	1453.43	1361.97	1001.67	946.46	839.27	683.09	725.20	756.73	705.08	729.20	674.71	719.92	716.34	773.44	767.44	706.21	642.21
	12.65%	11.56%	11.22%	10.96%	10.96%	9.91%	9.31%	8.87%	7.97%	8.07%	7.75%	6.86%	6.60%	5.87%	5.58%	5.45%	5.94%	6.19%	5.76%	5.50%
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	15.09	17.39	16.65	16.25	17.48	16.90	16.02
	0.19%	0.17%	0.17%	0.16%	0.16%	0.20%	0.19%	0.20%	0.21%	0.19%	0.16%	0.16%	0.15%	0.13%	0.13%	0.13%	0.12%	0.14%	0.14%	0.14%
4. Agriculture	745.87	754.16	748.70	735.64	718.60	737.15	746.91	734.48	728.82	738.46	724.11	697.23	690.41	650.49	680.78	660.63	652.39	656.42	669.63	674.09
	5.81%	5.64%	5.69%	5.55%	5.78%	7.30%	7.35%	7.77%	8.50%	8.21%	7.41%	6.79%	6.25%	5.66%	5.28%	5.02%	5.01%	5.29%	5.46%	5.77%
5. LULUCF	347.75	172.43	-195.75	-305.83	-135.96	-238.10	-410.64	-451.08	-195.50	-318.81	-385.41	-451.56	-451.26	-459.74	-414.49	-385.65	-275.59	-273.18	-272.34	-296.43
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	90.06	91.98	92.43	92.61	90.36	87.73	84.39	84.32	84.12	82.32	83.05	80.51	79.61	81.52	76.36	74.78	74.36	72.47	70.63	67.10
	0.70%	0.69%	0.70%	0.70%	0.73%	0.87%	0.83%	0.89%	0.98%	0.92%	0.85%	0.78%	0.72%	0.71%	0.59%	0.57%	0.57%	0.58%	0.58%	0.57%
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	NA	NA	NA	NA
Total GHG including LULUCF	13175.21	13539.61	12955.10	12958.25	12294.96	9865.60	9754.15	9006.80	8378.22	8672.82	9380.97	9823.64	10592.94	11026.24	12485.62	12766.74	12742.55	12124.71	11987.43	11387.95
	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%	100.00%	100.00%
Total GHG excluding LULUCF	12827.46	13367.18	13150.85	13264.08	12430.92	10103.70	10164.79	9457.88	8573.72	8991.63	9766.38	10275.20	11044.20	11485.97	12900.12	13152.40	13018.13	12397.88	12259.77	11684.38
	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%	100.00%	100.00%

Source: Environment Agency
Notes: Percentages are relative to the total GHG emissions excluding LULUCF.

1 Introduction

1.1 Background information on greenhouse gas inventories, climate change and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

1.1.1 Background information on climate change

1.1.1.1 Global Warming

Global warming is the increase in the average temperature of Earth's near-surface air and oceans since the mid-20th century and its projected continuation. Global surface temperature increased 0.74 ± 0.18 °C between the start and the end of the 20th century.[5] The Intergovernmental Panel on Climate Change (IPCC) concludes that most of the observed temperature increase since the middle of the 20th century was very likely caused by increasing concentrations of greenhouse gases resulting from human activity such as fossil fuel burning and deforestation. The IPCC also concludes that variations in natural phenomena such as solar radiation and volcanic eruptions had a small cooling effect after 1950.

Climate model projections summarized in the latest IPCC report indicate that the global surface temperature is likely to rise a further 1.1 to 6.4 °C during the 21st century. The uncertainty on this estimate arises from the use of models with differing sensitivity to greenhouse gas concentrations and the use of differing estimates of future greenhouse gas emissions. Most studies focus on the period leading up to the year 2100. However, warming is expected to continue beyond 2100 even if emissions stop, because of the large heat capacity of the oceans and the long lifetime of carbon dioxide in the atmosphere.

An increase in global temperature will cause sea levels to rise and will change the amount and pattern of precipitation, probably including expansion of subtropical deserts. Warming is expected to be strongest in the Arctic and would be associated with continuing retreat of glaciers, permafrost and sea ice. Other likely effects include changes in the frequency and intensity of extreme weather events, species extinctions, and changes in agricultural yields. Warming and related changes will vary from region to region around the globe, though the nature of these regional variations is uncertain.

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5 IPCC (2007-05-04), "Summary for Policymakers" (PDF). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. http://www.ipcc-wg1.unibe.ch/publications/wg1-ar4/wg1-ar4-spm.pdf. Retrieved 2010-03-23.

1.1.1.2 Climate Change in Luxembourg

Annual mean temperatures for Luxembourg-City are nowadays usually above the 30 years averages of the last century. Indeed, the 1951-1980, the 1961-1990 or the 1971-2000 mean yearly temperatures for the capital city – around 9°C – are nowadays regularly exceeded: since the turn of the 21st century, annual mean temperatures are comprised between 9.3°C (2001) and 11.3°C (2007). Yearly averages increase is mainly driven by higher air temperatures during winter seasons. Other meteorological stations disseminated throughout the country show similar results. With regard to other meteorological parameters – rainfalls, sunshine hours, relative humidity – no clear trends can be identified yet, probably because the very small size of the country (2 586 km^2) limits the identification of such changes.

Climate change effects are also witnessed by increasing frost-free periods, earlier blooming seasons and higher flood frequencies over the last 20 years. For the future, higher average yearly temperatures are anticipated with consequences on public health (heat waves), floods (higher frequency and intensity), vegetation cycles (longer periods with frost risks after early blooming) and forests (degradation of its phytosanitary state).

More details are provided in Section 2.1.2 of the NIR.

1.1.1.3 The Convention, the Kyoto Protocol and its flexible mechanisms

In 1992 Luxembourg signed the United Nations Framework Convention on Climate Change (UNFCCC) which sets an ultimate objective of stabilizing atmospheric concentrations of greenhouse gases at levels that would prevent "dangerous" human interference with the climate system. Such levels, which the Convention does not quantify, should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The UNFCCC covers all greenhouse gases not covered by the Montreal protocol : carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) as well as hydrogenated fluorocarbons (HFCs), perfluorated halocarbons (PFCs) and sulphur hexafluoride (SF_6).

Five years after adoption of the Climate Change Convention in 1997, governments took a further step forward and adopted the Kyoto Protocol (KP). Building on the Convention, the Kyoto Protocol sets out legally binding constraints on greenhouse gas emissions and "mechanisms" aimed at cutting the cost of curbing emissions. Under the terms of the Protocol, the industrialised parties – known as Annex 1 countries – pledged to reduce their greenhouse gas (GHG) emissions by 5% below the 1990 levels by the period 2008–2012. The European Union is also a Party to the Convention and the KP and agreed on a reduction target of 8% below 1990 levels during the five-year commitment period from 2008 to 2012. The EU and its Member States decided to achieve this goal jointly, for Luxembourg an emission target of minus 28% was set.

During an extensive review process in 2007, the so called Pre-commitment period review, the percentual reduction commitments of the Annex 1 countries were converted and fixed to absolute emission values, the so called assigned amounts.

Luxembourg signed the KP on 29th April 1998, and ratified the protocol on 31st May 2002. The KP entered into force on 16 February 2005, triggered by Russia's ratification in November 2004 which fulfilled the requirement that at least 55 Parties to the Convention ratified the Protocol.

The Protocol sets out three 'flexible mechanisms' to help countries meet their obligations to cut emissions.

- *Emission Trading*: Article 17 of the Kyoto Protocol allows Annex I Parties (basically, the industrialised nations) to purchase the rights to emit GHG from other Annex I countries which have reduced their GHG emissions below their assigned amounts. Trading can be carried out by intergovernmental emission trading, or entity-source trading where assigned amounts are allocated to sub-national entities.
- *Joint Implementation*: Article 6 allows an Annex I Party to gain a credit (converted to Assigned Amounts) by investing in another Annex I country in a project which reduces GHG emissions.
- *Clean Development Mechanism*: Article 12 allows an Annex I country (or companies in an Annex 1 country) which funds projects in developing countries (non-Annex I Party) to get credits for certified emission reductions providing that "benefits" accrue for the host country.

1.1.2 Background information on greenhouse gas inventories

As a Party to the UNFCCC, Luxembourg is required to produce and regularly update national GHG inventories, as well as to submit a National Inventory Report (NIR) containing detailed and complete information on the inventory, in order to ensure its transparency. To date, GHG inventories have been produced for the years 1990 to 2009, and NIRs have been submitted for the years 2006-2011.

Responsible for the preparation of Luxembourg's National Greenhouse Gas Inventory as well as the preparation of the NIR is the Air and Noise Division of the Environment Agency, under the political responsibility of the Ministry of Sustainable Development and Infrastructures.

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 NIR submitted in 2010.[6] It is based on data submitted to the UNFCCC in the Common Reporting Format (*CRF*) on 15 April 2011: submission 2011v1.3.[7] Besides being a submission under the UNFCCC, submission 2011v1.3 is also a mandatory submission under the Kyoto Protocol.

The structure of this NIR follows, as much as possible, the outlines as set out in the updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11 (see document FCCC/SBSTA/2006/9), as well as the annotated outline of the NIR that can be found on the UNFCCC website.[8]

This report was compiled by Dr Marc Schuman (Environment Agency). Specific responsibilities for this 2011 NIR have been as follows:

Executive Summary:	Marc Schuman
Chapter 1:	Marc Schuman (except 1.6: Kirsten Franz; 1.7: Traute Köther (UBA Austria))
Chapter 2:	Eric De Brabanter & Marc Schuman
Chapter 3:	Marc Schuman
Chapter 4:	Pierre Dornseiffer (except 4.7: Marc Schuman)
Chapter 5:	Marc Schuman with the help of Traute Köther
Chapter 6:	Eric De Brabanter, Jean-Paul Hoffmann
Chapter 7:	Willibald Croi, Jean-Paul Hoffmann, Georges Kugener, Marc Schuman, Marc Weyland, with the help of Peter Weiss (UBA Austria);
Chapter 8:	Serge Less, Dominique Manetta

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6 Luxembourg's National Inventory Report dated 30 June 2010 (covering inventory years 1990 to 2008)

7 Submission 2011v1.3 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.

8 ARR 2009, §17

Chapters 9 & 10:	Marc Schuman
Chapter 11:	Willibald Croi, Georges Kugener, Marc Schuman, with the help of Peter Weiss (UBA Austria)
Chapters 12 - 14:	Martine Kemmer, Marc Schuman
Chapters 15 & 16:	Marc Schuman

The GHG inventory reviewed in the present NIR covers the period 1990-2009 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 partially 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 are not discussed in this NIR and generating better emission estimates for these gases are part of our planned improvements.

1.1.3 Background information on supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

Besides the information that Parties to the Convention have to report annually, Parties to the Kyoto Protocol are additionally required to report supplementary information necessary to determine compliance with the regulations of the Protocol. This information is generally referred to as "supplementary information under Article 7, paragraph 1 of the Kyoto Protocol". Main elements of this information are the reporting on Kyoto Protocol 3.3 and 3.4 activities and reporting on national registries and Kyoto Protocol units:

1.1.3.1 Article 3.3 and 3.4 activities

Luxembourg reports only the mandatory Art. 3.3 activities. They include emissions/removals from human-induced Afforestation/Reforestation/Deforestation activities since 1990. In addition, Parties may elect to include emissions/removals from any of the following human-induced activities since 1990 (Art. 3.4): Forest management, Cropland management, Grazing land management and Revegetation. Despite its sink in CRF sector 5.A., Luxembourg has not elected any Article 3.4 activities due to the lack of reliable data allowing producing realistic estimates of the activities covered under Article 3.4.[9]

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[9] Luxembourg's initial report under the Kyoto Protokol (29.12.2006), Ministère de l'Environnement, http://unfccc.int/files/national_reports/initial_reports_under_the_kyoto_protocol/application/pdf/mev_initial_report_0612.pdf

Furthermore, Parties had to elect the accounting frequency for 3.3 and 3.4 activities: annual or at the end of the Commitment Period (for all other sectors the accounting frequency is annually). For the mandatory 3.3 activities Luxembourg has chosen accounting at the end of the Commitment Period.

1.1.3.2 National registry and Kyoto Protocol Units

Each Party to the Kyoto Protocol has to operate a national registry following the standards as defined in the Data Exchange Standards for Registry Systems under the Kyoto Protocol. The registry is an electronic database for the administration of Kyoto units that are used to account for greenhouse gas emissions under the commitments of the Kyoto Protocol. Like banks recording balances and transactions of money in accounts belonging to individuals or other entities, registries record balances of units of greenhouse gas emissions, so called Kyoto units, which are allocated to countries or other entities. The registry ensures the precise tracking of holdings, issuances, transfers, cancellations and retirements of allowances and Kyoto units.

Different types of Kyoto units exist, e.g. depending on the source of emissions/removals:

- Assigned Amount Units (AAUs) are the tradable units of the Assigned Amount (AA), which a country with a reduction commitment (Annex B country) gets allocated.
- Removal Units (RMUs) are Kyoto units which Annex B Parties can generate e.g. through national afforestation and other sink projects.
- Emissions Reduction Units (ERUs) are generated by Joint Implementation projects.
- Certified Emissions Reductions (CERs) are generated from Clean Development Projects.

Additionally, registries of EC and EEA countries administrate the European Emissions Trading Scheme, the traded units are EU Allowances (EUAs).

For more information on the National Registry and Kyoto Protocol Units, please refer to chapters 12 and 14.

1.2 Institutional Arrangement for Inventory Preparation including the legal and procedural arrangements for inventory planning, preparation and management

1.2.1 Overview of institutional, legal and procedural arrangements of compiling GHG inventory and supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

1.2.1.1 Overview of Luxembourg's obligations

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.

1.2.1.2 Luxembourg's 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 are involved in the inventory preparation in the future.

1.2.1.2.1 Single National Entity and other cross-cutting roles

The previously cited regulation designates the Environment Agency (*Administration de l'Environnement, AEV*)[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 "National Inventory Compiler" compiling and checking the information and GHG emission estimates coming from sector experts working in other administrations or services.

The Environment Agency has therefore the "technical" knowledge and responsibility for the GHG Inventories, but the "political" responsibility is staying with the Department of the Environment of the Ministry of Sustainable Development and Infrastructures – hereafter designated as MDDI-DEV – acting as UNFCCC National Focal Point. Thus, it is the Ministry that officially submits the inven-

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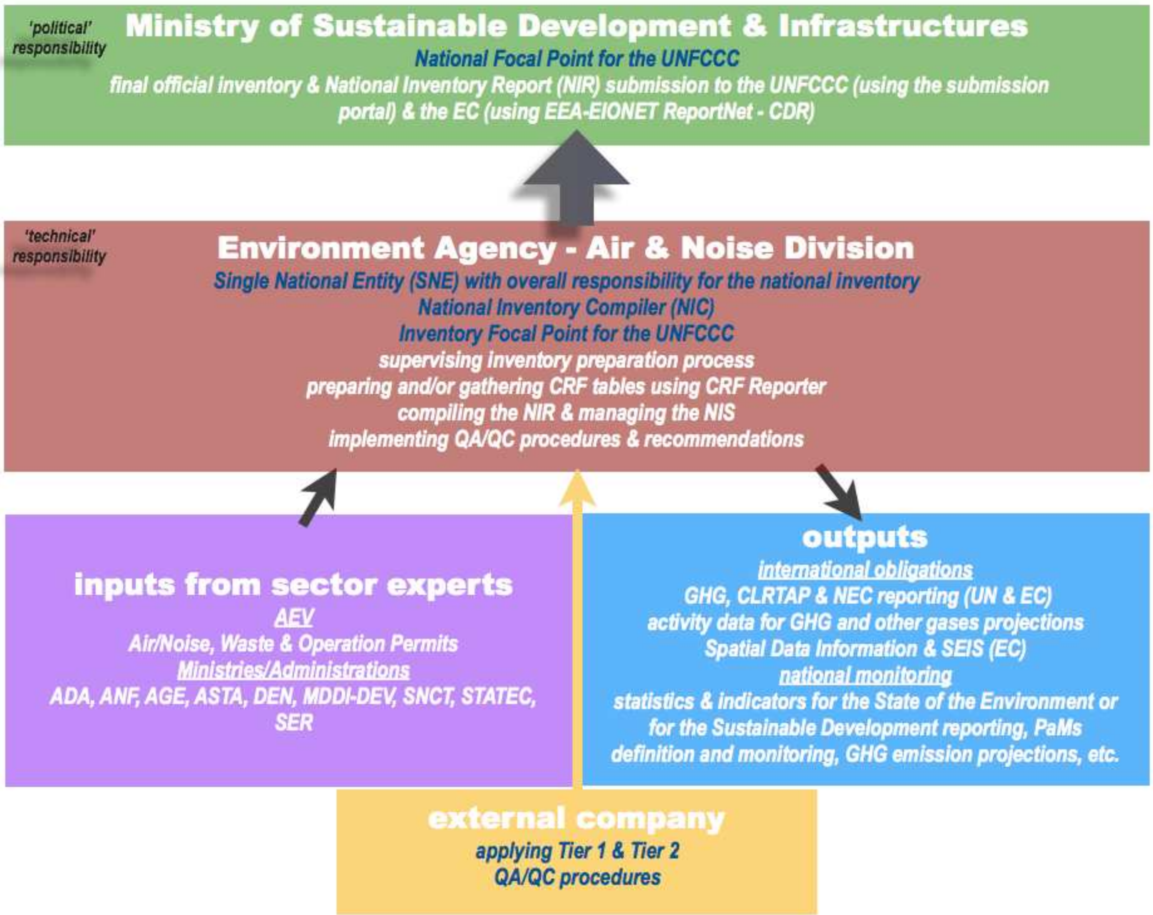
10 Règlement grand-ducal du 1er août 2007 relatif à la mise en place d'un Système d'Inventaire National des émissions de gaz à effet de serre dans le cadre de la Convention-cadre des Nations Unies sur le Changement Climatique, Mémorial A-N° 130 du 7 août 2007, pp. 2318-2320 : see http://www.legilux.public.lu/leg/a/archives/2007/1300708/1300708.pdf.

11 The Environment Agency is directly linked to the Ministry of Sustainable Development and Infrastructures 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).

tories and their related reports to the UNFCCC Secretariat and the European Commission (see Article 8 of the Regulation).

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 Air/Noise Division of this Agency is not only dealing with GHG reporting but also with reporting under the UNECE LRTAP Convention 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" – are extracted and adapted from the CLRTAP/NEC reporting schemes.

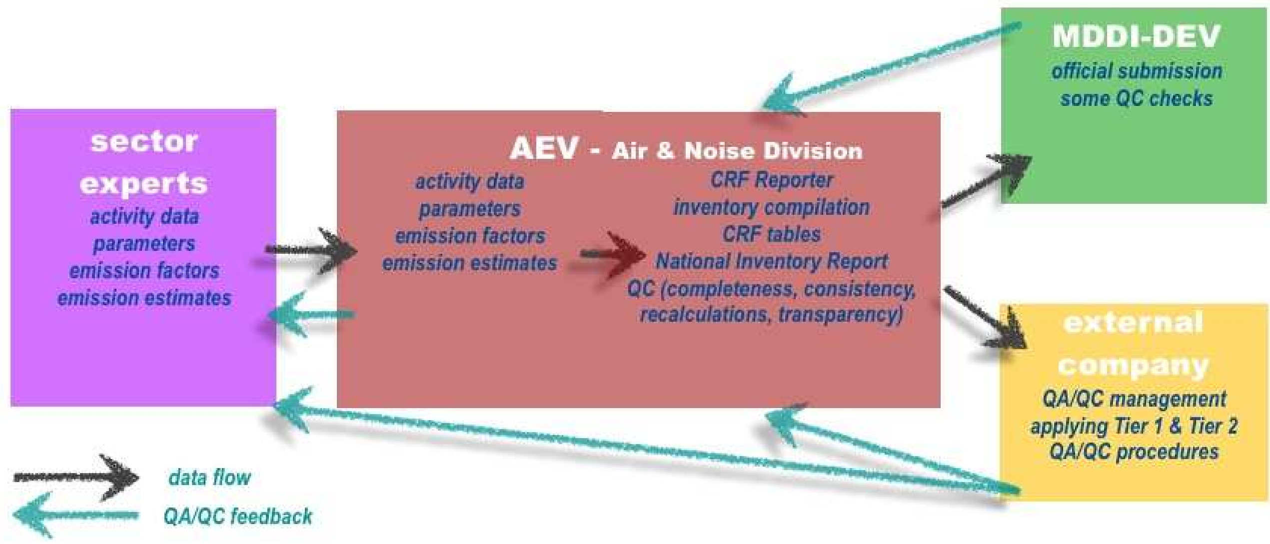
With regard to inputs for the monitoring of GHG emissions, having E-PRTR and EU-ETS managed by the Air/Noise Division of the Environment Agency ensures easy access to facilities' reported fuel and/or emissions that are subsequently integrated in GHG emissions calculations. The Environment Agency also 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 Air/Noise 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 1.6).

Figure 1-2 goes over the data flow process that is implied by the setting-up of the NIS. The Air/Noise Division of the Environment Agency not only collects and validates AD, EF, parameters and emission estimates from sector experts and compiles the inventories, 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

1.2.1.2.2 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	ANF – MDDI – SER – ASTA - AEV	ANF – SER – ASTA	ANF – 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 Sustainable Development and Infrastructures (MDDI): http://www.emwelt.lu/:

ANF = Nature & Forestry Administration (*Administration de la Nature et des 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

1.2.1.2.3 Luxembourg's emissions trading registry

Luxembourg's emissions trading registry is managed by Environment Agency on behalf of the Ministry of Sustainable Development and Infrastructures. This mandate was given to Environment Agency by the modified law of 23 décembre 2004 creating the emissions trading registry[14]. The Environment Agency has contracted Dr. Lippke & Dr. Wagner GmbH (Berlin) and Colt Telecom GmbH to support running the registry. The Environment Agency has the overall responsibility for the management of the registry and serves as a contact point for national and international authorities. Dr. Lippke & Dr. Wagner GmbH (Berlin) GmbH, on the other hand, is responsible for the software development and Colt Telecom GmbH is responsible for the operational management of the registry.

14 Loi du 23 décembre 2004 établissant un système d'échange de quotas d'émision de gaz à effet de serre, modifé par la loi du 27mars 2006. http://www.legilux.public.lu/leg/textescoodonnes/compilation/code_environnement/VOLUME/ATMOSPHERE/ATMOSPH1.pdf

Luxembourg's emissions trading registry has been operational since 2005 and serves both as registry for the EU Emissions Trading Scheme, and as the national registry for Luxembourg as a Party of the Kyoto Protocol.

1.2.2 Overview of inventory planning

The main planning of Luxembourg's GHG inventory is performed once a year during summer at the so called Decision Making Body meeting: a meeting between the Director of the Environment Agency, the head of the Air/Noise Division, the quality manager, and the national inventory compiler.

During the meeting, the quality manger and the national inventory compiler present an overview of the activities, during the previous reporting period, including information on audits and fulfilments of last year's improvement plan. On the basis of this report, the quality management system (QMS) is judged by the director and the head of the Air/Noise division, in collaboration with the quality manager and the national inventory compiler. If required, measures to optimize the QMS are defined. Finally, the improvement plan is elaborated on the basis of the previously conducted discussions. It consists of two parts:

- Quality management improvement plan: bases on findings of internal and external audits; it also includes a training plan for sector experts.
- Inventory improvement plan: bases on particular findings of reviews of the GHG inventory.

The decision making body prioritises the recommended improvements (including a timeline and responsibilities) and cares for associated resources.

1.2.3 Overview of inventory preparation and management, including for supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

Table 1-2 gives an overview on the tasks of inventory preparation together with a typical timeline.

Table 1-2– Inventory preparation timeline

Task	Description	Deadline
Decision making body meeting	Evaluation of the fulfilment of the previous improvement plan Preparation of a plan for QMS and inventory improvement, i.a. based on audit and review findings.	Summer
Kick-Off	Meeting of sector experts, quality manager and national inventory comiler; definition of a work plan	Summer
Activity data collection	Collection of activity data, including contracting out studies.	November 1st
Inventory preparation	Estimation of emissions for all sources, including collection of background data.	December 1st
Compilation of national inventory	Stocking the database and transfer to CRF reporter ; key category analysis and uncertainty assessment	December 31
Quality checks	Tier 1 and Tier 2 QA/QC activities	December
Compilation of report (Short-	Compilation of a inventory report "Short NIR" and submission to the	January 15

Task	Description	Deadline
NIR)	European Commission (Decision 280/2004/EC)	
Preparation of NIR	Compilation of the National Inventory Report	January - March
EU Submission NIR	Submission of the National Inventory Report to the EC	March 15
UNFCCC Submission NIR	Submission of the National Inventory Report to the UNFCCC	April 15

Table 1-3 gives an overview on the registry related tasks for providing the supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol including a timeline.

Table 1-3– Timeline for registry related tasks

Task	Description	Deadline
Standard Electronic Format (SEF)	Compilation of the SEF for the previous year	January 15
Information on changes in the national registry	Preparation of the chapter on the changes in the national registry, which is part of the NIR	April 15
Information on accounting of Kyoto Protocol units	Preparation of the chapter on information on the accounting of Kyoto Protocol units, which is part of the NIR. Compilation of the files for the Standard Independent Assessment Report (SIAR), which are submitted together with the NIR.	April 15

Finally, an official approval process has been established between the Single National Entity (SNE, Environment Agency) and the UNFCCC National Focal Point (NFP, MDDI). 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 (see Section 1.3). The NFP informs the Minister in charge of environmental affairs accordingly. Upon acceptance, the NFP uploads the submission from the CIRCALUX archive onto the UNFCCC submission portal and onto the European central data repository hosted by the EEA.[15]

1.3 Inventory preparation

1.3.1 GHG Inventory and KP-LULUCF inventory

Luxembourg's greenhouse gas inventory for the period 1990 to 2009 was compiled according to the recommendations for inventories set out in the UNFCCC reporting guidelines according to Decision 18/CP.8, the Common Reporting Format (CRF) (version 1.01), Decision 13/CP.9 and the new CRF for the Land Use Change and Forestry Sector. IPCC Guidelines have been applied as much as possible. These Guidelines are:

- the Revised 1996 IPCC Guidelines for National GHG Inventories (1996 IPCC-GL);

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

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

During the inventory preparation process, sector experts collect activity data, emission factors and all relevant information needed for estimating the emissions. The sector experts also have specific responsibilities regarding the choice of methods, data processing and archiving and for contracting studies, if needed. As part of the quality management system, the national inventory compiler approves the methodological choices. Sector experts are also responsible for performing Quality Control (QC) activities that are incorporated in the Quality Management System (QMS). All data collected together with emission estimates are archived on a central archiving system (see below), together with the well documented data sources in order to be able to perform future reconstructions of the inventory.

Supplementary information required under Article 7 of the Kyoto Protocol regarding KP-LULUCF is prepared by the same sector experts as for UNFCCC-LULUCF. Other Article 7 supplementary information is requested from Luxembourg's Emission Trading Registry, which is also located at the Environment Agency.

1.3.2 Data collection, processing and storage, including for KP-LULUCF inventory

For estimating GHG emissions, Luxembourg mostly used Microsoft Excel™ spreadsheets (Table 1-4).

Table 1-4 – Programs and software used for generating emission estimates

CRF Sector	Emissions calculated using …
Energy, excl. road transportation – CRF 1 except 1A3b	MS Excel 2003
Road transportation – CRF 1A3b	COPERT IV v8.0 and MS Excel 2003
Industrial Processes – CRF 2	MS Excel 2003
Solvent and Other Product Use – CRF 3	MS Excel 2003
Agriculture – CRF 4	MS Excel 2003
LULUCF – CRF 5	MS Excel 2003
Waste – CRF 6	MS Excel 2003

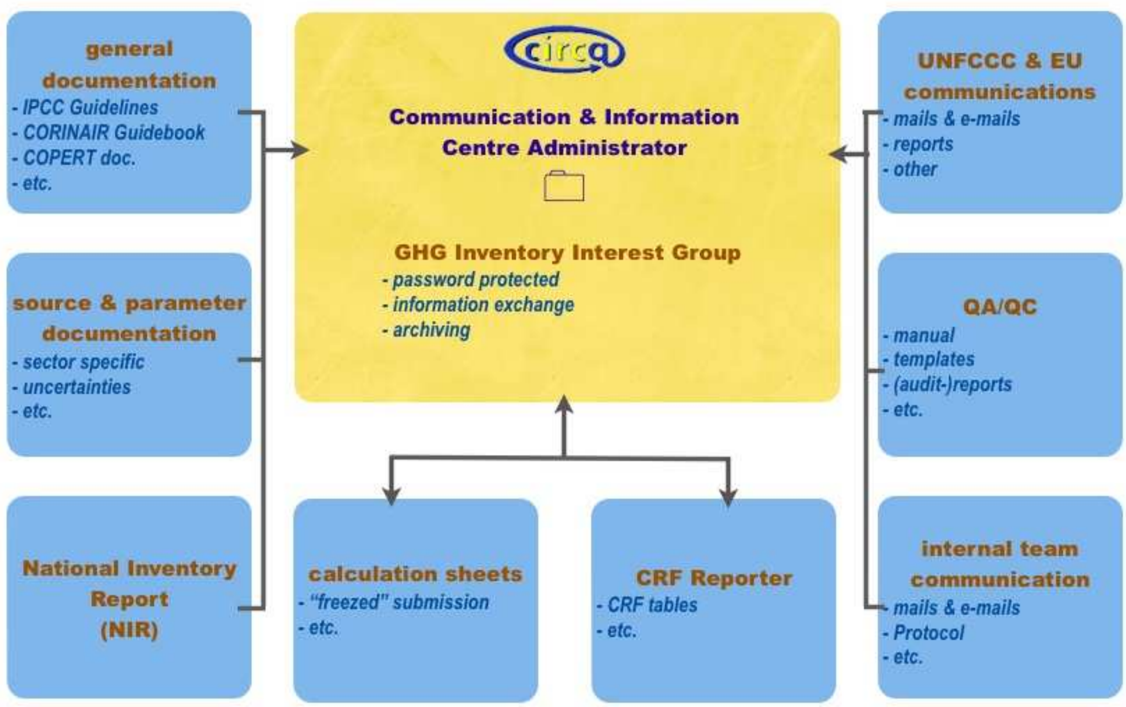
This way of proceeding offers a very flexible system that can be easily adjusted to new requirements. It is only for the estimation of road transportation emissions, where a dedicated computer program developed for the European Environment Agency (*EEA*) is used:

COPERT IV v8.0 is a Microsoft Windows™ software tool for the calculation of emissions from road transport.[16,17] The emissions calculated include all major pollutants (CO_2, CO, CH_4, NO_x, VOC, and 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.

GHG estimates produced by the sector experts are then being centralized and verified by the Single National Entity (i.e. the National Inventory Compiler (Environment Agency)).

A centralised data management and archiving system (based on the European Data Exchange and Storage System CIRCA) has been implemented (Figure 1-3). 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. The data stored on this system are backed up daily for the needs of data security. Furthermore, as part of the QMS, backups of the entire inventory information are made regularly on write-protected DVDs. This ensures the necessary documentation and archiving for future reconstruction of the inventory and for the timely response to requests during the review process.

Figure 1-3 – Data management and archiving system (CIRCALUX)



16 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.

17 The COPERT software is continuously being improved and updated using the latest scientific data.

For the generation of the CRF tables and the XML submission file, Luxembourg used the latest version of the UNFCCC's CRF-Reporter, i.e. version 3.5.2. As a large number of GHG source categories are not occurring in Luxembourg only around a hundred values per inventory year – other than notation keys – need to be transferred to the CRF-Reporter. 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 centralise the emission estimates (and all the associated data such as EFs, AD, Documentation, etc) in a centralised database. Specific software tools embedded in this database would then allow the automatic data transfer into the CRF-reporter software, without the need of the "copy-paste" procedure. Currently, Luxembourg is in the process of switching to the centralised database, and it is expected that the automatic transfer will be used for the next submission in 2012. 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.

1.3.3 Quality assurance/quality control (QA/QC) procedures and extensive review of GHG inventory and KP-LULUCF inventory

QA/QC procedures are performed as defined in the QMS plan (see Chapter 1.6).

Quality assurance, control and plausibility assessments of the estimates are being performed through internal audits covering all sectors, by the SNE[18] in collaboration with the QA/QC manager[19]. In addition, various checking procedures, included in the CRF-Reporter software are undertaken.

The NIR is circulated after publication to experts that are involved in estimation on greenhouse gas emissions in Luxembourg as identified by the National Inventory Compiler and the QA/QC manager.

Comments received from experts are considered for the inventory improvement plan.

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[18] And its partner, the Austrian Federal Environment Agency (Umweltbundesamt, Vienna, Austria).

[19] Currently contracted from SEG-Umwelt Service GmbH (Mettlach, Germany).

1.4 Methodologies and Data Sources Used

1.4.1 GHG inventory

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 this submission. A more detailed listing can be found in CRF table Summary 3. This table is also to be considered as the mandatory table requested by Annex I of the European Commission Decision 2005/166/EC.

Table 1-5 – Methodologies, data sources and EFs used by Luxembourg – 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 CS	NS SNCT	CS	CIV	NS SNCT	OTH	CIV	NS SNCT	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.

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/Annual Reports 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 sub-sections.

1.4.1.1 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 (annual reports, emission measurement reports);

- extracted from statistical information received from other ministries (Ministry of Economic Affairs and External Trade for energy (STATEC, 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*"[20] 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.[21] 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.

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.

1.4.1.2 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/EEA Guidebook and national studies or calculations leading to country specific EFs.

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

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

1.4.2 KP-LULUCF inventory

Land use and land use change data are based on satellite imagery, land cover maps held by the Nature and Forestry Agency and on information on agricultural practices from the Service of Rural Economics. These two institutions are the main data providers for the greenhouse gas reporting in the frame of the KP-LULUCF inventory.

Accordingly, the area of forest land reported for Afforestation/Reforestation and Deforestation (ARD) under the Kyoto Protocol has the same basis as the area reported for Land use changes from and to forests in the UNFCCC greenhouse gas inventory taking the different time frame (ARD areas starting with 1990) as well as the permanence of ARD areas into account.

Furthermore the methods used to estimate emissions/removals from ARD activities are of the same tier method as those used for the UNFCCC reporting. These are described in detail in Chapter 11.

1.5 Brief description of key categories, including KP-LULUCF

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 Environment Agency on the basis of submission 2010v1.2 to the UNFCCC. It comprises a level assessment for all years between 1990 and 2008, as well as a trend assessment for the trend of the year 2008 with respect to base year emissions, i.e. 1990. As stipulated in the IPCC-GPG-LULUCF, key categories have been first identified excluding LULUCF categories and then repeated for the full inventory including LULUCF categories.

1.5.1 GHG inventory (including and excluding KP-LULUCF)

The identified key categories are listed in Table 1-6 and Table 1-8. The key categories without LULUCF comprise 11250.87 Gg CO2e in the year 2009, which is a share of 96.3% of Luxembourg's total GHG emissions, excluding LULUCF.

Table 1-6 – Key categories excluding LULUCF based on emission data recorded in submission 2011v1.3

IPCC	IPCC source category	Fuel	Gas	2009 emissions Gg CO_2e	Share in 2009 national total GHG emissions (excl. LULUCF)
1A1a	Public Electricity and Heat Production	gaseous	CO_2	1081.43	9.26%
1A1a	Public Electricity and Heat Production	other	CO_2	70.15	0.60%
1A2a	Iron and Steel	gaseous	CO_2	322.05	2.76%
1A2a	Iron and Steel	liquid	CO_2	3.66	0.03%
1A2a	Iron and Steel	solid	CO_2	NO	NO
1A2c	Chemicals	gaseous	CO_2	133.30	1.14%
1A2c	Chemicals	liquid	CO_2	2.46	0.02%
1A2f	Other	gaseous	CO_2	284.84	2.44%
1A2f	Other	liquid	CO_2	75.38	0.65%
1A2f	Other	other	CO_2	35.85	0.31%
1A2f	Other	solid	CO_2	208.59	1.79%
1A3b	Road Transportation	diesel oil	CO_2	4875.70	41.73%
1A3b	Road Transportation	gasoline	CO_2	1112.84	9.52%
1A3b	Road Transportation	gasoline	N_2O	14.62	0.13%
1A4a	Commercial/Institutional	gaseous	CO_2	477.61	4.09%
1A4a	Commercial/Institutional	liquid	CO_2	14.27	0.12%
1A4b	Residential	gaseous	CO_2	482.59	4.13%
1A4b	Residential	liquid	CO_2	767.75	6.57%
1A4c	Agriculture/Forestry/Fisheries	liquid	CO_2	0.10	0.00%
2A1	Cement Production	-	CO_2	378.06	3.24%
2A7	Other – Glass Production	-	CO_2	62.10	0.53%
2C1	Iron and Steel Production	-	CO_2	128.66	1.10%
2F	Emissions of F-gases	-	F-gases	73.40	0.63%
4A1	Enteric Fermentation – Cattle	-	CH_4	240.03	2.05%
4B1	Manure Management – Cattle	-	CH_4	59.77	0.51%
4D1	Agricultural Soils – Direct Soil Emissions	-	N_2O	134.15	1.15%
4D2	Agricultural Soils – Pasture, Range & Paddock Manure	-	N_2O	56.96	0.49%
4D3	Agricultural Soils – Indirectl Emissions	-	N_2O	117.05	1.00%
6A1	Solid Waste Disposal on Land – Managed Waste Disposal on Land	-	CH_4	37.51	0.32%

Table 1-7 indicates which source categories have been identified as key categories for every reported year from 1990 to 2009.

Table 1-7 – Key categories excluding LULUCF (qualitative) of submission 2011v1.3: 1990-2009

IPCC	IPCC source category	Fuel	Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2009
				LA	LA	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	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	X	X
1A2a	Iron and Steel	liquid	CO_2	X	X	X	X	X	X	X	X	X	X	X	X									X
1A2a	Iron and Steel	solid	CO_2	X	X	X	X	X	X	X	X													
1A2c	Chemicals	gaseous	CO_2			X		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	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	X	
1A2f	Other	other	CO_2												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	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	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	X	
1A3b	Road Transportation	diesel oil	N_2O																					X
1A3b	Road Transportation	gasoline	N_2O									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	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	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	X	X
1A4c	Agricul-ture/Forestry/Fisheri es	liquid	CO_2												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	X	X
2A7	Other – Glass Pro-duction	-	CO_2						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
2C1	Iron and Steel Pro-duction	-	CO_2	X	X	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-gas es															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	X	X	
4B1	Manure Manage-ment – Cattle	-	CH_4						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	X	X	
4D2	Agricultural Soils – Pasture, Range & Paddock Manure	-	N_2O							X	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	X	X	
6A1	Managed Waste Disposal on Land	-	CH_4	X	X	X	X	X	X	X	X	X	X	X	X	X	X							

Table 1-8 indicates which source categories – including LULUCF - have been identified as key categories for every reported year from 1990 to 2009. The key categories comprise 10478.53 Gg CO_2e in the year 2009, which is a share of 92.0% of Luxembourg's 2009 total GHG emissions, including LULUCF.

Table 1-8 – Key categories including LULUCF based on emission data recorded in submission 2011v1.3

IPCC	IPCC source category	Fuel	Gas	2009 emissions Gg CO_2e	Share in 2009 national total GHG emissions (incl. LULUCF)
1A1a	Public Electricity and Heat Production	gaseous	CO_2	1081.43	9.50%
1A2a	Iron and Steel	gaseous	CO_2	322.05	2.83%
1A2a	Iron and Steel	solid	CO_2	NO	NO
1A2a	Iron and Steel	liquid	CO_2	3.66	0.03%
1A2c	Chemicals	gaseous	CO_2	133.30	1.17%
1A2c	Chemicals	liquid	CO_2	2.46	0.02%
1A2f	Other	gaseous	CO_2	284.84	2.50%
1A2f	Other	liquid	CO_2	75.38	0.66%
1A2f	Other	solid	CO_2	208.59	1.83%
1A3b	Road Transportation	diesel oil	CO_2	4875.70	42.81%
1A3b	Road Transportation	gasoline	CO_2	1112.84	9.77%
1A4a	Commercial/Institutional	gaseous	CO_2	477.61	4.19%
1A4a	Commercial/Institutional	liquid	CO_2	14.27	0.13%
1A4b	Residential	gaseous	CO_2	482.59	4.24%
1A4b	Residential	liquid	CO_2	767.75	6.74%
2A1	Cement Production	-	CO_2	378.06	3.32%
2C1	Iron and Steel Production	-	CO_2	128.66	1.13%
4A1	Enteric Fermentation – Cattle	-	CH_4	240.03	2.11%
4D1	Agricultural Soils – Direct Soil Emissions	-	N_2O	134.15	1.18%
4D3	Agricultural Soils – Indirectl Emissions	-	N_2O	117.05	1.03%
5A1	Forest Land Remaining Forest Land	-	CO_2	-393.14	-3.45%
5A2	Land converted to Forest Land	-	CO_2	-78.00	-0.68%
5E2	Land converted to Settlements	-	CO_2	109.23	0.96%

Table 1-9 indicates which source categories have been identified as key categories for every reported year from 1990 to 2009.

Table 1-9 – Key categories including LULUCF (qualitative) based on emission data recorded in submission 2011v1.3: 1990-2009

IPCC	IPCC source category	Fuel	Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2009
				LA	LA	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																			
1A1a	Public Electricity and Heat Production	other	CO_2																					X
1A2a	Iron and Steel	gaseous	CO_2									X	X	X	X	X	X	X	X	X	X	X	X	
1A2a	Iron and Steel	solid	CO_2	X	X																			
1A2a	Iron and Steel	liquid	CO_2		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	2008	2009	2009
				LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	TA
1A2c	Chemicals	gaseous	CO_2	X	X																			X
1A2c	Chemicals	liquid	CO_2	X	X	X	X	X	X	X	X	X	X	X	X	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	X	X
1A2f	Other	liquid	CO_2	X	X							X	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	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	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	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	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
1A4b	Residential	gaseous	CO_2	X	X	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	X	X
1A4c	Agricul-ture/Forestry/Fisheri es	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	X	X
2C1	Iron and Steel Pro-duction	-	CO_2	X	X	X	X	X	X	X	X	X	X	X						X	X	X		X
2F	Emissions of F-gases	-	F-gas.																					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	X	X	
4D1	Agricultural Soils – Direct Soil Emissions	-	N_2O	X	X	X	X	X	X			X	X	X									X	
4D3	Agricultural Soils – Indirectl Emissions	-	N_2O	X	X	X		X	X															
5A1	Forest Land Remain-ing Forest Land	-	CO_2	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5A2	Land converted to Forest Land	-	CO_2	X	X																			
5E2	Land converted to Settlements	-	CO_2	X	X			X	X			X												

The key category with the highest contribution to the national total emissions in 2009 is 1.A.3.b Road Transportation – diesel oil (CO_2). The contribution to the national total emissions in the base year was 10.5 %, whereas in 2009 this contribution has increased to 41.7 %. [22] This strong increase is due to the general increase of road performance, but also due to a shift from gasoline to diesel driven vehicles. Category 1.A.3.b Road Transportation – diesel oil (CO_2) is the most important category in terms of emission trends and, since 1990, emissions have increased by 265%.

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22 The percentages given here are those obtained by the level assessment excluding LULUCF. Including LULUCF, they would be 10.2 % and 42.8 % respectively.

The second most important source of greenhouse gas emissions in 2009 in Luxembourg is 1.A.3.b Road Transportation – gasoline (CO_2). Its contribution to national total emissions is 9.5% in 2009 compared to 9.5% in the base year, followed by 1.A.1.a – Public Electricity and Heat Production – gaseous fuels (CO_2) with a contribution of 9.3% for 2009 (NO in 1990).

The key category with the highest contribution to national removals is 5.A.1 Forest land remaining forest land (CO_2). In the key category analysis including LULUCF it is the seventh largest category in the level assessment (3.45 % in 2009) and is also a key category in the trend assessment. Removals from this category increased by 264 % from 1990 to 2009. This sharp increase is mainly due to the fact that in 1990 this category was a source (see Section 7.2 for more details).

1.5.2 KP-LULUCF inventory

According to the IPCC GPG for LULUCF the key categories for Kyoto Protocol activities can be derived from the identified key categories in the UNFCCC inventory as follows: Whenever a category is identified as key in the UNFCCC inventory, the associated activity under the Kyoto-Protocol can be considered as key in reporting under the Kyoto-Protocol.

In Luxembourg's case, in the UNFCCC inventory, only *5.A.1 - Forest Land Remaining Forest Land* is regarded as a key category in 2009. As neither AR (afforestation and reforestation) nor D (deforestation) are corresponding (Kyoto Protocol) categories to (UNFCCC) category 5.A.1 (compare Table 6 in this NIR and Table 5.4.4 in GPG LULUCF), none of the mandatory Article 3.3 activities – Luxembourg opted for – are identified as key according to the quantitative analysis. However, categories *5.A.2 - Land converted to Forest Land* and *5.E.2 – Land converted to Settlements* have been key in the past, 1990-1991 for *5.A.2* and 1990-1991, 1994-1995 and 1998 for *5.E.2*. Therefore, both categories - aforestation and reforestation, deforestation – could be regarded as key according to the qualitative criteria applied. However:

- for *5.A.2 - Land converted to Forest Land*: The qualitative criterion becomes negligible because the assessment of the uncertainty of *5.A.2* is not required according to Tier 1 methodology, because the change in living biomass is set to zero.[23]
- for *5.E.2 - Land converted to Settlements*:
    - by applying the quantitative approach, this category is not considered as key. According to the GPG-LULUCF, countries should identify and sum up the emission estimates associated with forest conversion to any other land category (deforestation). This was done and the sum was found to be lower than the smallest category

23 2006 IPCC Guidelines , chapter 8.2.1.4 Uncertainty assessment; page 8.11.

considered key in the quantitative analysis, thus deforestation was not identified as key.[24]

The qualitative criterion becomes negligible because the assessment of the uncertainty of *5.E.2* is in the order of less than 10% for total land area in each category due to very high resolution satellite images[25] of the small country.[26]

1.6 Information on the QA/QC plan including verification and treatment of confidentiality issues where relevant

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[27] 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:

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).

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24 1.19% against 1.39% of the lowest key category (2.C.1).

25 See also Chapter 7.1.3.2 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

26 Reference: Expert judgement on the basis of 2006 IPCC Guidelines, chapter 3.5 Uncertainties associated with the approaches, Table 3.7 Summary of uncertainties under approaches 1 to 3; page 3.20.

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

1.6.1 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.

1.6.2 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[28].

Luxembourg's QMS follows a Plan-Do-Check-Act-Cycle (PDCA-cycle)[29], 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:

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

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

- firm build-up with a quality manual consisting of a chart with all relevant documents, handling instructions and deadlines for check (Figure 1-4);
- 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 has evolved continuously and many improvements have already been realised.

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.

1.6.3 QMS Structure

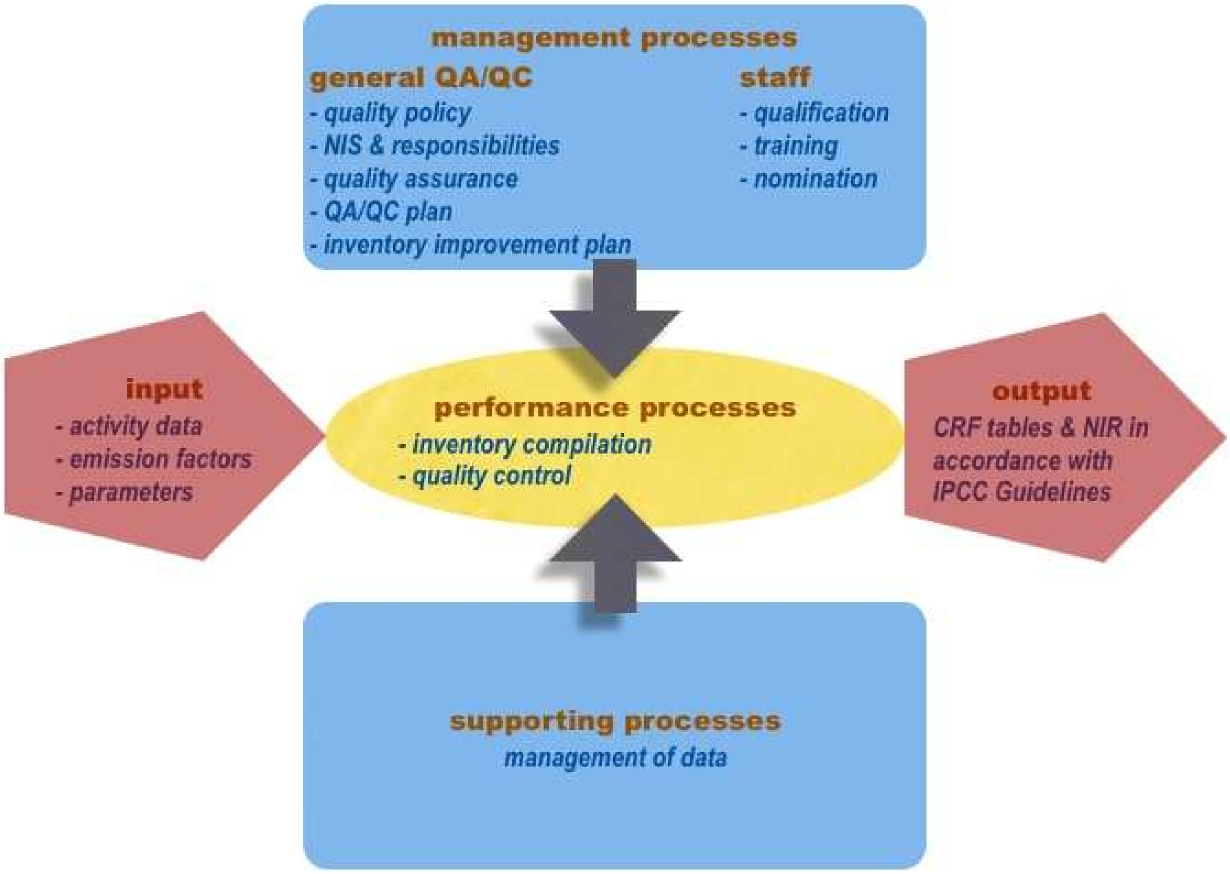
Luxembourg's Quality Management System (QMS) of the GHG Inventory is organised in three layers (Figure 1-4):

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 1-4 – QMS structure



1.6.4 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 1-5).

Figure 1-5 – Extract of QA/QC Manual

	QA/QC procedure	purpose	document	content	handling	interval of document check
management processes	quality policy	basis of the implemented quality management system	quality policy	obligation to prepare and improve a GHG inventory according the demands resulting from UNFCCC, Kyoto protocol and other obligations	the head of administration, NIC and quality manager check validity of quality policy -> adjustment if necessary -> announcement	yearly before kick-off meeting
	general QA/QC	organisation of inventory work	definitions and list of abbreviations	explanation of important terms and abbreviations that are used	NIC and quality manager check validity -> adjustment if necessary	yearly before kick-off meeting
			Luxembourg's National Inventory System	organisation of Luxembourg's National System, organigram, position of QA/QC within the organisation, handling of submission	"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" (RGD) dictates handling of submission (AEV -> EIONET, MEV -> UNFCCC); NIC and quality manager check validity -> adjustment if necessary -> announcement	yearly before kick-off meeting
			responsibilities	personnel involved in inventory work (collection of activity data, selection of emission factors and methods, calculation of emissions, data compilation, uncertainties, recalculations, identification of key categories, etc.)	nomination of sector experts and data suppliers according RGD; NIC and quality manager check validity -> adjustment if necessary -> announcement	yearly before kick-off meeting
	personnel		nominations	nominations of sector experts and data suppliers according RGD	nomination by minister of environment; NIC and quality manager check validity -> information of ministry if necessary	yearly before kick-off meeting
			job specification and obligation for secrecy	description of job and tasks, request of data secrecy	NIC and quality manager check validity -> adjustment if necessary; announcement per mail	yearly before kick-off meeting
			personal file	proof of sector expert's qualification	sector experts complete their personal file	current
	quality assurance	to support and complete quality control measures	internal audit programm	checklist for performance of internal reviews (conformity with IPCCC Guidelines, target-performance comparison)	internal audit of general aspects by quality manager, of sector specific aspects by NIC -> internal audit report -> QA/QC plan	yearly before kick-off meeting
		check of formal aspects	internal audit report	audited sectors, observations, proposed improvements	report prepared by quality manager and NIC -> generation of QA/QC plan	current
		check of applicability & comparisons	external audit report	audited sectors, observations, proposed improvements	report prepared by external persons or organisations -> generation of QA/QC plan	current
			audit list	date, audit character, audited sectors, auditors, hence prepared audit reports and QA/QC plans	auditlist completed by NIC and quality manager	current
			inconsistencies	procedure for handling of inconsistencies (that are detected during compilation of inventory, in internal or external audits)	documenting and archiving of indication of inconsistency (audit report, annotation) -> informing of NIC and quality manager -> entry of proposals for improvement in QA/QC plan	yearly before kick-off meeting
	QA/QC plan	list of objectives and proposed actions in order to improve inventory's quality	QA/QC plan	general and sector specific improvement plan	result of internal and external audits; documenting of detected inconsistencies or possibilities for improvement in QA/QC plan by NIC and quality manager -> definition of deadlines -> check if objectives have been achieved during the following audits	current
performance processes	inventory		inventory timetable	general timetable with dates of submission; sector specific timetables; deadlines; timetable QA/QC	NIC, quality manager and sector experts check validity -> adjustment if necessary -> announcement per mail	yearly before kick-off meeting
			calculation sheets	calculated emissions; information on activity data, data suppliers (QA/QC), emission factors, calculation methods and special events; information on completeness, revisions and planned improvements of emission data	sector experts complete their calculation sheets -> transfer to NIC before deadline; check of document by NIC and quality manager; check of data content by sector expert	yearly before kick-off meeting
			documentation standard operating procedure	calculated emissions; information on activity data, data suppliers (QA/QC), emission factors, calculation methods and special events; documentation shall be replaced by calculation sheets as soon as possible	sector experts describe calculation of emissions -> transfer to NIC before deadline; check of document by NIC and quality manager; check of data content by sector expert;	yearly before kick-off meeting
			NIR and crf-tables	national greenhouse gas inventory	sector experts submit calculation sheets to NIC before deadline -> NIC generates crf-tables and compiles NIR -> submission of crf-tables and NIR to EU and UNFCCC	current according the deadlines
	quality control	activities to assess and maintain the quality of the inventory being compiled	data validation	Accuracy checks on data acquisition and calculations	performance by sector experts before submission; completion of checklists; archiving of checks; transmission of completed checklists in common with NIR data to NIC	yearly before kick-off meeting
supporting processes	data managemen	definition of data naming and archiving	data flow	cooperation between the competent authorities and organisations; exchange and archiving of data and information	sector experts calculate emissions and perform data validation checks -> submission of calculations to NIC -> NIC validates methods, activity data and emission factors, generates crf-tables and compiles NIR; NIC and quality manager perform internal audit on NIR compilation -> generation of a QA/QC plan including proposed improvements -> information of sector experts and implementation of improvements	yearly before kick-off meeting
			management of input data for multiple use	procedure for handling of input data that serve several sectors		yearly before kick-off meeting
			data management on CIRCA	instruction for data naming and archiving	NIC designates access authorisation	yearly before kick-off meeting

Sources: SEG Umwelt-Service GmbH and Environment Agency.

1.6.5 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 Table 1-2 in Section 1.2.3).

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

1.6.5.1 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

1.6.5.2 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

1.6.5.3 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.

1.6.6 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 1-6 – 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)

Sources: Umweltbundesamt Austria, SEG Umwelt-Service GmbH and Environment Agency.

1.6.6.1 Quality Control procedures

The following Quality Control procedures are conducted:

a) Yearly meeting of the decision making body (the decision making body consists of the head of the AEV, the National Inventory Compiler and the quality manager) in order to appoint responsibilities, priorities and schedules for inventory work.

b) Checklists for data supplier that have to be completed by external suppliers of input data in order to assure the reliability of reported data.

c) 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 1-7.

Figure 1-7 – Data Validation Checklist

Data:	1990 - 2xxx																	
Source:	CRF	XXX		Snap	XX XX													
	Activity data			check done			Emission factor			check done			Emissions			check done		
Greenhouse gas	CO_2	CH_4	N_2O	Remarks	Date	Person	CO_2	CH_4	N_2O	Remarks	Date	Person	CO_2	CH_4	N_2O	Remarks	Date	Person
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 is correct																		
Check that parameters and units are correctly recordedand that appropriate conversion factors are used																		
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	CO_2	CH_4	N_2O	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						
Check that qualifications, assumptions and expert judgements are recorded						
Formal check						
Designation of uncertainties is understandable						
Uncertainties complete						
documentation of fundamental assumption concerning expert judgement						
Archiving of data and records ensured						

Sources: Umweltbundesamt Austria, SEG Umwelt-Service GmbH and Environment Agency.

d) 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).

e) Checklists for verification of methods, activity data and emission factors that have to be completed by sector experts.

f) Checklist for survey of sectoral work (completeness and compliance of NIR-chapter and crf-tables, implementation of planned improvements, transmission of sector specific QC checklists) that has to be completed by NIC.

g) Checklist for the monitoring of internal and external reviews that has to be completed by the quality manager.

1.6.6.2 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.

1.6.6.3 Improvement plan

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

The improvement plan is segmented in a QA/QC plan, that contains recommendations for the improvement of the QMS and an inventory improvement plan, that contains recommendations for inventory improvement.

The decision making body prioritises the recommended improvements and cares for associated resources.

1.6.6.4 Planned improvements

The following QMS improvements shall be implemented in 2011 and the following years:

- Strengthening the implementation of the QMS in general
- Implementation of QC procedures in the LULUCF sector
- Strengthening the implementation of QAQC procedures in KP-LULUCF
- Development of the four-eyes principle in inventory work
- Establishment of criteria for the prioritization of the QA/QC plan
- Continuance in QA/QC training of NIC and sector experts

1.6.7 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 "Circalux" within the folder "Inventaires gaz à effet de serre"[30]. 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.

1.6.8 Treatment of confidentiality issues

In this submission, there is no data reported using the notation key C (confidential).

1.7 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

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. [31] 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.

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.

1.7.1 GHG inventory

In December 2007, the Environment Agency contracted Austrian Research Centers GmbH - ARC [32] for performing a detailed uncertainty analysis of Luxembourg's GHG inventory[33]. National infor-

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

31 2000 IPCC GPG – Chapter UNCERTAINTIES

32 www.arcs.ac.at/

mation or at least national expert knowledge directly from the stage of inventory development was used for the assessment of uncertainties.

Since 2007, when the study[33] on uncertainties was undertaken, some of the CRF sectors have been revised. Furthermore new key categories were 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[33].

Due to limited resources and assigned priority within the inventory preparation for submission 2011v1.3 only a TIER 1 uncertainty analysis was performed. It is planned to update the TIER 2 analysis periodically.

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

1.7.1.1 Data origin

In the following, the used activities, as evaluated within the framework of the study[33], are described.

1.7.1.1.1 Data origin - Energy & Transport

Activities

A comprehensive top-down – bottom-up approach was conducted by the Environment Agency for the entire energy sector. The following partners were involved in these:

- «Ministère de l'Economie et du Commerce Extérieur», «Ministère de l'Environnement» and «Ministère des Transports » ;
- 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);
- Service Central de la Statistique et des Etudes Economiques (STATEC);
- all relevant fuel importer and fuel distributors;
- plant operators;
- Société Nationale des Chemins de fer Luxembourgeois (CFL).

Primary energy carrier in Luxembourg is natural gas. Gas is used in the major power plant (TwinErg), in industry including electro-steel works (Arcelor, now known as Arcelor-Mittal) and in domestic heating (private households as well as commerce). The ministry of economic affairs collects consumption / import data from the only provider SOTEG. Since 2006, other providers

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

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.

<u>Emission factors</u>

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 [34]

[34] Ntziachristos and Samaras, 2000, EEA Technical Report No 45, EEA, Copenhagen (Denmark)

to alternate emission factors [35, 36] indicates differences up to a factor 3 with COPERT III emission factors (but also within each other).

1.7.1.1.2 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 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.

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35 INFRAS, 2004, Handbuch Emissionsfaktoren des Strassenverkehrs (HBEFA 2.1), Bern (Switzerland)

36 Winiwarter, 2005, IR-05-055, IIASA, Laxenburg (Austria)

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.

<u>Glass production:</u>
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.

<u>F-gases:</u>
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.

1.7.1.1.3 Data origin - Solvent and Other product use

<u>Solvents:</u>
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.

<u>N_2O use:</u>
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.

1.7.1.1.4 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.

1.7.1.1.5 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.

1.7.1.2 Assessing input uncertainties

In the following the assessing input uncertainties as evaluated within the framework of the study[33] are described.

1.7.1.2.1 Method

Information on uncertainty from a number of national assessments[37] 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.

1.7.1.2.2 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[38]). 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 Syri37, 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

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37 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).

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

calculated according to fuel sold, this factor is directly applicable also on "road fuel sales to non residents" or "road fuel exports": see Section 2.1.6). 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[37], 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.[37].

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.[37]), 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[39] for Austria.

1.7.1.2.3 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).

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

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[37]. This is much higher than the 1% used but not explained by Ramirez-Ramirez et al.[37] but in line with Boogerts and Starcks[40] 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[37] but somewhat higher than the 20% suggested by Ramirez-Ramirez et al.[37], which however are not explained.

1.7.1.2.4 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 covered 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.

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

1.7.1.3 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 2.80% and a trend uncertainty of 1.79% and the TIER 1 approach including LULUCF suggests an overall level uncertainty of 3.45% and a trend uncertainty of 2.89% (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 1-10, 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[41].

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.

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

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

Key IPCC Source Categories	Gas	1990 (BY) emissions	2009 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 introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty
		Gg CO_2 equivalent		%	%	%	%	%	%	%	%	%		
1A1a - Gaseous Fuels	CO_2	0.00	1081.43	0.50%	0.50%	0.71%	0.07%	8.43%	8.43%	0.06%	0.06%	0.08%	0	0
1A1a - Other Fuels	CO_2	33.29	70.15	10.00%	0.50%	10.01%	0.06%	0.31%	0.55%	0.00%	0.08%	0.08%	0	0
1A2a - Liquid Fuels	CO_2	58.95	3.66	2.00%	0.50%	2.06%	0.00%	-0.39%	0.03%	0.00%	0.00%	0.00%	1	0
1A2a - Solid Fuels	CO_2	4958.74	0.00	2.50%	1.00%	2.69%	0.00%	-35.08%	0.00%	-0.35%	0.00%	0.35%	1	0
1A2a - Gaseous Fuels	CO_2	400.27	322.05	0.50%	0.50%	0.71%	0.02%	-0.33%	2.51%	0.02%	0.02%	0.03%	0	0
1A2c - Liquid Fuels	CO_2	120.75	2.46	2.00%	0.50%	2.06%	0.00%	-0.84%	0.02%	0.00%	0.00%	0.00%	1	0
1A2c - Gaseous Fuels	CO_2	57.45	133.30	0.50%	0.50%	0.71%	0.01%	0.63%	1.04%	0.01%	0.01%	0.01%	0	0
1A2f - Liquid Fuels	CO_2	80.64	75.38	2.00%	0.50%	2.06%	0.01%	0.02%	0.59%	0.00%	0.02%	0.02%	1	0
1A2f - Solid Fuels	CO_2	332.50	208.59	3.00%	1.00%	3.16%	0.06%	-0.73%	1.63%	-0.01%	0.07%	0.07%	1	0
1A2f - Gaseous Fuels	CO_2	224.99	284.84	0.50%	0.50%	0.71%	0.02%	0.62%	2.22%	0.02%	0.02%	0.02%	0	0
1A2f - Other fuels	CO_2	0.00	35.85	2.00%	1.00%	2.24%	0.01%	0.28%	0.28%	0.00%	0.01%	0.01%	1	0
1A3b - Gasoline	CO_2	1220.58	1112.84	2.00%	0.50%	2.06%	0.20%	0.01%	8.68%	0.00%	0.25%	0.25%	1	0
1A3b - Diesel Oil	CO_2	1342.54	4875.70	2.00%	0.50%	2.06%	0.86%	28.45%	38.01%	0.14%	1.08%	1.08%	1	0
1A3b - Gasoline	N_2O	18.44	14.62	2.00%	100.00%	100.02%	0.13%	-0.02%	0.11%	-0.02%	0.00%	0.02%	1	0
1A3b - Diesel Oil	N_2O	4.96	51.39	2.00%	60.00%	60.03%	0.26%	0.37%	0.40%	0.22%	0.01%	0.22%	1	0
1A4a - Liquid Fuels	CO_2	464.32	14.27	2.00%	0.50%	2.06%	0.00%	-3.19%	0.11%	-0.02%	0.00%	0.02%	1	0
1A4a - Gaseous Fuels	CO_2	169.61	477.61	0.50%	0.50%	0.71%	0.03%	2.52%	3.72%	0.03%	0.03%	0.04%	0	0
1A4b - Liquid Fuels	CO_2	464.32	767.75	2.00%	0.50%	2.06%	0.14%	2.69%	5.99%	0.01%	0.17%	0.17%	1	0
1A4b - Gaseous Fuels	CO_2	169.61	482.59	0.50%	0.50%	0.71%	0.03%	2.56%	3.76%	0.03%	0.03%	0.04%	0	0
1A4c - Liquid Fuels	CO_2	15.65	81.25	3.00%	0.50%	3.04%	0.02%	0.52%	0.63%	0.00%	0.03%	0.03%	1	0
2A1 - Cement Prod.	CO_2	569.88	378.06	1.50%	2.00%	2.50%	0.08%	-1.10%	2.95%	0.08%	0.06%	0.10%	0	0
2A7 - Glass Prod.	CO_2	53.57	62.10	2.00%	5.00%	5.39%	0.03%	0.10%	0.48%	0.03%	0.01%	0.04%	0	0
2C1 . Iron & Steel Prod.	CO_2	984.91	128.66	5.00%	1.00%	5.10%	0.06%	-5.99%	1.00%	0.01%	0.07%	0.07%	0	0
2F	*F-gases*	14.67	73.40	NE	NE	NE	NE	0.47%	0.57%	NE	NE	NE	0	0

Key IPCC Source Categories	Gas	1990 (BY) emissions	2009 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 introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty
		Gg CO_2 equivalent		%	%	%	%	%	%	%	%	%		
4A1 - Enteric Ferm. - Cattle	*CH_4*	256.91	240.03	2.00%	30.00%	30.07%	0.62%	0.05%	1.87%	0.79%	0.05%	0.80%	0	0
4B1 - Manure Man. - Cattle	*CH_4*	47.48	59.77	2.00%	144.57%	144.58%	0.74%	0.13%	0.47%	0.95%	0.01%	0.95%	0	0
4D1 - Agric. Soils - direct soil emissions	*N_2O*	162.84	134.15	10.00%	150.00%	150.33%	1.73%	-0.11%	1.05%	-0.17%	0.15%	0.22%	1	0
4D2 - Agric. Soils - pasture, range & paddock manure	*N_2O*	58.79	56.96	25.08%	173.21%	175.01%	0.85%	0.03%	0.44%	0.05%	0.16%	0.16%	1	0
4D3 - Agric. Soils - indirect emissions	*N_2O*	141.92	117.05	20.00%	150.00%	151.33%	1.52%	-0.10%	0.91%	-0.14%	0.26%	0.30%	1	0
6A1 -Solid Waste disposal on Land	*CH_4*	74.59	37.51	12.00%	25.00%	27.73%	0.09%	-0.24%	0.29%	-0.06%	0.05%	0.08%	1	0
5A1 - Forest Land remaining Forest Land	CO_2	239.26	-393.14	3.00%	55.00%	55.08%	-1.85%	-4.76%	-3.06%	-2.38%	-0.13%	2.39%	0	0
Total excl. LULUCF	***CO_2e***	**12503.18**	**11383.41**				**2.80%**					**1.79%**		
% National Total excl. LULUCF	**%**	**97.48%**	**97.42%**											
National Total excl. LULUCF	***CO_2e***	**12826.86**	**11684.38**											
0.0000 = NO														

Table 1-11 – Uncertainty analysis of Luxembourg's GHG inventory - Table 6.1 - Tier 1 including LULUCF

Key IPCC Source Categories	Gas	1990 (BY) emissions	2009 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 introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty
		Gg CO_2 equivalent		%	%	%	%	%	%	%	%	%		
1A1a - Gaseous Fuels	CO_2	0.00	1081.43	0.50%	0.50%	0.71%	0.07%	8.43%	8.43%	0.06%	0.06%	0.08%	0	0
1A1a - Other Fuels	CO_2	33.29	70.15	10.00%	0.50%	10.01%	0.06%	0.31%	0.55%	0.00%	0.08%	0.08%	0	0
1A2a - Liquid Fuels	CO_2	58.95	3.66	2.00%	0.50%	2.06%	0.00%	-0.39%	0.03%	0.00%	0.00%	0.00%	1	0
1A2a - Solid Fuels	CO_2	4958.74	0.00	2.50%	1.00%	2.69%	0.00%	-35.08%	0.00%	-0.35%	0.00%	0.35%	1	0
1A2a - Gaseous Fuels	CO_2	400.27	322.05	0.50%	0.50%	0.71%	0.02%	-0.33%	2.51%	0.02%	0.02%	0.03%	0	0
1A2c - Liquid Fuels	CO_2	120.75	2.46	2.00%	0.50%	2.06%	0.00%	-0.84%	0.02%	0.00%	0.00%	0.00%	1	0
1A2c - Gaseous Fuels	CO_2	57.45	133.30	0.50%	0.50%	0.71%	0.01%	0.63%	1.04%	0.01%	0.01%	0.01%	0	0
1A2f - Liquid Fuels	CO_2	80.64	75.38	2.00%	0.50%	2.06%	0.01%	0.02%	0.59%	0.00%	0.02%	0.02%	1	0
1A2f - Solid Fuels	CO_2	332.50	208.59	3.00%	1.00%	3.16%	0.06%	-0.73%	1.63%	-0.01%	0.07%	0.07%	1	0
1A2f - Gaseous Fuels	CO_2	224.99	284.84	0.50%	0.50%	0.71%	0.02%	0.62%	2.22%	0.02%	0.02%	0.02%	0	0
1A2f - Other fuels	CO_2	0.00	35.85	2.00%	1.00%	2.24%	0.01%	0.28%	0.28%	0.00%	0.01%	0.01%	1	0
1A3b - Gasoline	CO_2	1220.58	1112.84	2.00%	0.50%	2.06%	0.20%	0.01%	8.68%	0.00%	0.25%	0.25%	1	0
1A3b - Diesel Oil	CO_2	1342.54	4875.70	2.00%	0.50%	2.06%	0.86%	28.45%	38.01%	0.14%	1.08%	1.08%	1	0
1A3b - Gasoline	N_2O	18.44	14.62	2.00%	100.00%	100.02%	0.13%	-0.02%	0.11%	-0.02%	0.00%	0.02%	1	0
1A3b - Diesel Oil	N_2O	4.96	51.39	2.00%	60.00%	60.03%	0.26%	0.37%	0.40%	0.22%	0.01%	0.22%	1	0
1A4a - Liquid Fuels	CO_2	464.32	14.27	2.00%	0.50%	2.06%	0.00%	-3.19%	0.11%	-0.02%	0.00%	0.02%	1	0
1A4a - Gaseous Fuels	CO_2	169.61	477.61	0.50%	0.50%	0.71%	0.03%	2.52%	3.72%	0.03%	0.03%	0.04%	0	0
1A4b - Liquid Fuels	CO_2	464.32	767.75	2.00%	0.50%	2.06%	0.14%	2.69%	5.99%	0.01%	0.17%	0.17%	1	0
1A4b - Gaseous Fuels	CO_2	169.61	482.59	0.50%	0.50%	0.71%	0.03%	2.56%	3.76%	0.03%	0.03%	0.04%	0	0
1A4c - Liquid Fuels	CO_2	15.65	81.25	3.00%	0.50%	3.04%	0.02%	0.52%	0.63%	0.00%	0.03%	0.03%	1	0
2A1 - Cement Prod.	CO_2	569.88	378.06	1.50%	2.00%	2.50%	0.08%	-1.10%	2.95%	0.08%	0.06%	0.10%	0	0
2A7 - Glass Prod.	CO_2	53.57	62.10	2.00%	5.00%	5.39%	0.03%	0.10%	0.48%	0.03%	0.01%	0.04%	0	0
2C1 . Iron & Steel Prod.	CO_2	984.91	128.66	5.00%	1.00%	5.10%	0.06%	-5.99%	1.00%	0.01%	0.07%	0.07%	0	0
2F	*F-gases*	14.67	73.40	NE	NE	NE	NE	0.47%	0.57%	NE	NE	NE	0	0

Key IPCC Source Categories	Gas	1990 (BY) emissions	2009 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 introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty
		Gg CO_2 equivalent		%	%	%	%	%	%	%	%	%		
4A1 - Enteric Ferm. - Cattle	CH_4	256.91	240.03	2.00%	30.00%	30.07%	0.62%	0.05%	1.87%	0.79%	0.05%	0.80%	0	0
4B1 - Manure Man. - Cattle	CH_4	47.48	59.77	2.00%	144.57%	144.58%	0.74%	0.13%	0.47%	0.95%	0.01%	0.95%	0	0
4D1 - Agric. Soils - direct soil emissions	N_2O	162.84	134.15	10.00%	150.00%	150.33%	1.73%	-0.11%	1.05%	-0.17%	0.15%	0.22%	1	0
4D2 - Agric. Soils - pasture, range & padlock manure	N_2O	58.79	56.96	25.08%	173.21%	175.01%	0.85%	0.03%	0.44%	0.05%	0.16%	0.16%	1	0
4D3 - Agric. Soils - indirect emissions	N_2O	141.92	117.05	20.00%	150.00%	151.33%	1.52%	-0.10%	0.91%	-0.14%	0.26%	0.30%	1	0
5A1 - Forest Land remaining Forest Land	CO_2	239.26	-393.14	3.00%	55.00%	55.08%	-1.90%	-4.55%	-2.98%	-2.32%	-0.13%	2.32%	0	0
5A2 - LUC to Forest Land	CO_2	-113.06	-78.00	NE	NE	NE	NE	0.15%	-0.59%	NE	NE	NE	0	0
5E2 - LUC to settlements	CO_2	138.93	109.23	NE	NE	NE	NE	-0.08%	0.83%	NE	NE	NE	0	0
Total excl. LULUCF	**CO_2e**	**12586.20**	**11060.27**				**3.45%**					**2.89%**		
% National Total excl. LULUCF	**%**	**95.53%**	**97.12%**											
National Total excl. LULUCF	**CO_2e**	**13174.61**	**11387.95**											

0.0000 = NO

1.7.2 KP-LULUCF inventory

Uncertainties of emissions/removals of the ARD units have not been assessed in submission 2011v1.3, this is planned for submission 2012.

1.8 General assessment of completeness

1.8.1 GHG inventory

CRF table 9(a) on completeness has been filled for every reported year 1990 to 2009. 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 2011v1.3. Hence, if missing information is encountered in CRF table 9(a) for some years, this is 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.

1.8.1.1 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 as well as the sub-categories wetlands, settlements and other lands, which were not estimated in the previous submission.

1.8.1.2 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.

1.8.1.3 Geographic coverage

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

1.8.1.4 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.

1.8.1.5 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 1-12, transparency and completeness of submission 2010v2.1 – and of Luxembourg's latest submission – submission 2011v1.3 – are compared. The exercise focuses on the inventory year 2008 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 1-12, the transparency has remained essentially the same between the two submissions. It was sligtly increased for CRF Sector 1, where notation keys where corrected.

With regards to completeness, the improvement of the inventory has been continued: rise from 94% to 96%. This increase in completeness is the result of a revised set of estimates (especially for F-gases), and most importantly the corrections of some notation keys for CRF Sectors 1, 2, 5 and 6 – see relevant chapters further in this NIR.

Table 1-12 – Transparency and completeness in UNFCCC submissions 2010v2.1 and 2011v1.3: 2008

CRF Sector	Submission 2010v2.1					Submission 2011v1.3				
	# estimates	*IE*	*NE*	*TR*	*CP*	# estimates	*IE*	*NE*	*TR*	*CP*
Energy (sectoral approach) – CRF 1	87	3	0	97%	100%	87	0	0	100%	100%
Industrial Processes – CRF 2	104	2	10	98%	90%	104	2	4	98%	96%
Solvent and Other Product Use – CRF 3	10	0	0	100%	100%	10	0	0	100%	100%
Agriculture – CRF 4	55	0	0	100%	100%	55	0	0	100%	100%
LULUCF – CRF 5	36	1	9	99%	75%	36	1	9	99%	75%
Waste – CRF 6 (*)	18	3	1	97%	94%	18	3	0	97%	100%
Total	**310**	**9**	**20**	**90%**	**94%**	**310**	**6**	**13**	**93%**	**96%**

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

1.8.2 KP-LULUCF inventory

All activities according to Article 3.3 of the Kyoto Protocol are estimated. Luxembourg did not elect Article 3.4 activities.

2 Trends in greenhouse gas 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", 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. Therefore, in Section 2.1, specific national circumstances are examined. These specific conditions are relating to socio-economic characteristics that have significant effects on Luxembourg's GHG total emissions when applying IPCC accounting rules. This first section is complemented by a discussion of how both the UNFCCC and the Kyoto Protocol are challenging Luxembourg's action with regard to climate change (Section 2.2) and by a general overview of the national circumstances (Section 2.3). Section 2.4 concludes this chapter with an overview of the main developments of and drivers to GHG emissions in Luxembourg since 1990.

2.1 National Circumstances

This section, i.e. 2.1 National Circumstances, has not been updated since the last submission, however, no substantial changes occured.

2.1.1 The Grand-Duchy of Luxembourg

The Grand Duchy of Luxembourg has been an independent sovereign state since the Treaty of London was signed on 19 April 1839. The country is a **parliamentary democracy** in the form of a **constitutional monarchy** and is the second smallest Member State of the EU-27, after Malta. For many years, it has been characterized by **high economic and demographic growth rates**. The country is **located in the heart of North-Western Europe** and has direct borders with Belgium, Germany and France (Figure 2-1). It is therefore a crossroad for international trade and related transport flows, the most dynamic source of its GHG emissions.

Luxembourg is a territory of 2 586 km². The maximum distance from north to south is some 82 km, from west to east about 52 km (Figure 2-2). Of the total area of Luxembourg, in 2009, 86% was agricultural land and land under forest – with around 51% for agriculture and 35% for forests. The built-up areas occupied about 9% of the total surface and land covered by water and transport infrastructure about 5% (Table 2-1 & Figure 2-3).[42]

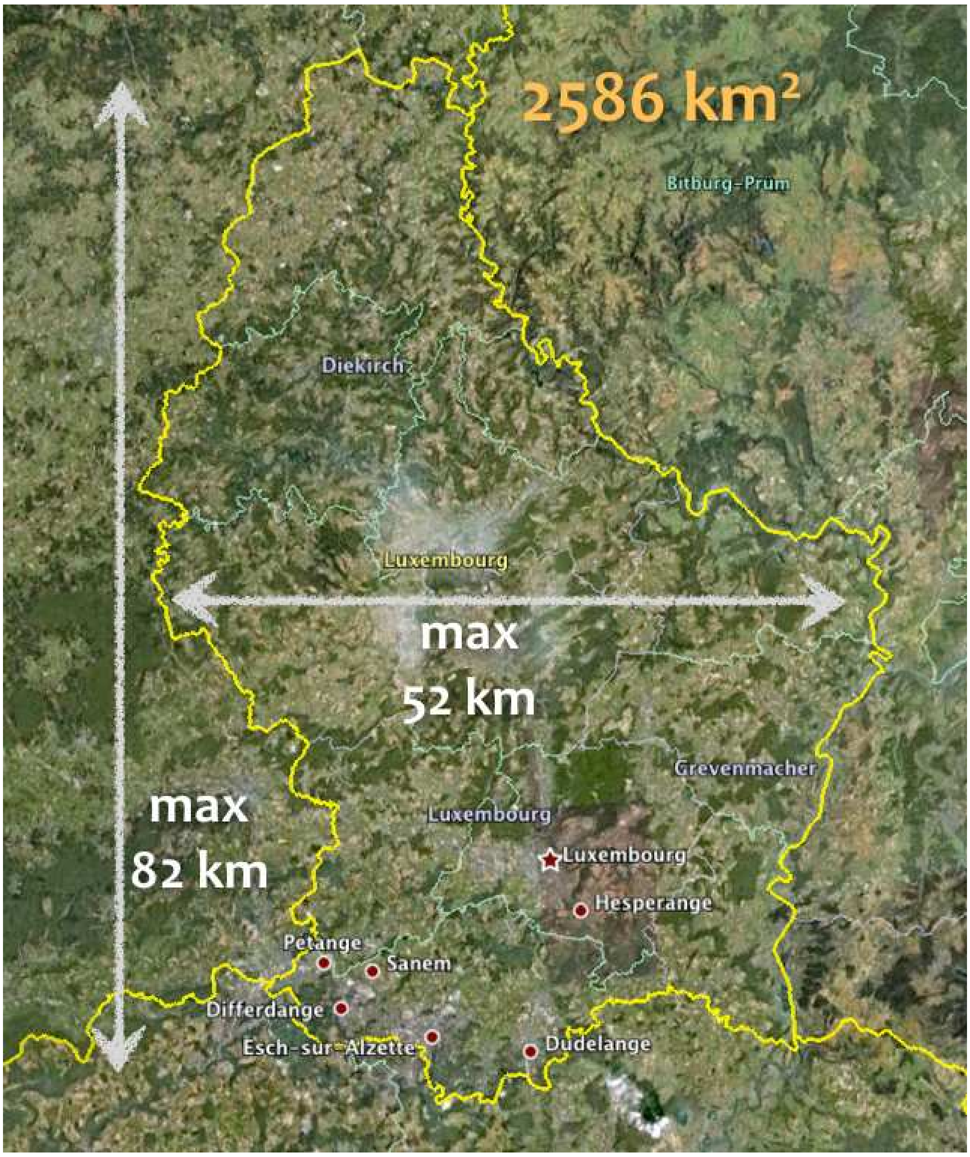
The north of Luxembourg is a part of the Ardennes and is called "Ösling". Its altitude is at an average of 400 to 500 meters above sea level. The "Ösling" landscape is affected by hills and deep river valleys, as for instance the Sure River (Sauer). With 560 m, the highest elevation is called the "Kneiff" 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.

Figure 2-1 – GEOGRAPHIC LOCATION OF LUXEMBOURG

Source: Google Earth.

[42] STATEC, www.statec.lu, "A1101 - Utilisation du sol 1972-2009".

Figure 2-2 – LUXEMBOURG SIZE



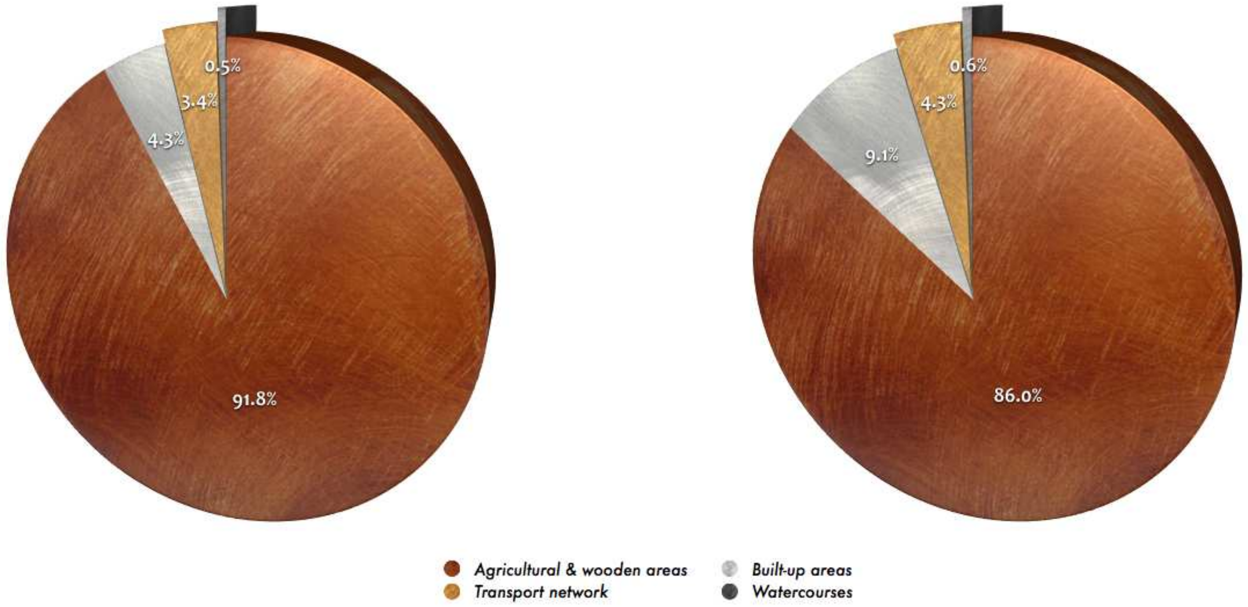
Source: Google Earth.

Table 2-1 – Land use in Luxembourg: 1972-2009

percentages	1972	1990	2000	2005	2008	2009
Total land	100.0	100.0	100.0	100.0	100.0	100.0
Agricultural & wooden area	93.2	91.8	87.4	86.5	86.0	85.9
Built-up area	3.1	4.3	8.1	8.7	9.1	9.2
of which industrial area & other	…	…	*2.7*	*2.8*	*2.9*	*2.9*
Transport network & sheets of water	3.2	3.4	3.9	4.2	4.3	4.3
Watercourses	0.5	0.5	0.6	0.6	0.6	0.6

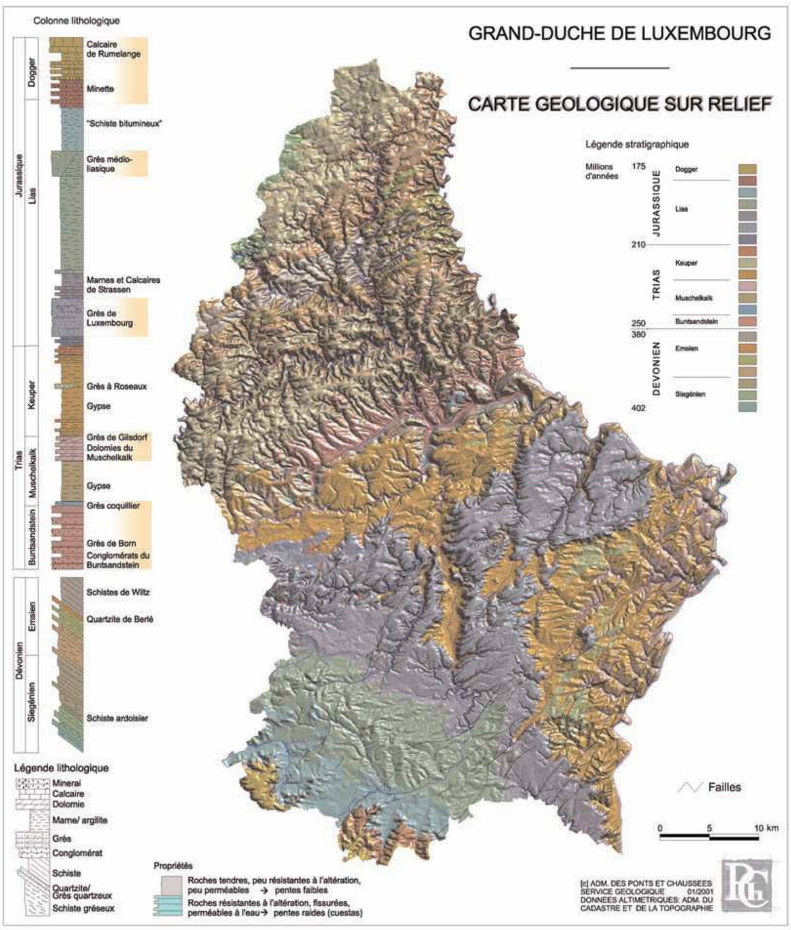
Source: STATEC, *Luxembourg in Figures 2009*, page 6: http://www.statistiques.public.lu/fr/publications/horizontales/luxChiffresEN/index.html

Figure 2-3 – Land use: 1990 & 2008



Source: STATEC, *Luxembourg in Figures 2009*, page 6: http://www.statistiques.public.lu/fr/publications/horizontales/luxChiffresEN/index.html

Figure 2-4 – 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

2.1.2 Climate[43]

2.1.2.1 Situation: an increasing average air temperature during the last decades

The climate in Luxembourg can be characterized as a **moderate oceanic Western European climate** with mild winters and comfortable summers.

As shown by the long-term annual means (WMO reference period from 1961 to 1990) measured at the Findel-Airport meteorological station,[44] temperatures have an unimodal distribution, with the lowest long-term mean values occurring during January (0.0°C) and the highest air temperature in July (16.9°C) (Table 2-2).

Absolute minimum and maximum air temperatures in the reference period 1961-1990 reach from –17.8°C in January (1979) to 35.1°C in July (1964).[45] According to definitions for GHG reporting, with an annual average air temperature below 15°C, **Luxembourg is situated in a cool climate region**.

Climate conditions have significant impacts on energy use for heating or cooling purposes. An increase in average air temperature in the forthcoming years could have a positive impact on energy consumption, especially in the residential, commercial and institutional sectors. However, in case of a substantial increase of average air temperatures, an increase in energy consumption related to a more frequent use of air conditioning systems is to be expected.

As shown by measures at the Findel-Airport meteorological station, two conclusions can be drawn: firstly, an increase in average air temperature is observed over the last decades; secondly, other meteorological parameters do not show such clear trends (Table 2-3). Similar observations have been obtained in scientific studies on the climate in Luxembourg.[46] Concerning air temperatures, these studies show a clear positive trend from 1910 up to the 1950s, then about 3 decades of stabilisation, followed by several colder years. From 1990 onwards, annual mean air temperatures for the city of Luxembourg started to increase rather sharply to systematically be over the 1961-

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43 This section has been prepared by Pfister, L., Junk, L. & Hoffmann, L. of the *Centre de Recherche Public-Gabriel Lippmann*.

44 http://www.aeroport.public.lu/fr/meteo/index.html.

45 Absolute minimum and maximum air temperatures ever recorded were -20.2°C (2 February 1956) and 37.9°C (8 & 12 August 2003).

46 Ries, C. (éditeur) (2005), *Contribution à la climatologie du Luxembourg: analyses historiques, scenarios futurs* in Ferrantia 43, Musée National d'Histoire Naturelle, Luxembourg, 21-84,(http://www.mnhn.lu/recherche/ferrantia/publications/Ferrantia43.pdf)
Pfister, L., Drogue, G., Poirier, C., and Hoffmann, L. (2005), *Evolution du climat et répercussions sur le fonctionnement des hydrosystèmes au Grand-Duché de Luxembourg au cours des 150 dernières années* in Ferrantia 43, Musée National d'Histoire Naturelle, Luxembourg, 85-100,(http://www.mnhn.lu/recherche/ferrantia/publications/Ferrantia43.pdf)

1990 mean value (Figure 2-5). Luxemburg-City temperature highs have mostly been observed during the last 15-20 years (Figure 2-6).

Further analysis of the data suggests that the average air temperature in Luxembourg has increased during the winter seasons, coupled with longer frost-free periods.

With regard to annual precipitation, no clear changes can be detected from the direct measurements (Table 2-2). However, the seasonal distribution of precipitation totals has shown substantial variability through the past 130 years (Figure 2-7). Most of this variability can be attributed to changes in the atmospheric circulation patterns. An increase in westerly atmospheric fluxes during winter months has reportedly been responsible over the past 30 years for significant redistributions of winter rainfall totals. In combination with higher air temperatures, this has led to higher flood frequencies in most national river basins.[47]

2.1.2.2 Projections: continuing rise in air temperature

Preliminarily results taken from an ongoing study of the Department "Environment and Agrobiotechnology" of the *Centre de Recherche Public-Gabriel Lippmann* suggest an increase in mean air temperature for the Grand-Duchy of Luxembourg. Based on selected results of the FP6 ENSEMBLES project climate change projections,[48] mean annual temperatures are expected to reach up to 11.6°C for the period 2071 till 2100. This value refers to the GHG emission scenario A1B (Figure 2-8).

Preliminarily results concerning changes in precipitation suggest a relative stability in annual totals until 2100. However, a substantial redistribution of seasonal precipitation totals can be expected in the second half of the 21st century, with a decrease in summer rainfall and an increase in winter precipitation (Figure 2-9).

2.1.2.3 Expected impacts of climate change in Luxembourg: forests and water in the forefront

According to a report published by the EEA,[49] reproducing an EEA map based on IPCC reports showing key past and projected impacts and effects for the main bio-geographic regions of Europe,

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47 Pfister, L., Hoffmann, L., and Humbert, J. (2000), *Recent Trends in Rainfall-Runoff Characteristics in the Alzette River Basin, Luxembourg* in Climatic Change, volume 45, Springer Netherlands, 323-337.
Pfister, L., Drogue, G., El Idrissi, A., Iffly, J.F., Poirier, C., and Hoffmann, L. (2004), *Spatial Variability of Trends in the Rainfall-Runoff Relationship: A Mesoscale Study in the Mosel Basin* in Climatic Change, volume 66, Springer Netherlands, 67-87.

48 http://ensembles-eu.metoffice.com.

49 European Environment Agency, Joint Research Centre, World Health Organization (2008), *Impacts of Europe's Changing Climate – 2008 indicator-based assessment*, EEA Report No 4/2008 & JRC Reference Report No JRC47756, Copenhagen (http://www.eea.europa.eu/publications/eea_report_2008_4)

Luxembourg is part of the "central & eastern Europe" area (cf. Map S.1, p. 19 of the aforementioned report). The threats identified for this peculiar region are:

- more temperature extremes;
- less summer precipitation;
- more river floods in winter;
- higher water temperature;
- higher crop yield variability;
- increased forest fire danger;
- lower forest stability.

Two of these threats are of main concern for Luxembourg: **floods and forest stability**. Temperatures extremes and summer precipitation reduction are also causes for concern: impacts on human health and especially on the most fragile persons and the elderly (heat, air quality) and impacts on water quality in summer when rivers flows are usually at their lowest.

According to the researchers of the *Centre de Recherche Public-Gabriel Lippmann*, the projected changes in air temperature are likely to induce a modification of the vegetation period in Luxembourg. The start of the vegetation period is defined as the exceeding of the 5°C daily mean temperature threshold in spring for at least 30 successive days; the end of the vegetation period corresponds to the undershooting of this threshold until the end of the year.[50]

In Luxembourg, the vegetation period is expected to be initiated earlier in spring and to last longer into the autumn (Figure 2-10). During the early stages of the vegetation period this might cause an increased risk of frost damages to vegetation.

The increase of temperatures, especially during the winter period, already has significant impacts on the phenology of plants (earlier flowering dates) and animals (e.g. earlier breeding dates of birds, advancement of life cycle of insects, three instead of two yearly cycles), but also on the migratory behaviour of birds and insects (i.e. species now winter in Luxembourg that in former times migrated to Spain or northern Africa). Furthermore, the temperature changes have an impact on the bio-geography of plants and animals, with new species with a Mediterranean distribution, formerly unknown in Luxembourg, which recently appeared in the country fauna (e.g. Nomophila noctuella, Udea ferrugalis, Brenthis daphne) and flora (some moss species). Bio-climatic approaches also indicate that some relict species of the last glaciation period (e.g. Lycaena helle) will disappear from Luxembourg with the expected temperature increase.

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50 Chmielewski, F.M., and Rötzer, T. (2001), *Response of tree phenology to climate change across Europe*. In Agricultural and Forest Meteorology, 108, 101-112.

The climate projections for the second half of this century will also have significant impacts on the bio-meteorological conditions in Luxembourg. The higher air temperatures, especially during night times (important recreation time for humans) also increase the likelihood of extreme heat events such as the one that struck Europe in August 2003. Besides impact on the human health, this will also lead to more frequent and more stringent stress conditions for agricultural plants and forestry, most severely impacting perennial forest trees. Observations on the phytosanitary state of Luxembourg forest – a rather "old" forest – show a sharp degradation – which seems to have stabilised nowadays – resulting, among other factors, from climate change. The ageing of the forest also increases the risk of outbreak of diseases and of infestation by insects and other parasites that could proliferate if more mild winters and overall general temperatures are recorded in Luxembourg.

With regard to water, the most analysed phenomena so far are floods. It is known that; due to major redistributions of, essentially, winter rainfalls, a higher inundation frequency is being recorded since the river systems have reacted to these changes with a statistically significant increase of maximum daily runoff during winter.[51] This is why an observation hydro-climatic network (*réseau d'observation hydro-climatologique*) has been put in place from the mid 1990s.[52] Its main functions consist in continuously (24h/24h) monitoring Luxembourg's water courses, and in the realization and the updating of an atlas of areas of the national territory subjected to swellings and floods. The network also suggests anti-flooding measures and participates to renaturation projects aiming at re-creating natural areas which used to act as natural reservoirs for containing rising waters.[53]

Table 2-2 – Long-term mean values (1961-1990) of air temperature and precipitation for Findel-Airport station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average air t° [°C]	0.0	1.1	4.0	7.5	11.8	14.9	16.9	16.4	13.4	9.1	3.8	1.0	8.3
Mean min. air t° [°C]	-2.3	-1.8	0.6	3.3	7.1	10.2	12.0	11.8	9.3	5.7	1.2	-1.3	4.8
Mean max. air t° [°C]	2.3	4.2	8.0	12.1	16.8	19.9	22.0	21.0	18.2	13.0	6.6	3.3	12.3
Mean annual precipitation sum [mm]	71.2	61.7	70.0	61.2	81.2	82.2	68.4	72.3	70.0	74.6	83.2	79.6	875.5

Source: ASTA, *Annuaire météorologique et hydrologique 1990.*

51 Pfister, L., Drogue, G., Poirier, C., and Hoffmann, L. (2005), *Evolution du climat et répercussions sur le fonctionnement des hydrosystèmes au Grand-Duché de Luxembourg au cours des 150 dernières années* in Ferrantia 43, Musée National d'Histoire Naturelle, Luxembourg, 85-100.(http://www.mnhn.lu/recherche/ferrantia/publications/Ferrantia43.pdf)

52 http://www.hydroclimato.lu/.

53 For an example, look at http://www.luxnatur.lu/alzrena1.htm.

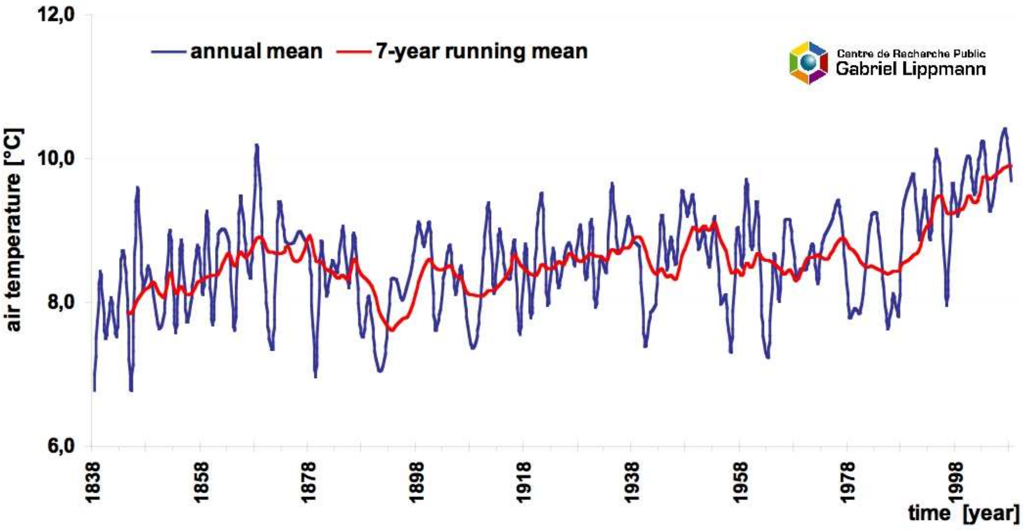
Table 2-3 – Mean values of air temperature, precipitation, sunshine duration and relative humidity for Findel-Airport station for different time spans

	1961-1990	1971-2000	1990	2000	2005	2007	2009
Mean air t° [°C]	8.3	8.7	9.8	10.0	9.6	10.4	9.9
Precipitation sums [mm]	875.5	862.4	1046..0	1036.4	718.2	1031.6	890.2
Accumulated sunshine duration [h]	1630.2	1648.5	1772.3	1643.9	1906.0	1887.0	1879.8
Mean relative humidity [%]	79	78	74	79	78	76	76

Sources: ASTA, *Annuaire météorologique et hydrologique 1990* and Findel-Airport station (SMA).

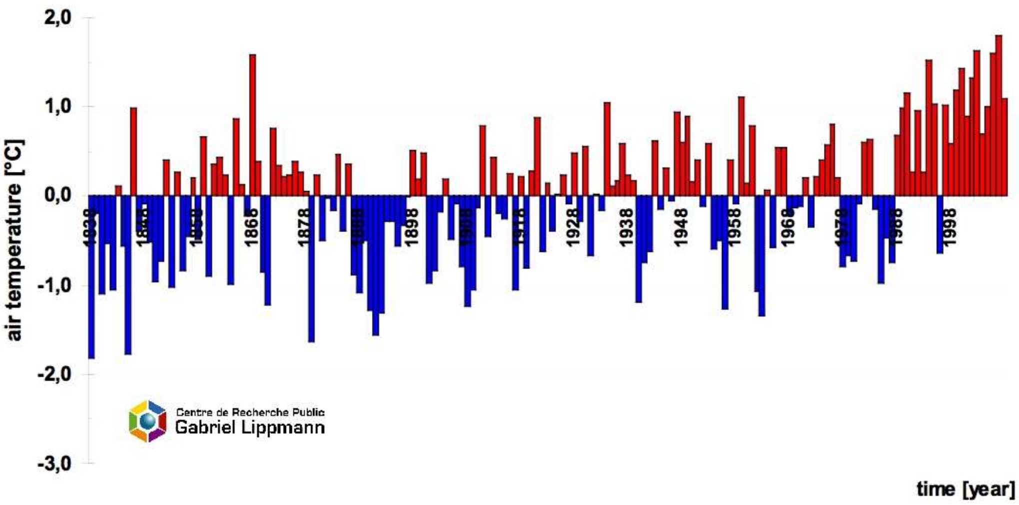
Note: the mean air t° for the reference period 1951-1980 was 8.2°C. From 2010 onwards, the reference period will be 1981-2010 with a mean t° around 9°C.

Figure 2-5 – Average annual air temperature (blue line) and 7-year running mean (red line) for Luxembourg-City: 1838-2007



Source: *Centre de Recherche Public-Gabriel Lippmann*, unpublished.

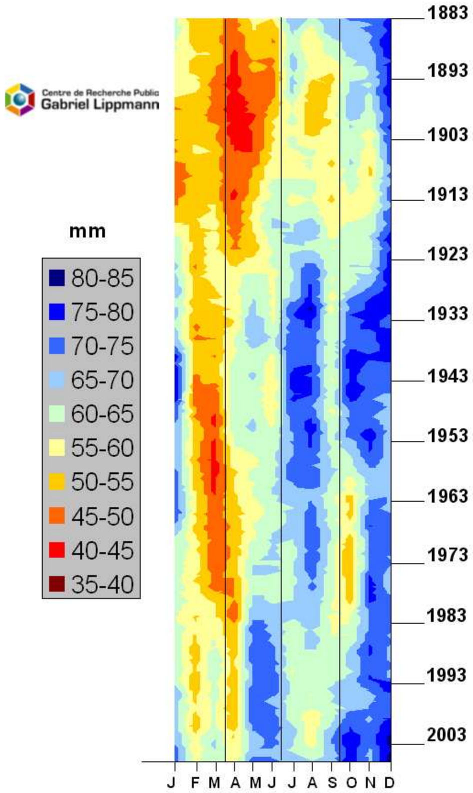
Figure 2-6 – Anomalies of annual air temperature from the reference period 1961-1990 for Luxembourg-City



Source: *Centre de Recherche Public-Gabriel Lippmann*, unpublished.

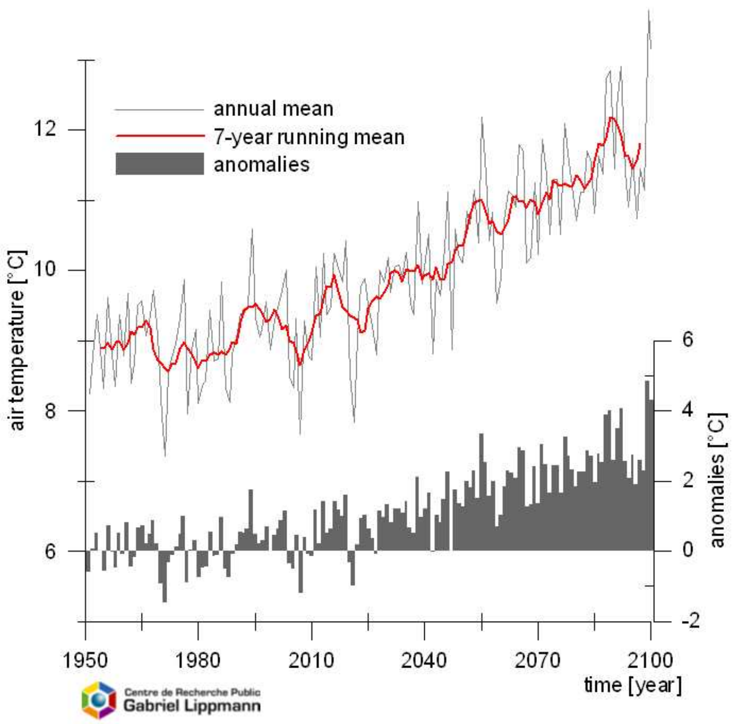
Note: anomalies from the reference period 1961 till 1990: long-term mean: 8.6°C.

Figure 2-7 – Rainfalls 1883-2006: 30 years moving averages



Source: *Centre de Recherche Public-Gabriel Lippmann*, unpublished.

Figure 2-8 – Projections of mean annual air temperature

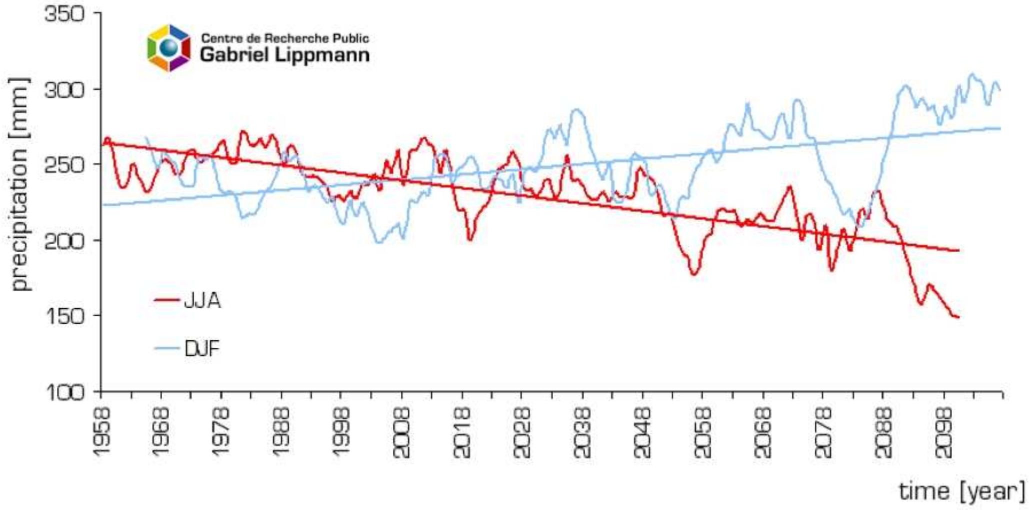


Source: *Centre de Recherche Public-Gabriel Lippmann*, unpublished.

Notes: (1) based on selected ENSEMBLES data sets, A1B emission scenario.

(2) anomalies from the reference period 1961 till 1970: long-term mean: 8.9°C.

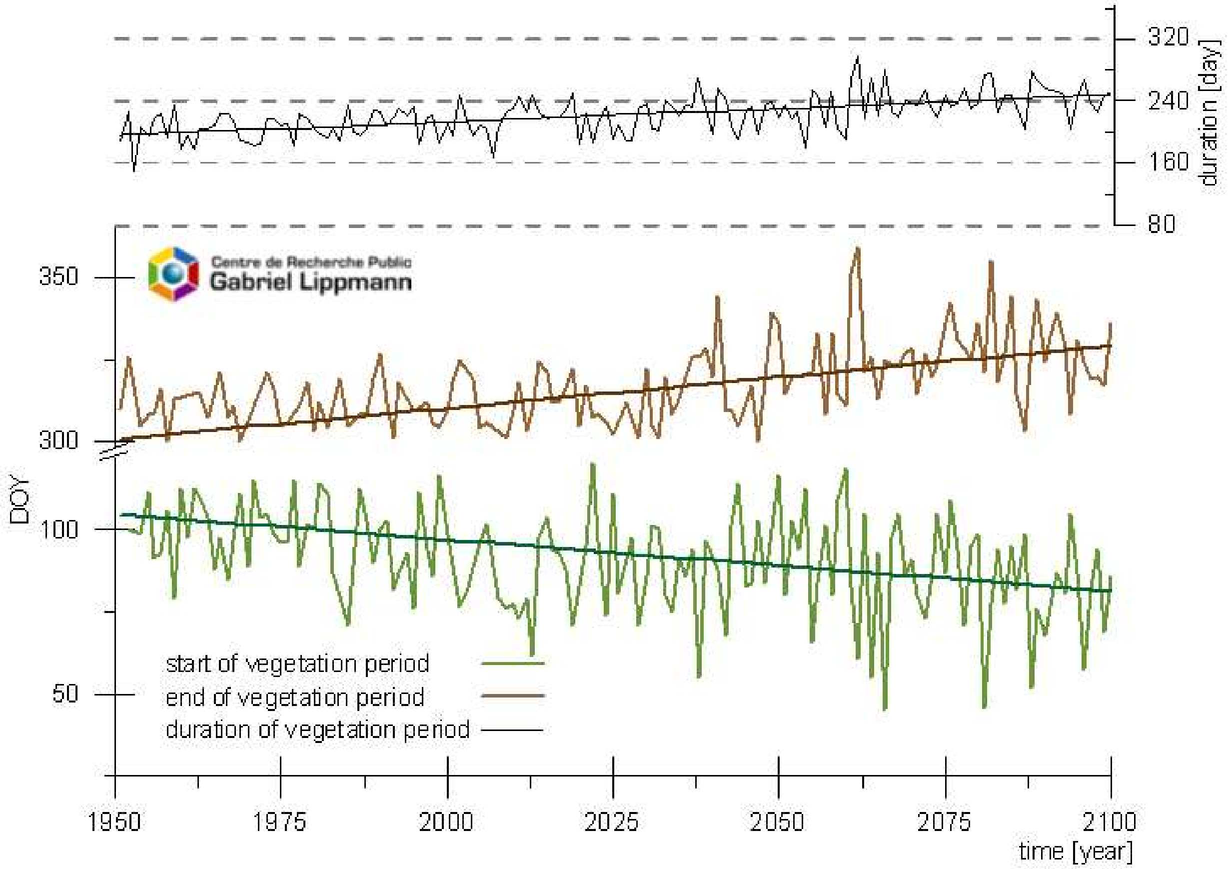
Figure 2-9 – Projections of precipitation sums for the meteorological summer and winter seasons



Source: *Centre de Recherche Public-Gabriel Lippmann*, unpublished.

Note: based on selected ENSEMBLES data sets, A1B emission scenario.

Figure 2-10 – Start, end and duration of the vegetation period



Source: *Centre de Recherche Public-Gabriel Lippmann*, unpublished.

Notes: (1) based on selected ENSEMBLES data sets, A1B emission scenario.
(2) end and duration of the vegetation period as defined by Chmielewski & Rötzer (2001).
(3) DOY = day(s) of year.

2.1.3 Population and workforce

2.1.3.1 A strong population growth driven by immigration

End 2008, the population of Luxembourg amounted to 493 500 inhabitants. Within 48 years, the residential population has grown by some 179 000 inhabitants or about 57% – slightly more than 28% since 1990 (Table 2-4). The average annual growth rate of the resident population of Luxembourg is high compared to the rates of its neighbouring regions: between 1990 and 2008, the average annual growth rate for Luxembourg (1.4%) was more than 3.5 times higher than its equivalent for the *Grande Région*.[54] It even reached 1.5% p. a. since 2000 (Figure 2-12).

Demographic growth in Luxembourg is actually dominated by immigration. Nationals themselves saw their number stagnating, and without immigrants taking the citizenship of Luxembourg they would even have fallen. End 2008, almost 44% of the residential population did not have the citizenship of Luxembourg. This percentage was only 30% in 1990, as depicted in Figure 2-11. The main driver behind these demographic trends is the economic restructuring and development of the country towards the tertiary sector coupled with attractive wages, which is presented in Section 2.1.4.

Population projections are based on scenarios derived from past statistical data. It therefore comes as no surprise that population forecasts a continuation of the demographic trend in Luxembourg. Projections calculated in the framework of the European Commission (EC) Ageing Working Group predict that 700 000 inhabitants could be living in Luxembourg by 2050 (Figure 2-12). As it is the case for any forecasts, these predictions should be treated with caution because they cannot predict radical changes in the economic structure or demographics of a country, especially a small one whose economy relies heavily on a few economic sectors. However, since population growth is one of the key drivers for domestic energy use, mainly in the housing and transportation sector, these forecasts illustrate the scale of one of the many challenges Luxembourg is facing in the definition of measures aiming at reducing its GHG emissions.

Table 2-4 – Population: 1960-2008

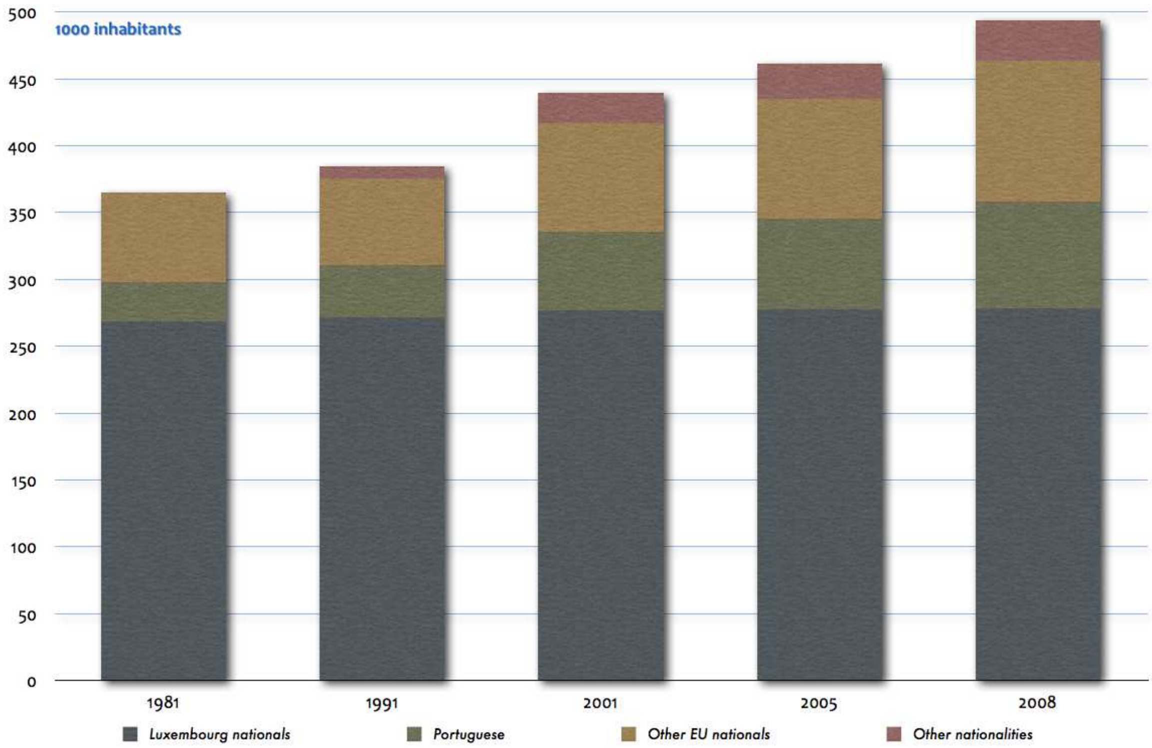
calculated on 31st December	1960	1990	2000	2002	2003	2004	2005	2006	2007	2008
Resident population (x 1000)	314.9	384.4	439.0	448.3	455.0	461.2	469.1	476.2	483.8	493.5

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

54 Refer to Box 2-1 for a presentation of the *Grande Région*.

Figure 2-11– Population structure on 31st December: 1981-2008

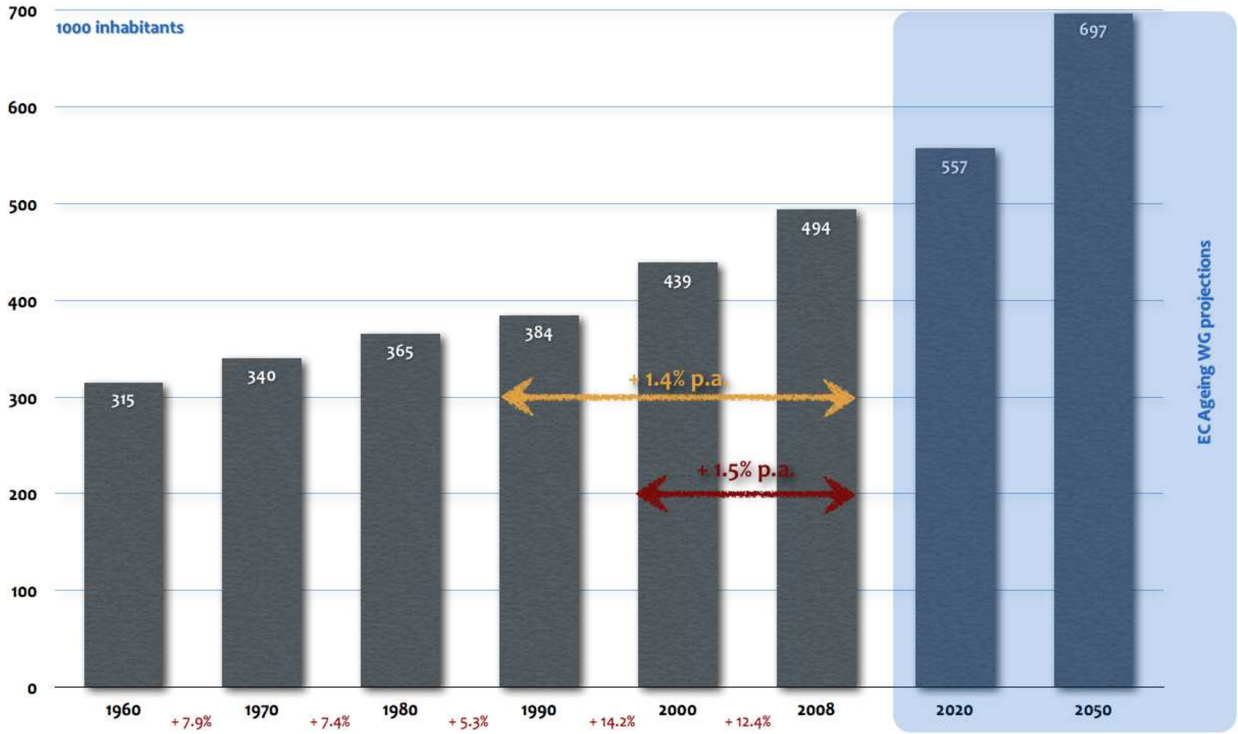


Source: STATEC, *Statistical Yearbook*, Table B.1000:

http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=463&IF_Language=fra&MainTheme=2&FldrName=1

Note: 1981, 1991 and 2001 data are coming from population censuses held every decade, other years are calculated by STATEC.

Figure 2-12 – Population growth on 31st December: 1960-2050



Source: STATEC, *Statistical Yearbook*, Table B.1100 (and projections prepared for the EC Ageing Working Group):

http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=467&IF_Language=fra&MainTheme=2&FldrName=1

Box 2-1 – The *Grande Région*

The *Grande Région* is the geographic unit that includes Luxembourg, the Region of Wallonia in Belgium, Lorraine in France and two German *Länder*: Saarland and Rheinland-Pfalz.

Today, this structure is more a cooperative space than an effective integrated region defining and modelling its own policies and development. This is the result of the diversity of the territories constituting the *Grande Région*, of its dimension and of the barriers created by institutional and administrative structures in each country. De facto, being a sovereign state amongst country regions, Luxembourg has a special status in this cooperative space: it is the main driving force behind the *Grande Région*, a position re-enforced by its demographic and economic development as shown by the figures in the table below.

Grande Région entity	population change % 1990-2007	population annual average growth rate % 1990-2007	GDP average growth rate % 2000-2006	paid workers in 2008 1990=100
BE-Wallonia	5.90%	0.34%	1.90%	115
DE-Rheinland-Pfalz	9.50%	0.58%	0.90%	114
DE-Saarland	-2.00%	-0.06%	1.70%	108
FR-Lorraine	1.70%	0.08%	1.60%	108
Luxembourg	**25.70%**	**1.32%**	**4.70%**	**193**

Wallonia: paid workers in 2006.

More information on the Grande Région can be found on line:

http://www.granderegion.net/fr/index.html

http://www.grande-region.lu/eportal/pages/HomeTemplate.aspx

2.1.3.2 Workforce: the importance of cross-border commuters

The economic restructuring and development of Luxembourg led to a doubling of the paid workers in almost 20 years (1990-2008). The resident population of Luxembourg nationality was unable to meet this increasing demand for labour. The number of Luxembourg nationals employed increased from some 85 700 units in 1990 to 94 100 in 2008, representing an average annual growth of only 0.5%. How, therefore, could this urgent economic need be satisfied? The initial response was to resort to immigration. The number of foreign employees living and working in Luxembourg rose from 51 000 in 1990 to about 92 100 in 2008 – an average annual growth rate of 3.3%. But, this was not enough. So the cross-border commuters came into play. Between 1990 and 2008, the number of cross-border workers increased from 33 700 to 146 000, at an average annual growth rate of 8.5% (Table 2-5).[55]

End 2008, among the paid workers, 49.2% of the commuters came from France, 25.8% from Belgium and 25% from Germany. In total, the commuters accounted for 43.8% of all paid workers in Luxembourg and for 29.5% (i.e. more than a quarter) of the residential population (Figure 2-13).[56]

55 Figures indicated in this paragraph are annual cumulative averages.

56 Calculated from STATEC, *Indicateurs rapides*, Serie L: http://www.statistiques.public.lu/stat/tableviewer/document.aspx?ReportId=352.

The commuting flows amongst the various regions of the *Grande Région* clearly show the economic attraction of Luxembourg (Figure 2-14).

A vast majority of workers from abroad commute by car.[57] 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.

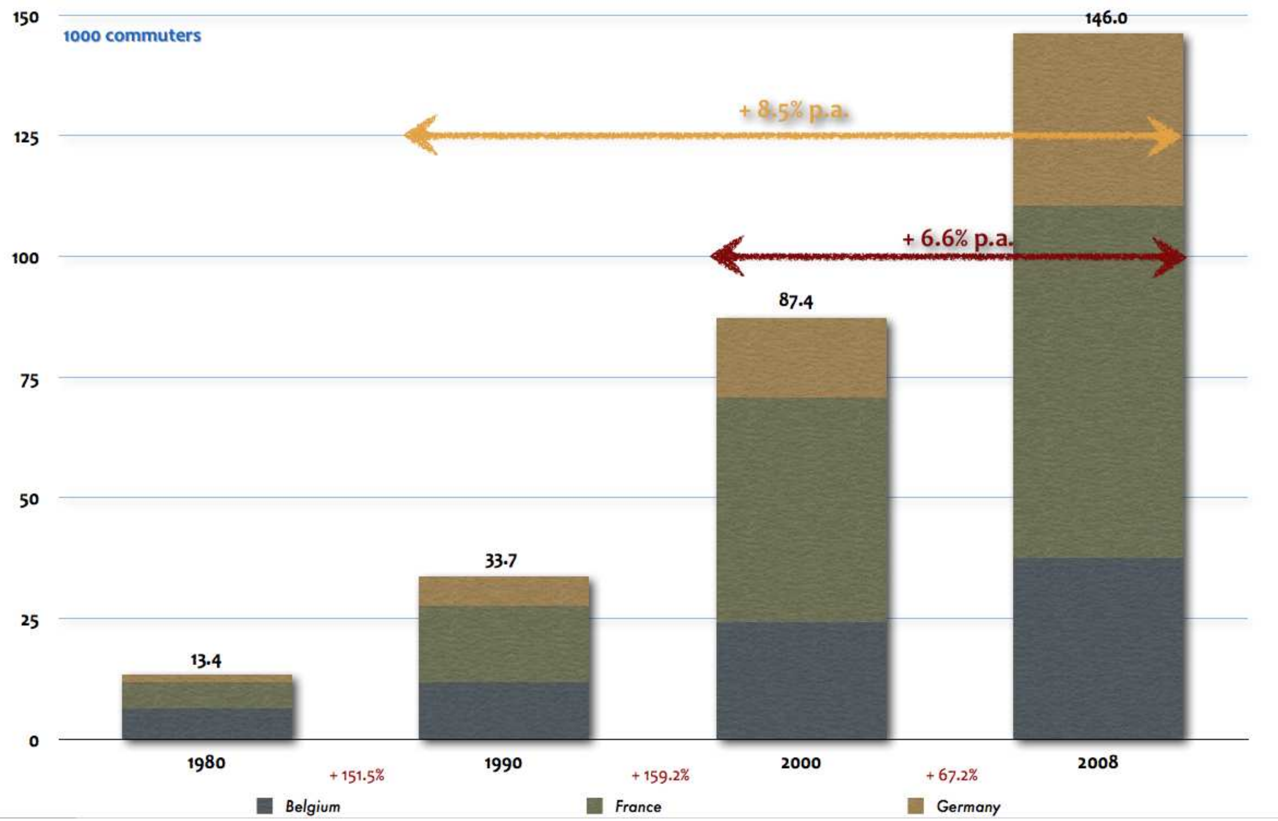
Table 2-5 – Paid workers: 1980-2008

annual cumulative averages x1000	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007	2008
Resident workers – Lux. nationals	85.1	85.7	87.4	89.0	91.2	91.4	90.9	91.3	92.7	93.5	94.1
Resident workers – foreigners	38.5	51.0	70.1	73.4	74.6	75.9	78.5	80.8	83.5	86.8	92.1
Cross-border workers	13.4	33.7	87.4	97.3	103.0	106.9	111.9	118.3	126.2	136.2	146.0
Total paid workers	**137.0**	**170.4**	**244.9**	**259.7**	**268.8**	**274.2**	**281.3**	**290.4**	**302.4**	**316.5**	**332.2**

Sources: MDDI-DEV calculations on the basis of STATEC, *Statistical Yearbook*, Table B.5106 & B.5107: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=359&IF_Language=fra&MainTheme=2&FldrName=5&RFPath=37 http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=360&IF_Language=fra&MainTheme=2&FldrName=5&RFPath=37 and STATEC, *Indicateurs rapides*, Série L: http://www.statistiques.public.lu/stat/tableviewer/document.aspx?ReportId=352

Note: annual cumulative averages are simply the sum of the workers at the end of each month divided by 12.

Figure 2-13 – Cross-border commuters growth: annual cumulative averages 1980-2008



Source: STATEC, *Indicateurs rapides*, Série L: http://www.statistiques.public.lu/stat/tableviewer/document.aspx?ReportId=352

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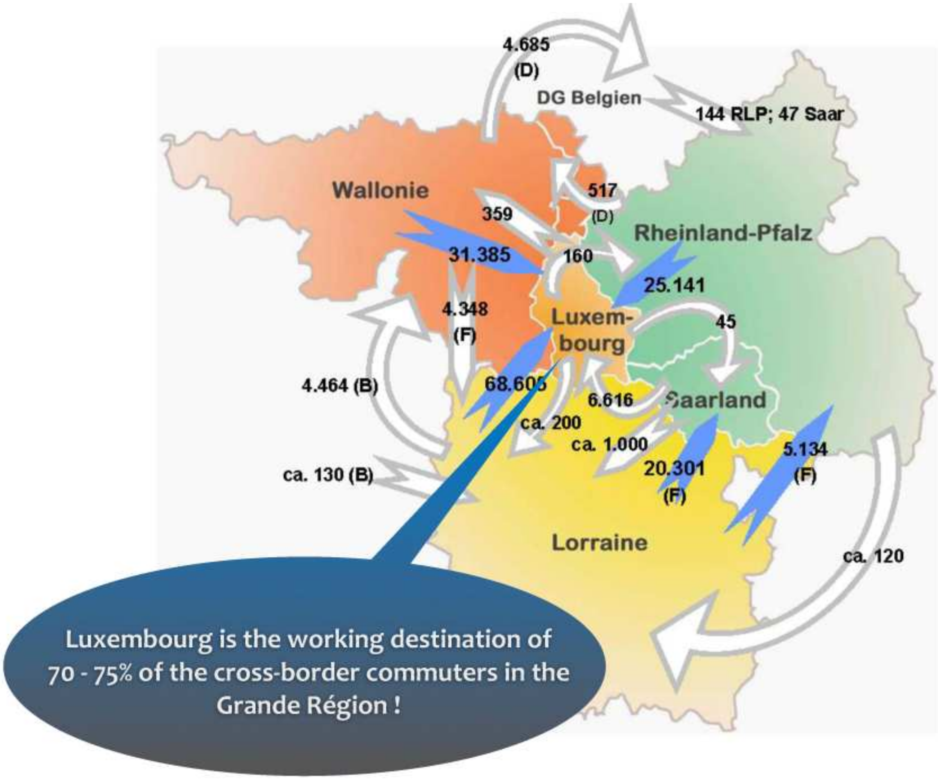
57 In 2007 , 89% of the cross-border commuters were only using their car for their home-work journeys according to a recent study: http://www.ceps.lu/pdf/6/art1415.pdf?CFID=1253513&CFTOKEN=38691590&jsessionid=20303f926e506f584f4d.

Figure 2-14 – COMMUTING FLOWS 2007-2008



Source: 6th Report of the OIE (*Observatoire Interrégional de l'Emploi*), July 2009.

2.1.4 Economic profile

One of the main characteristics of economic growth in Luxembourg is its volatility. Generally speaking, the economic cycle in Luxembourg follows that of other European countries, but the amplitude of the GDP variations is more pronounced. This is a common feature of small economies, open to the outside world, and therefore more vulnerable to external shocks. It would however appear that over the past ten years the amplitude of GDP variations in Luxembourg has diminished, as has the gap in relation to the European cycle.

The economic restructuring and development of the country towards the tertiary sector from the 1960s-70s, led to the following economic cycles since 1990:

- up to 1992, the continuation of the exceptional growth initiated around 1985;
- the effects of the economic slowdown in Luxembourg during the period between 1992 and 1996 and the economic downturn in 2001 – as well as the less impressive growth in 2002-2004 – which is mirrored by a stagnation of the GDP level per inhabitant in Luxembourg in comparison with the EU-15;
- the good economic performance of Luxembourg between 2005 and 2008;
- the financial and economic crisis that started end 2008. It has been particularly pronounced in the first semester of 2009 and is therefore not yet visible in the submission related to this report, i.e. submission 2010v1.2.

Nowadays, gross value added is mainly generated in the financial intermediation (banking and insurances), real estate and services to business sector. The share of total gross value added in this branch has increased from about 39% in 1995 to 49% in 2008.[58] 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 2008. Other service activities ranged between a share of 15 to 17.5% and construction kept a rather constant share in total gross value added at around 6%. The contribution of the agricultural sector is negligible with less than 1% (Table 2-6 & Figure 2-15).

Nevertheless, GHG emissions trends in Luxembourg are not so much influenced by the economic profile of the country, but for the most part by:

- the energy-mix for both production and consumption of fuels (liquid, solid, gaseous, biomass): more on this in the next section;
- due to its size and the size of its energy and industrial sector, structural changes in these sectors that could be initiated by a single entity;
- road transportation related fuel sales: more on this in Section 2.1.6.

Table 2-6– Sectoral gross value added at current prices: 1995-2008

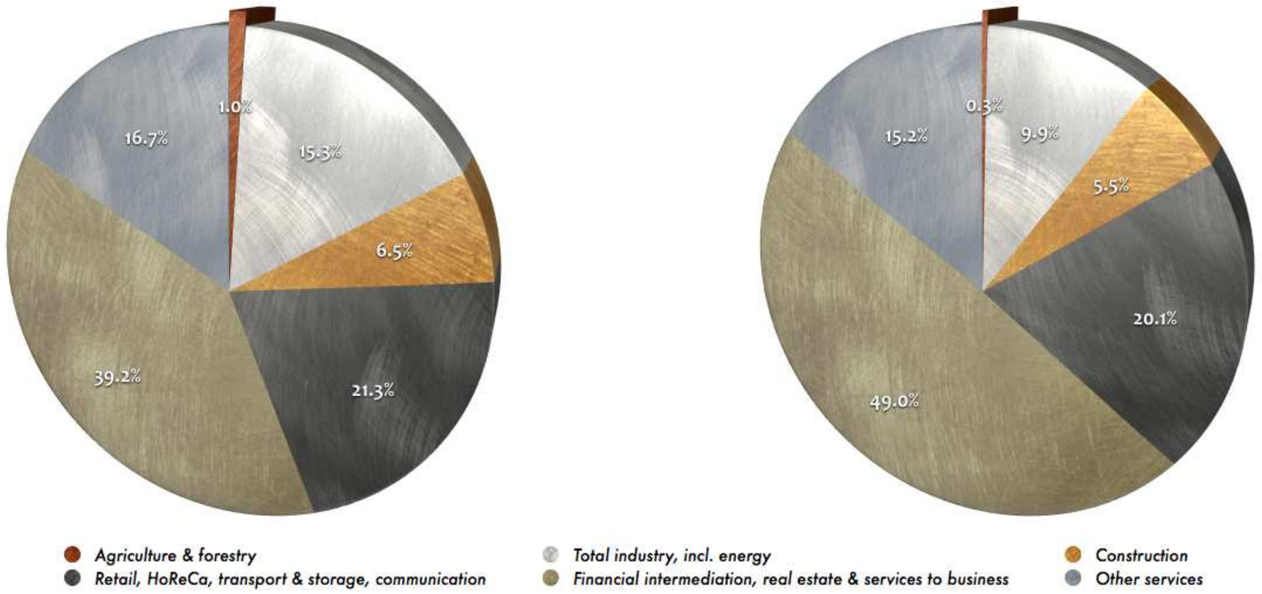
mio. EUR		1995	2000	2002	2003	2004	2005	2006	2007	2008
Agriculture, hunting, forestry & fishing (A & B)		140.6	134.3	143.6	141.5	143.3	120.5	117.1	131.9	119.8
	%	*1.0%*	*0.7%*	*0.7%*	*0.6%*	*0.6%*	*0.4%*	*0.4%*	*0.4%*	*0.3%*
Total industry, including energy (C to E)		2088.6	2475.1	2523.9	2682.8	2790.0	2856.9	3068.2	3539.9	3507.8
	%	*15.3%*	*12.6%*	*11.7%*	*11.5%*	*11.4%*	*10.6%*	*10.0%*	*10.5%*	*9.9%*
Construction (F)		884.1	1126.4	1446.5	1497.1	1547.2	1640.4	1786.1	1845.2	1951.7
	%	*6.5%*	*5.7%*	*6.7%*	*6.4%*	*6.3%*	*6.1%*	*5.8%*	*5.5%*	*5.5%*
Wholesale & retail trade, repair of motor vehicles, motorcycles and personnal & households goods; hotels & restaurants; transport, storage & communication (G to I)		2915.7	4274.1	4848.8	5015.0	5266.2	5561.1	6066.9	6694.5	7149.2
	%	*21.3%*	*21.8%*	*22.5%*	*21.6%*	*21.5%*	*20.5%*	*19.7%*	*19.8%*	*20.1%*
Financial intermediation; real estate, renting & business activities (J & K)		5366.0	8587.2	8975.5	9968.7	10428.3	12311.1	14943.1	16421.6	17419.4
	%	*39.2%*	*43.8%*	*41.7%*	*42.9%*	*42.6%*	*45.5%*	*48.5%*	*48.6%*	*49.0%*
Other services (public administration & defence, compulsory social security; edication; health & social work; other community social & personal service activities; private households with employed persons (L to P)		2279.9	3026.3	3603.9	3930.3	4315.0	4583.1	4818.3	5135.4	5410.2
	%	*16.7%*	*15.4%*	*16.7%*	*16.9%*	*17.6%*	*16.9%*	*15.6%*	*15.2%*	*15.2%*
Total: all NACE rev1.1 branches		13675.1	19623.4	21542.2	23235.3	24490.0	27073.2	30799.7	33768.5	35558.0

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

58 Data prior to 1995 are and will not be translated into the new European System of Accounts (ESA).

Figure 2-15 – Sectoral gross value added at current prices: 1995 & 2008



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

2.1.5 Energy

2.1.5.1 A total change in Luxembourg's energy-mix

Primary and final energy consumption in Luxembourg experienced dramatic changes since 1990. Overall primary energy consumption increased by 22.4% between 1990 and 2007.[59] Whereas solid fuels and coal declined by more than 93% over the period, liquid fuels (excl. kerosene) and natural gas consumptions increased by 69.4% and 179.9% respectively (Table 2-7 & Figure 2-16).

Final energy consumption increased by 20.4% between 1990 and 2007. As for primary energy consumption, all the energy sources have seen their consumption increase over the period, except solid fuels and coal (Table 2-8 & Figure 2-17).

However, over the period 1990-2007, the final energy-mix of Luxembourg changed considerably 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. Indeed, in 2007, 84% of the final energy consumption was covered by fossil

59 2008 energy balances have not yet been completed at the time this report has been finalized: major revision and reorganization of the energy data are currently on-going at STATEC.

fuels – 62% by liquid fuels including the important volume of road fuels,[60] 20% by natural gas and 2% by coal. The remaining 16% of the consumption were either electricity (14%) and energy produced using cogeneration techniques (1.4%) or wood and biofuels (0.4%). Going back to 1990, 31% of the final energy consumption was stemming from solid fuels and coal, 44% from liquid fuels, 14% from natural gas and 11% from electricity (Table 2-8 & Figure 2-17). What did happen?

- regarding solid fuels and coal, the important decline (-92.1%) is the result of a change in production processes in the steel industry sector: the production process was moved from blast furnaces to electric arc furnaces between 1994 and 1998 and, therefore, solid fuels (mainly imported coke, but also imported anthracite) were replaced, to a very large extent, by electricity and natural gas;
- liquid fuels increase (+69.7%) was driven by road fuel sales, and especially "road fuel sales to non residents" (see Section 2.1.6);
- the 70.9% increase in natural gas final consumption followed the continuous extension of the natural gas network in Luxembourg so that this fuel ranked second after the consumption of liquid fuels in 2007 – and even first if "road fuel sales to non residents" are not considered.

Natural gas has also become the main energy source of Luxembourg's national electricity production capacity. In 1990, more than 90% of Luxembourg's electric energy consumption was imported and one medium size power plant of about 70 MW was run by the iron and steel company Arbed.[61] That power plant was mainly run on blast furnace gas – a side product of the blast furnaces in the steel industry – and was phased out in 1998 after the last blast furnace went out of service .In the early 1990s, small combined heat-power (CHP) installations (or 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 ultra-modern TWINerg power plant started its commercial operation. Located in Esch-sur-Alzette, TWINerg is a gas and steam turbine power station running on natural gas, with an electrical output of 350 MWel (efficiency 55.7%).[62] There are plans for decoupling heat at a later stage (28 MWth) for remote heating of the new Belval-Ouest district project.[63] If almost all of these cogeneration plants run on natural gas, gas oil remains the emergency fuel in case of a natural gas supply disruption.

The impact of TWINerg in the primary energy consumption mix is clearly visible in Table 2-7 and its associated Figure 2-16: electricity imports dropped and natural gas primary consumption in-

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60 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: cf section 2.1.6 below.

61 Then Arcelor and now, Arcelor-Mittal.

62 http://www.twinerg.lu/en_index.html, "Environment" tab.

63 http://www.agora.lu.

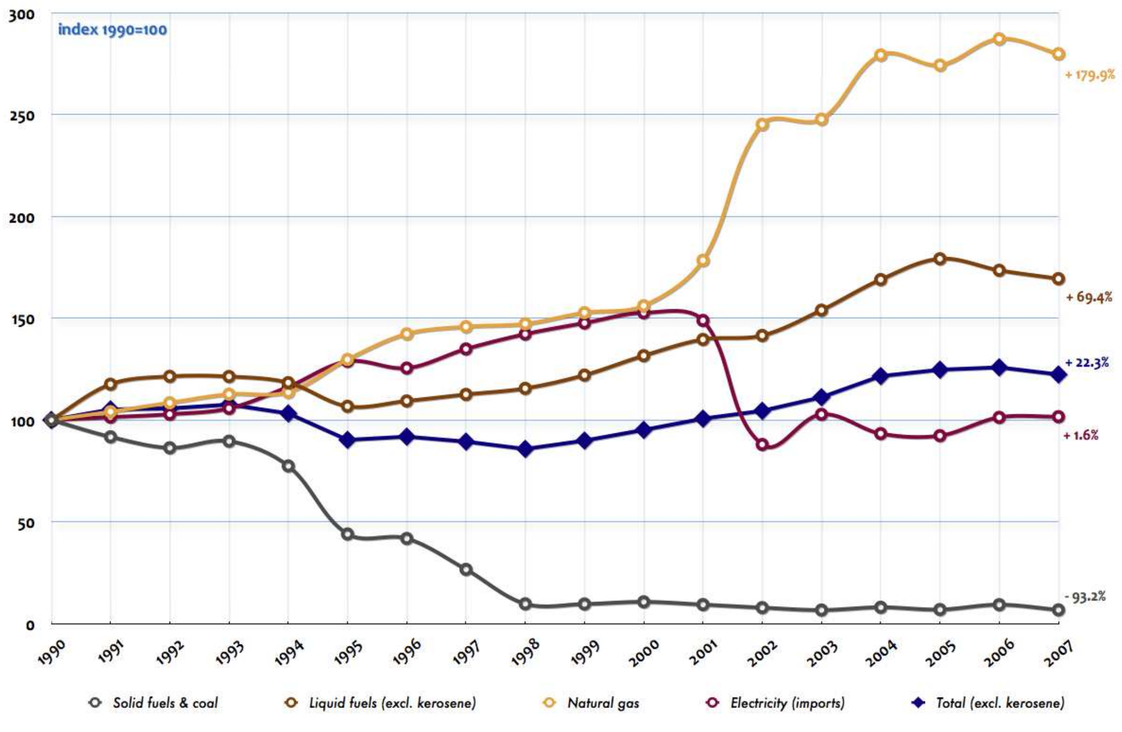
creased. To complement this analysis, an energy balance for electric power is provided (Table 2-9 & Figure 2-18).

Table 2-7 – Primary energy consumption (excl. air transport): 1990-2007

1000 toe	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999
Solid fuels & coal	**1198,61**	**1099,27**	**1034,88**	**1073,87**	**928,05**	**527,59**	**501,20**	**319,20**	**116,62**	**115,50**
	34,32%	*29,92%*	*28,04%*	*28,58%*	*25,74%*	*16,74%*	*15,63%*	*10,23%*	*3,89%*	*3,68%*
Liquid fuels (excl. kerosene)	**1456,42**	**1711,93**	**1768,12**	**1767,28**	**1723,27**	**1554,27**	**1592,53**	**1638,96**	**1682,32**	**1777,20**
	41,70%	*46,60%*	*47,90%*	*47,03%*	*47,80%*	*49,32%*	*49,66%*	*52,50%*	*56,15%*	*56,62%*
Kerosene	**127,60**	**132,97**	**128,79**	**127,72**	**162,15**	**183,86**	**199,82**	**229,35**	**289,80**	**326,99**
Natural gas	**477,55**	**496,86**	**517,89**	**537,96**	**542,83**	**619,38**	**679,47**	**696,24**	**703,01**	**729,21**
	13,67%	*13,53%*	*14,03%*	*14,32%*	*15,06%*	*19,66%*	*21,19%*	*22,30%*	*23,47%*	*23,23%*
Electricity (imports)	**318,22**	**322,65**	**327,21**	**336,34**	**370,05**	**409,85**	**399,29**	**429,16**	**452,41**	**469,72**
	9,11%	*8,78%*	*8,86%*	*8,95%*	*10,26%*	*13,01%*	*12,45%*	*13,75%*	*15,10%*	*14,96%*
Waste incineration (with heat	**26,84**	**27,92**	**28,16**	**26,94**	**26,34**	**25,15**	**19,40**	**23,14**	**26,41**	**31,62**
recovery)	*0,77%*	*0,76%*	*0,76%*	*0,72%*	*0,73%*	*0,80%*	*0,60%*	*0,74%*	*0,88%*	*1,01%*
Biomass (1)	**15,00**	**15,00**	**15,00**	**15,00**	**15,00**	**15,00**	**15,00**	**15,00**	**15,00**	**15,40**
	0,43%	*0,41%*	*0,41%*	*0,40%*	*0,42%*	*0,48%*	*0,47%*	*0,48%*	*0,50%*	*0,49%*
Biogas	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**0,13**	**0,29**
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0,00%*	*0,01%*
Total (excl. kerosene)	**3492,64**	**3673,63**	**3691,26**	**3757,39**	**3605,54**	**3151,24**	**3206,89**	**3121,70**	**2995,90**	**3138,94**

1000 toe	2000	2001	2002	2003	2004	2005	2006	2007
Solid fuels & coal	**128,26**	**112,03**	**94,10**	**79,94**	**96,22**	**82,89**	**111,53**	**81,00**
	3,86%	*3,19%*	*2,58%*	*2,06%*	*2,27%*	*1,90%*	*2,54%*	*1,90%*
Liquid fuels (excl. kerosene)	**1916,19**	**2032,22**	**2060,74**	**2241,71**	**2460,46**	**2609,28**	**2526,84**	**2466,90**
	57,68%	*57,81%*	*56,46%*	*57,74%*	*57,95%*	*59,92%*	*57,49%*	*57,73%*
Kerosene	**311,64**	**337,06**	**365,19**	**380,44**	**407,36**	**420,60**	**393,62**	**422,10**
Natural gas	**745,47**	**852,06**	**1170,77**	**1183,02**	**1333,47**	**1309,80**	**1371,31**	**1336,54**
	22,44%	*24,24%*	*32,08%*	*30,47%*	*31,41%*	*30,08%*	*31,20%*	*31,28%*
Electricity (imports)	**485,74**	**473,73**	**279,92**	**327,01**	**296,91**	**293,72**	**322,28**	**323,37**
	14,62%	*13,48%*	*7,67%*	*8,42%*	*6,99%*	*6,74%*	*7,33%*	*7,57%*
Waste incineration (with heat	**30,77**	**28,15**	**26,72**	**31,42**	**38,19**	**35,79**	**38,17**	**38,91**
recovery)	*0,93%*	*0,80%*	*0,73%*	*0,81%*	*0,90%*	*0,82%*	*0,87%*	*0,91%*
Biomass (1)	**15,40**	**15,40**	**15,40**	**15,40**	**15,40**	**15,97**	**15,94**	**16,40**
	0,46%	*0,44%*	*0,42%*	*0,40%*	*0,36%*	*0,37%*	*0,36%*	*0,38%*
Biogas	**0,55**	**2,01**	**2,29**	**4,13**	**4,99**	**7,43**	**8,91**	**9,98**
	0,02%	*0,06%*	*0,06%*	*0,11%*	*0,12%*	*0,17%*	*0,20%*	*0,23%*
Total (excl. kerosene)	**3322,38**	**3515,60**	**3649,94**	**3882,63**	**4245,64**	**4354,88**	**4394,98**	**4273,10**

Figure 2-16 – Primary energy consumption (excl. air transport): 1990-2007



Sources: Ministry of Economic Affairs and External Trade-Energy Department and FiFo Köln.

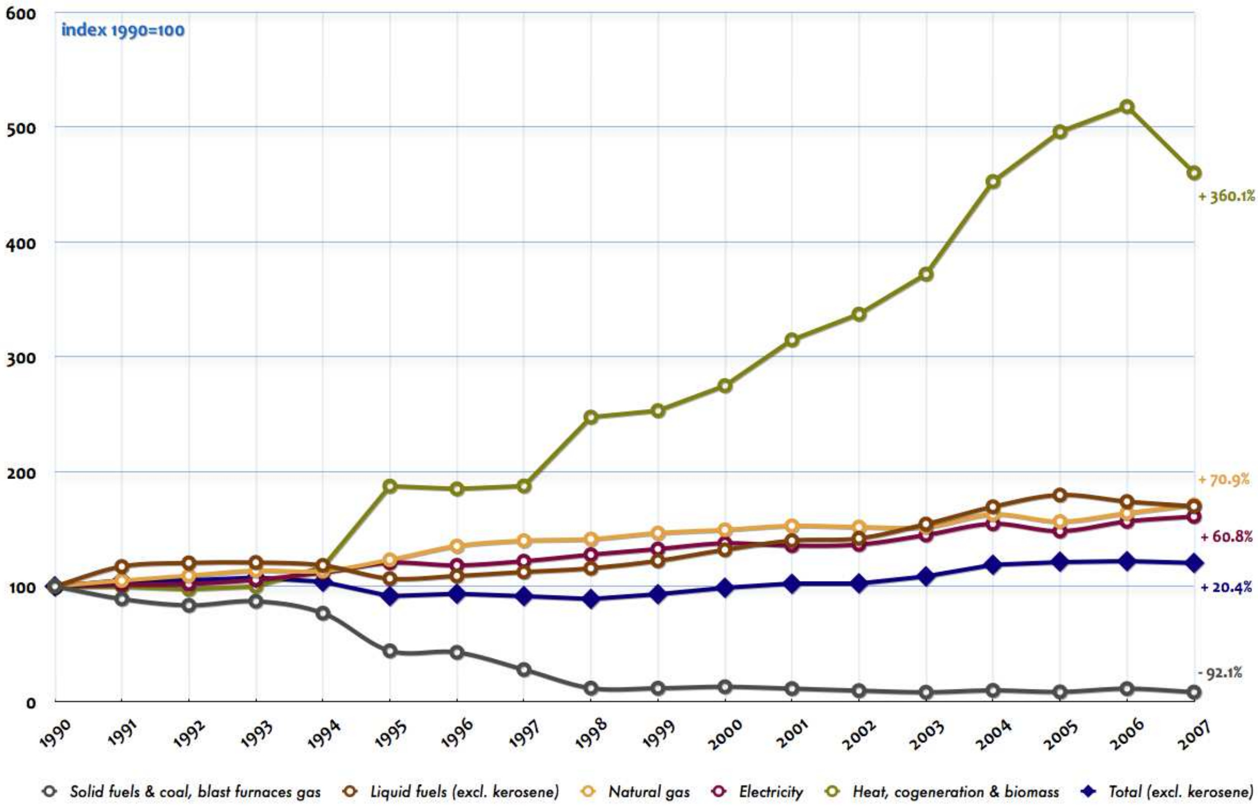
Note: (1) wood only up to 2004 included, wood and biofuels in 2005, 2006 and 2007 (*data prepared in March 2009, subject to changes since that date*)

Table 2-8 – Final energy consumption (excl. air transport): 1990-2007

1000 toe	1990 (base year)	1991	1992	1993	1994	1995	1996	1997	1998	1999
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**
	30,84%	*26,13%*	*24,43%*	*24,93%*	*22,72%*	*14,79%*	*14,02%*	*9,28%*	*3,96%*	*3,74%*
solid fuels & coal	819,56	736,47	704,10	733,06	651,29	382,99	374,29	248,93	116,62	115,50
blast furnaces gas	201,72	172,56	148,42	155,59	131,45	65,25	59,99	32,27	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**
	43,89%	*48,98%*	*50,16%*	*49,24%*	*49,89%*	*51,21%*	*51,17%*	*53,96%*	*57,05%*	*57,61%*
Kerosene	**127,60**	**132,97**	**128,79**	**127,72**	**162,15**	**183,86**	**199,82**	**229,35**	**289,80**	**326,99**
Natural gas	**464,14**	**487,02**	**507,24**	**527,48**	**525,22**	**571,29**	**627,00**	**648,61**	**655,32**	**679,43**
	14,01%	*14,00%*	*14,53%*	*14,80%*	*15,25%*	*18,85%*	*20,24%*	*21,41%*	*22,23%*	*22,03%*
Electricity	**357,63**	**363,04**	**364,75**	**378,03**	**400,27**	**430,70**	**422,96**	**435,93**	**456,15**	**473,77**
	10,80%	*10,44%*	*10,45%*	*10,60%*	*11,62%*	*14,21%*	*13,65%*	*14,39%*	*15,47%*	*15,36%*
Heat, cogeneration & biomass	**15,40**	**15,40**	**15,00**	**15,40**	**18,00**	**28,84**	**28,47**	**28,86**	**38,09**	**38,96**
	0,46%	*0,44%*	*0,43%*	*0,43%*	*0,52%*	*0,95%*	*0,92%*	*0,95%*	*1,29%*	*1,26%*
heat & cogeneration	NO	NO	NO	NO	3,00	13,84	13,07	13,46	22,69	23,56
biomass **(1)**	15,40	15,40	15,00	15,40	15,00	15,00	15,40	15,40	15,40	15,40
Total (excl. kerosene)	**3312,06**	**3478,35**	**3489,99**	**3565,25**	**3444,91**	**3031,39**	**3097,85**	**3029,41**	**2948,17**	**3084,49**

1000 toe	2000	2001	2002	2003	2004	2005	2006	2007
Solid fuels & coal, blast furnaces gas	**128,26**	**112,03**	**94,10**	**79,94**	**96,22**	**82,89**	**111,53**	**81,00**
	3,92%	*3,31%*	*2,77%*	*2,22%*	*2,45%*	*2,06%*	*2,76%*	*2,03%*
solid fuels & coal	128,26	112,03	94,10	79,94	96,22	82,89	111,53	81,00
blast furnaces gas	NO	NO	NO	NO	NO	NO	NO	NO
Liquid fuels (excl. kerosene)	**1915,99**	**2031,88**	**2060,51**	**2241,59**	**2460,36**	**2609,28**	**2526,84**	**2466,90**
	58,58%	*60,02%*	*60,64%*	*62,26%*	*62,55%*	*64,84%*	*62,58%*	*61,87%*
Kerosene	**311,64**	**337,06**	**365,19**	**380,44**	**407,36**	**420,60**	**393,62**	**422,10**
Natural gas	**692,52**	**708,62**	**703,73**	**704,09**	**754,88**	**726,15**	**759,97**	**793,00**
	21,17%	*20,93%*	*20,71%*	*19,56%*	*19,19%*	*18,04%*	*18,82%*	*19,89%*
Electricity	**491,69**	**484,32**	**487,84**	**517,26**	**552,15**	**529,57**	**559,68**	**575,15**
	15,03%	*14,31%*	*14,36%*	*14,37%*	*14,04%*	*13,16%*	*13,86%*	*14,43%*
Heat, cogeneration & biomass	**42,31**	**48,45**	**51,90**	**57,27**	**69,69**	**76,36**	**79,74**	**70,86**
	1,29%	*1,43%*	*1,53%*	*1,59%*	*1,77%*	*1,90%*	*1,97%*	*1,78%*
heat & cogeneration	26,91	33,05	36,50	41,87	54,29	60,39	63,80	54,46
biomass **(1)**	15,40	15,40	15,40	15,40	15,40	15,97	15,94	16,40
Total (excl. kerosene)	**3270,77**	**3385,30**	**3398,08**	**3600,15**	**3933,30**	**4024,25**	**4037,76**	**3986,91**

Figure 2-17 – Final energy consumption (excl. air transport): 1990-2007



Sources: Ministry of Economic Affairs and External Trade-Energy Department and FiFo Köln.

Note: (1) wood only up to 2004 included, wood and biofuels in 2005, 2006 and 2007 (*data prepared in March 2009, subject to changes since that date)*

Table 2-9– Energy balance for electric power: 1990-2008

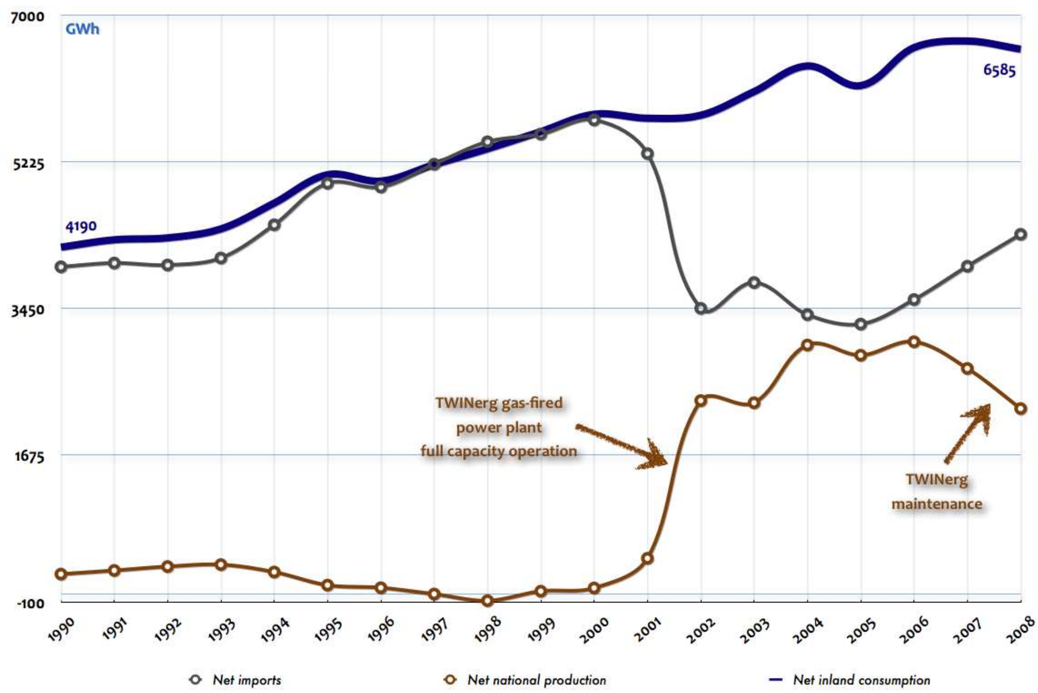
GWh		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Imports		**4708,28**	**4713,87**	**4517,87**	**4453,75**	**5026,76**	**5707,38**	**5725,89**	**6040,48**	**6388,99**	**6212,79**
National production		**626,24**	**676,37**	**662,49**	**669,79**	**626,80**	**537,67**	**503,77**	**414,77**	**343,23**	**371,12**
	cogeneration	NO	NO	NO	NO	30,00	99,84	122,35	124,83	198,03	205,15
	thermic power stations	558,72	622,11	594,14	607,83	505,96	346,53	307,87	205,38	45,38	52,29
	of which, TWINerg **(2)**	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	hydro-electricity	67,52	54,26	68,35	61,96	90,84	91,30	73,55	81,71	94,75	95,53
	wind	NO	NO	NO	NO	NO	NO	NO	2,74	4,61	17,14
	biomass	NO	NO	NO	NO	NO	NO	NO	0,12	0,46	1,01
	photovoltaic	NO	NO	NO	NO	NO	NO	NO	0,00	0,00	0,00
Total		**5334,52**	**5390,24**	**5180,36**	**5123,54**	**5653,56**	**6245,06**	**6229,66**	**6455,25**	**6732,22**	**6583,91**
exports		**754,92**	**715,17**	**542,95**	**394,41**	**565,57**	**744,15**	**808,06**	**846,96**	**924,12**	**654,97**
conversion uses and losses		**389,32**	**395,43**	**334,28**	**318,06**	**364,83**	**434,15**	**431,95**	**418,98**	**428,05**	**340,97**
net inland consumption		**4190,27**	**4279,65**	**4303,13**	**4411,08**	**4723,16**	**5066,76**	**4989,66**	**5189,31**	**5380,05**	**5587,98**
Total		**5334,52**	**5390,24**	**5180,36**	**5123,54**	**5653,56**	**6245,06**	**6229,66**	**6455,25**	**6732,22**	**6583,91**

Summary in GWh	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Net imports	**3953,36**	**3998,70**	**3974,92**	**4059,35**	**4461,19**	**4963,24**	**4917,84**	**5193,52**	**5464,86**	**5557,82**
Net national production (1)	**236,91**	**280,95**	**328,21**	**351,73**	**261,97**	**103,52**	**71,82**	**-4,21**	**-84,81**	**30,15**
Net inland consumption	**4190,27**	**4279,65**	**4303,13**	**4411,08**	**4723,16**	**5066,76**	**4989,66**	**5189,31**	**5380,05**	**5587,98**
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
Net inland consumption in 1000 toe **(2)**	360,01	367,69	369,71	378,98	405,79	435,31	428,69	445,84	462,23	480,10

GWh		2000	2001	2002	2003	2004	2005	2006	2007	2008
Imports		**6465,87**	**6389,20**	**6390,70**	**6562,18**	**6506,31**	**6391,61**	**6823,54**	**6846,58**	**6829,87**
National production		**428,47**	**842,18**	**2785,42**	**2784,39**	**3373,52**	**3336,72**	**3518,95**	**3190,23**	**2707,96**
	cogeneration	227,96	321,41	341,50	382,28	421,57	417,92	438,09	362,39	378,35
	thermic power stations	51,74	374,43	2312,42	2285,48	2787,37	2736,60	2866,49	2598,86	2089,25
	of which, TWINerg **(2)**	*NO*	*323,03*	*2275,65*	*2237,29*	*2731,06*	*2646,00*	*2774,01*	*2511,69*	*2047,16*
	hydro-electricity	119,46	114,39	97,38	73,94	95,64	85,03	102,67	107,19	121,23
	wind	24,74	23,70	24,73	26,17	39,40	52,25	57,99	64,29	60,59
	biomass	4,54	8,20	9,30	15,13	20,34	27,22	32,60	36,59	38,51
	photovoltaic	0,04	0,05	0,08	1,40	9,20	17,70	21,11	20,90	20,03
Total		**6894,34**	**7231,39**	**9176,12**	**9346,57**	**9879,83**	**9728,33**	**10342,49**	**10036,81**	**9537,83**
exports		**736,85**	**1066,79**	**2939,92**	**2799,41**	**3131,58**	**3131,31**	**3266,55**	**2886,84**	**2483,53**
conversion uses and losses		**359,49**	**414,82**	**450,53**	**475,68**	**366,33**	**452,92**	**472,35**	**466,47**	**466,16**
net inland consumption		**5798,00**	**5749,79**	**5785,67**	**6071,48**	**6381,92**	**6144,11**	**6603,59**	**6683,49**	**6588,14**
Total		**6894,34**	**7231,39**	**9176,12**	**9346,57**	**9879,83**	**9728,33**	**10342,49**	**10036,81**	**9537,83**

Summary in GWh	2000	2001	2002	2003	2004	2005	2006	2007	2008
Net imports	**5729,01**	**5322,42**	**3450,78**	**3762,77**	**3374,73**	**3260,30**	**3556,99**	**3959,74**	**4346,34**
Net national production (1)	**68,99**	**427,37**	**2334,89**	**2308,71**	**3007,19**	**2883,81**	**3046,60**	**2723,76**	**2238,79**
Net inland consumption	**5798,00**	**5749,79**	**5785,67**	**6071,48**	**6381,92**	**6144,11**	**6603,59**	**6683,49**	**6585,14**
Net inland consumption in Mio. MJ	20856,11	20682,68	20811,76	21839,86	22956,54	22101,11	23753,92	24041,34	23687,54
Net inland consumption in 1000 toe **(3)**	498,14	494,00	497,08	521,64	548,31	527,88	567,35	574,22	565,77

Figure 2-18 – Energy balance for electric power: 1990-2008



Sources: 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.

(2) as indicated in the main text, the TWINerg power plant started its commercial operation in 2002. The recorded value for 2001 corresponds to a testing phase in production.

(3) net inland consumption expressed in 1000 toe differs slightly from the corresponding figures in Table 2-8 – less than 2% – because data sources, units and calculations are not exactly the same. The on-going work at STATEC on energy statistics aims, among other things, at avoiding these minor discrepancies.

data prepared in June 2010 (subject to changes since that date)

2.1.5.2 Road transportation

2.1.5.2.1 Diverse inland and cross-border 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 (Figure 2-19) 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.

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 sales to non residents**" whether they are in transit or commuting for work or leisure. Indeed, due to a policy of low taxed fuel (gasoline and diesel), Luxembourg is an attractive "fuelling station" for daily commuters from neighbouring countries and cross-border shoppers, but, in first instance, for international road transit traffic crossing its territory (mainly freight transport). "Road fuel sales to non residents" is briefly defined in Box 2-2.

With numerous trucks transiting through Luxembourg, as well as a passenger cars market dominated by diesel vehicles in at least two of its neighbouring countries – namely Belgium and France – it is not surprising that diesel oil is the first liquid fuel in terms of volumes sold (Figure 2-20).

The allocation of fuel sales between residents ("domestic") and non-residents ("exports") is not made on the basis of statistics or counting, but well using the COPERT model. Details are provided in Section 3.2.8.3 of this report.

Box 2-2 – "Road fuel sales to non residents"

It covers fuel sales to non-residents, i.e.:

1. road vehicles in transit: freight trucks, buses & coaches, passenger cars, whose an important share fills up in Luxembourg because of lower fuel prices;
2. cross-border commuters who are also benefiting of the cheaper fuel prices;

3. “fuel tourism”, known as “*Tanktourismus*” in Luxembourg: people driving especially to Luxembourg for benefiting of lower fuel prices, as well as lower prices on other commodities such as non-alcoholic & alcoholic drinks, tobacco, etc. (Luxembourg usually applies the lower taxation rates adopted at EU levels, i.e. 15%).

In the subsequent chapters & sections of this NIR, “road fuel sales to non residents” are named “(road) fuel exports”

2.1.5.2.2 Effects on GHG emissions: an untypical situation

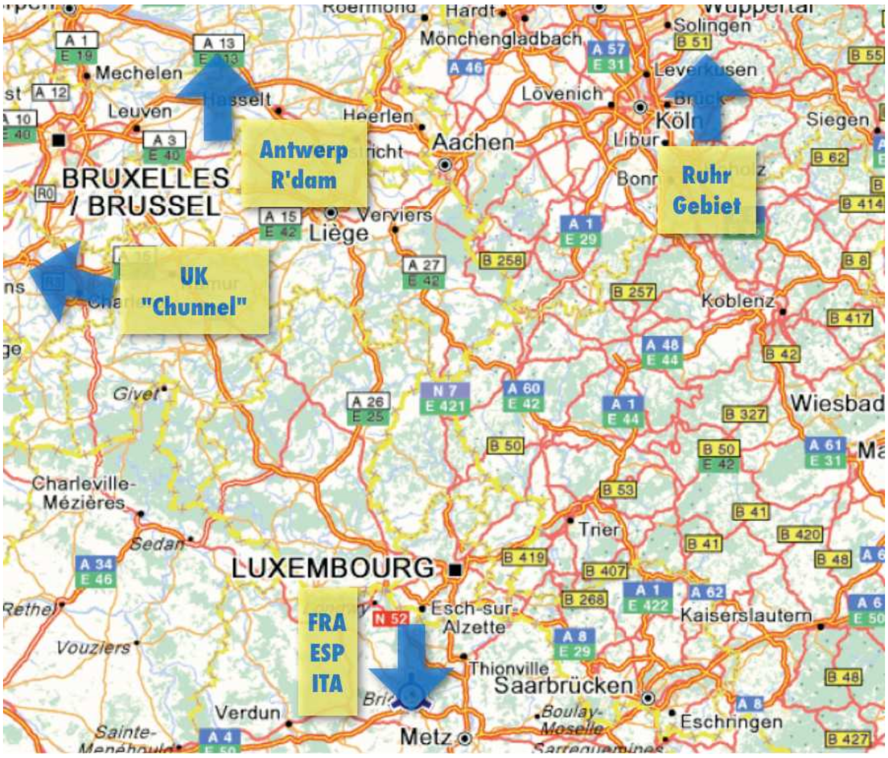
Combining the size of the country and of its economy, on the one side, and lower road fuel prices that implies a disproportionate volume of road fuel sales compared to its resident population, on the other side, Luxembourg presents a completely untypical and unique structural feature in its GHG emissions balance. In 2008, some 6.65 Mio. t CO_2e were produced by the road transportation sector and out of these, 4.96 Mio. t CO_2e, or 74.5%, was the result of road fuels bought by non-residents and were, consequently, merely emitted abroad. That last amount represented around 39.7% of the total 2008 GHG emissions for Luxembourg (excluding LULUCF) – 53.25% for the whole CRF sub-category 1A3b (Figure 2-21).

Both emissions generated by the national vehicles fleet and by the non-residents – “road fuel exports” – showed dramatic increases over the period: +85% and +181% respectively.[64] For the national fleet, the evolution is correlated with both the population and economic activity growth. It is also explained by an increasing rate for passenger cars per inhabitants (from 515 to 675 passenger cars per 1000 inhabitants between 1991 and 2007, i.e. the highest rate within the EU[65]). Regarding “road fuel exports”, the rise is undoubtedly linked to the growing number of commuters crossing the borders every working day as well as to the general increase of road freight traffic in Europe.

64 Corresponding percentages were +68% and +211% in 2005, the peak year with regard to road transportation related emissions.

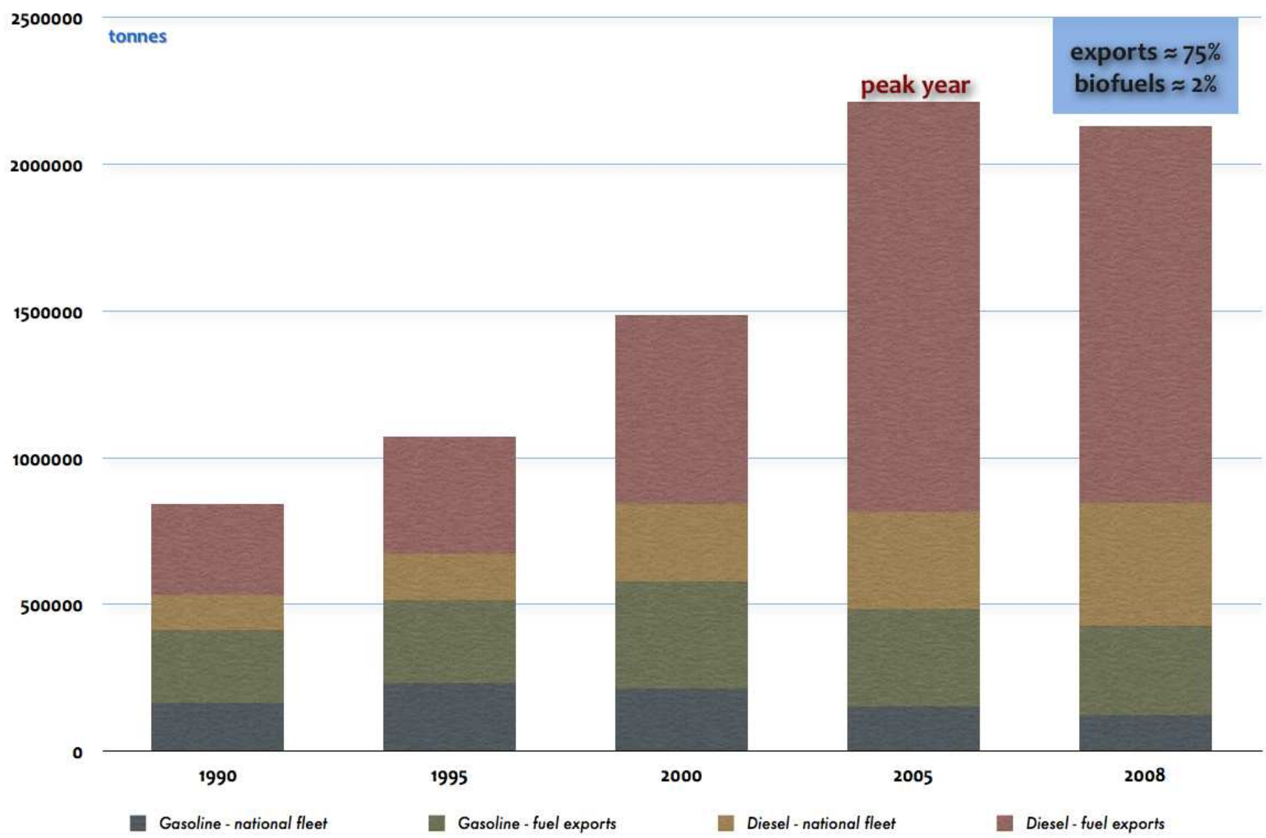
65 Data extracted from EUROSTAT databases (updated 8-6-2010) and from EUROSTAT, *Energy, transport and environment indicators*, 2009 edition, p.92-93.

Figure 2-19 – Main road freight axes crossing Luxembourg



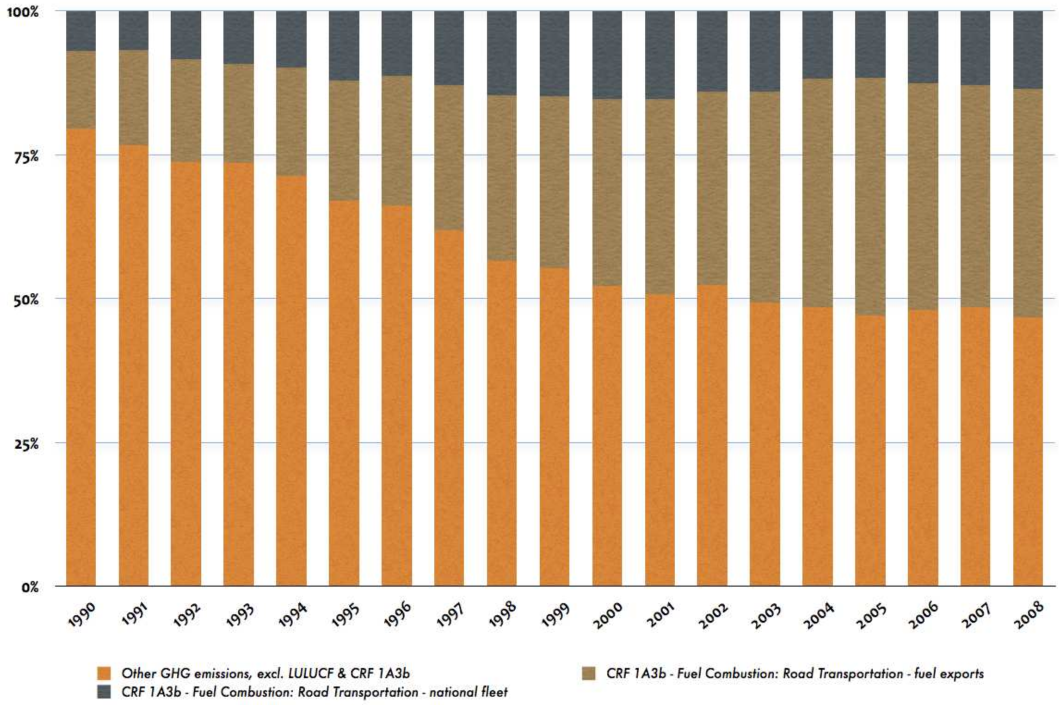
Source: ViaMichelin.

Figure 2-20 – Road fuel sales: 1990-2008 in tonnes



Sources: Environment Agency and MDDI-DEV.

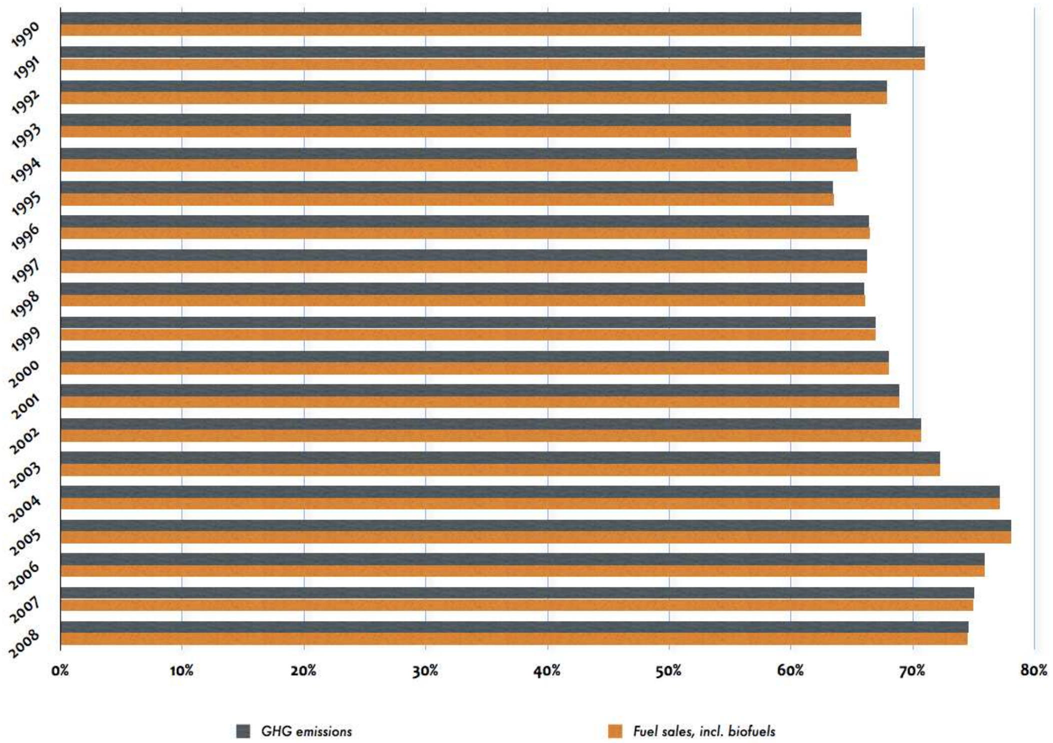
Figure 2-21 – GHG emissions for road transportation (CRF sub-category 1A3B): 1990-2008



Sources: Environment Agency and MDDI-DEV.

Note: excluding CO_2 emissions from biofuels, which are reported as "memo item".

Figure 2-22 – Share of "road fuel exports" in fuel sales and in CRF sub-category 1A3B GHG emissions: 1990-2008



Sources: Environment Agency and MDDI-DEV.

Note: biofuels are included in fuel sales from 2004 onwards. They are not included in GHG emissions for CO_2 as they are reported as "memo item".

2.1.6 UNFCCC and Kyoto Protocol: a demanding challenge for Luxembourg

2.1.6.1 The road transportation dilemma

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. However, since road transportation, and more precisely "road fuel exports", is the main contributor to GHG emissions in Luxembourg, as underlined in the new Government programme,[66] Luxembourg will aim at progressively reducing road transport related emissions, though a complete phasing-out of "road fuel exports" is not foreseen. To do so, the Government intends to progressively increase the excise duties on road fuels taking into account the market prices of crude and refined petroleum products.

2.1.6.2 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 (see Section 2.4 for details).

These last years, the construction of a single power station, the TWINerg gas and steam plant, represents a further illustrative example as depicted in Section 2.1.5. When TWINerg started its operation in mid-2002, Luxembourg, which did not have so far any substantial electricity generating capacity, saw, at once, its GHG emissions increasing by 0.9 to 1 Mio. t CO_2e per year. To give

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66 A new Government has started its work after the general elections of June 2009. Its program can be read here: http://www.gouvernement.lu/gouvernement/programme-2009/index.html. For the climate change policy, go to *Programme gouvernemental* > *Ministère du Développement durable et des Infrastructures* > section II. 3.

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 EU Emissions Trading Scheme sector (EU-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. Also, a sufficiently long breakdown in one of the main industrial unit of the country could have impacts on the total GHG emissions, such as the long maintenance operation of the TWINerg power plant in 2008 demonstrates.

If these issues might not be a major concern for large economies, it is for Luxembourg, as shown by the examples discussed above.

2.1.6.3 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 is 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 EU-ETS – decreased to just 2.4 Mio. t CO_2e in 1998 – or 26.5% 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).[67]

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 CHP installations and the ultramodern gas and steam power station (TWINerg) that have been promoted and are operating in Luxembourg since 1998, and that use natural gas and, sometimes, gas oil as inputs, have led to an additional amount of approx. 1.2 Mio. t CO_2e in the GHG balance.[68] 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

67 The lowest share (24%) was obtained in 2001, the year prior to the one TWINerg started its production.

68 1 Mio. t CO_2e for the TWINerg and 0.2 Mio. t CO_2e for CHP installations.

thanks to increased efficiency, is counterproductive for Luxembourg. For this reason, the new Government recalls in its Programme that it will only promote heat production from renewable energy sources, focusing mainly on biomass, wood and solar energy.[69] More precisely, CHP installations using renewable energies, biogas addition in distribution networks and the mobilization of wood resources will be favoured.

2.1.6.4 The "origin" principle of the IPCC reporting Guidelines vs. "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, for 2007, GHG emissions according to the IPCC Guidelines are some 0.8 Mio. t CO_2e "too high" (Figure 2-12).[70] The same correction for the year 2012 has been evaluated in the framework of the second National Allocation Plan 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.[71]

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:[72] it has been estimated that electricity net imports – with, nowadays, an average emission factors of 0.75 (kt CO_2 per GWh) – have fallen by more than 1 100 GWh since 1998 and have been replaced by national electricity generation with a current average emission factor of 0.41 (kt CO_2 per GWh).

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69 Refer to footnote 24 for references.

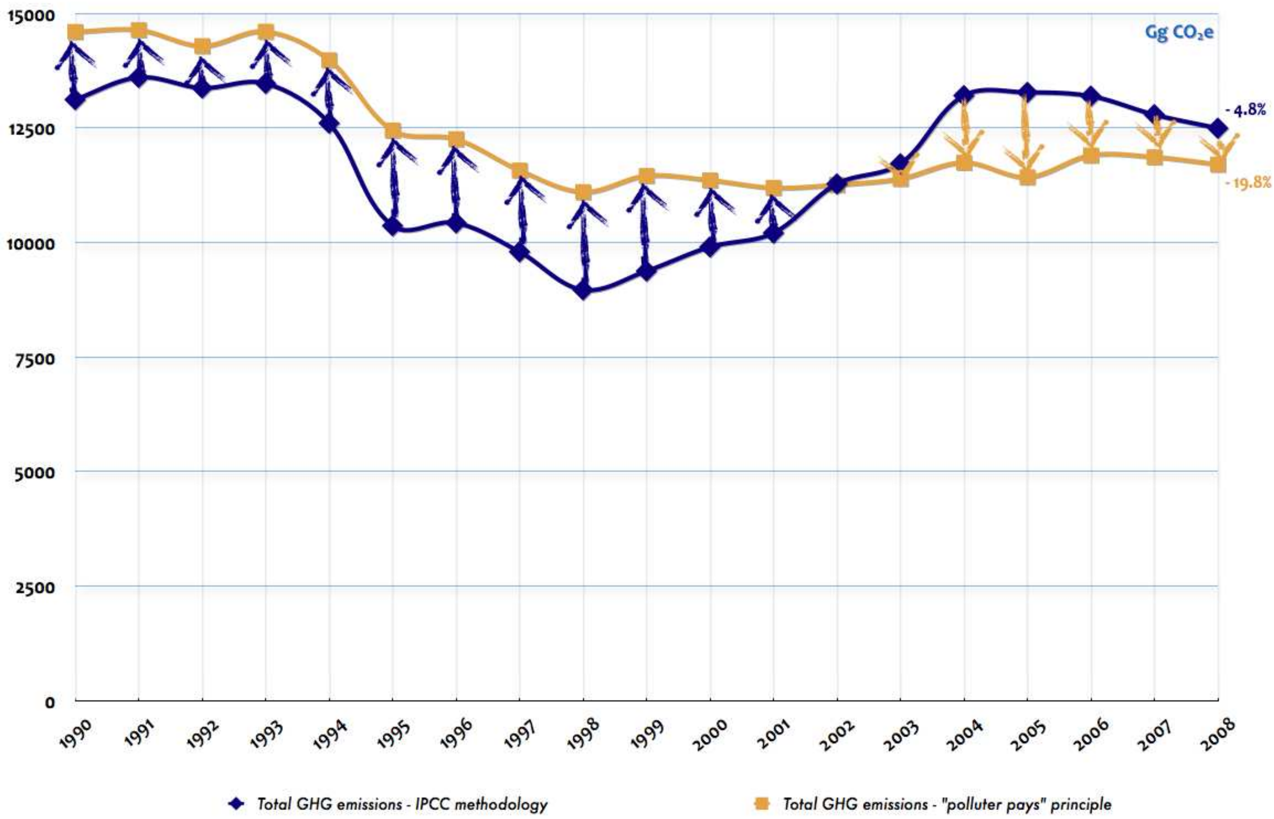
70 After having reached a "surplus" of almost 1.9 Mio. t CO_2e in 2005.

71 However, the latest developments of GHG trends and composition in Luxembourg, combined with the actual financial and economic crisis effects, tend to indicate that this "surplus" of 4.8 Mio. t CO_2e by 2012 is probably overestimated.

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

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.

Figure 2-23 – Total GHG emissions, excluding LULUCF – two approaches: 1990-2008



Sources: Environment Agency and MDDI-DEV.

Note: the "polluter pays" principle figures have been obtained from the total GHG emission according to the IPCC methodology by excluding emissions from "road fuel exports" and for electricity generated that is exported, and by adding an estimate for electricity production emissions generated abroad for satisfying Luxembourg consumption (i.e. emissions relating to electricity imports):

emissions "polluter pays" principle = emissions IPCC methodology – emissions "road fuel exports" + emissions electricity net imports

2.1.7 National circumstances: overview

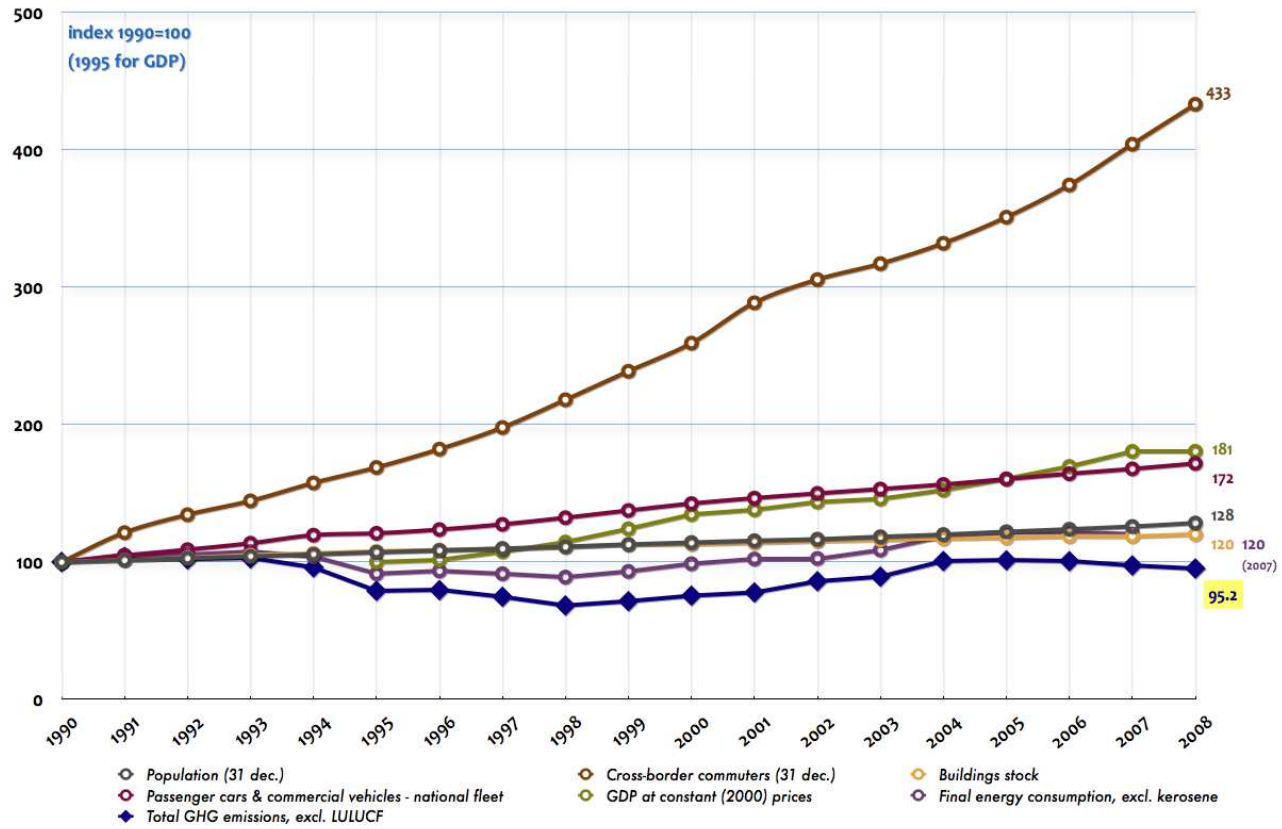
Key points that plays a role on GHG emissions trends in the past and in the future are:

- a country characterized by both **high demographic** and **high economic growth** in a stagnating region, hence an **attractive economic destination**;
- **strong population growth** due to immigration and that is expected to go on;

- **even stronger cross-border commuters growth** that is expected as well to go on once the financial and economic crisis will be over;
- **increase of built-up areas** (housing, offices, services, infrastructures) as a consequence of the previous statements;
- location at the **heart** of the main Western Europe **transit routes** for both **goods and passengers**;
- **increase of transport flows** as a consequence of the previous statements;
- **small** size and open economy: a new industrial project, a technological change, a closure or a breakdown of a production unit might have significant impacts on the GHG emissions and increase the overall uncertainty of GHG projections;
- **limitations in taxation policies** due to short distances to neighbouring countries;
- a country that **needs to co-operate and to interact with its neighbours** since environmental issues become quickly cross-border issues;
- **limited national** GHG emissions reduction potential.

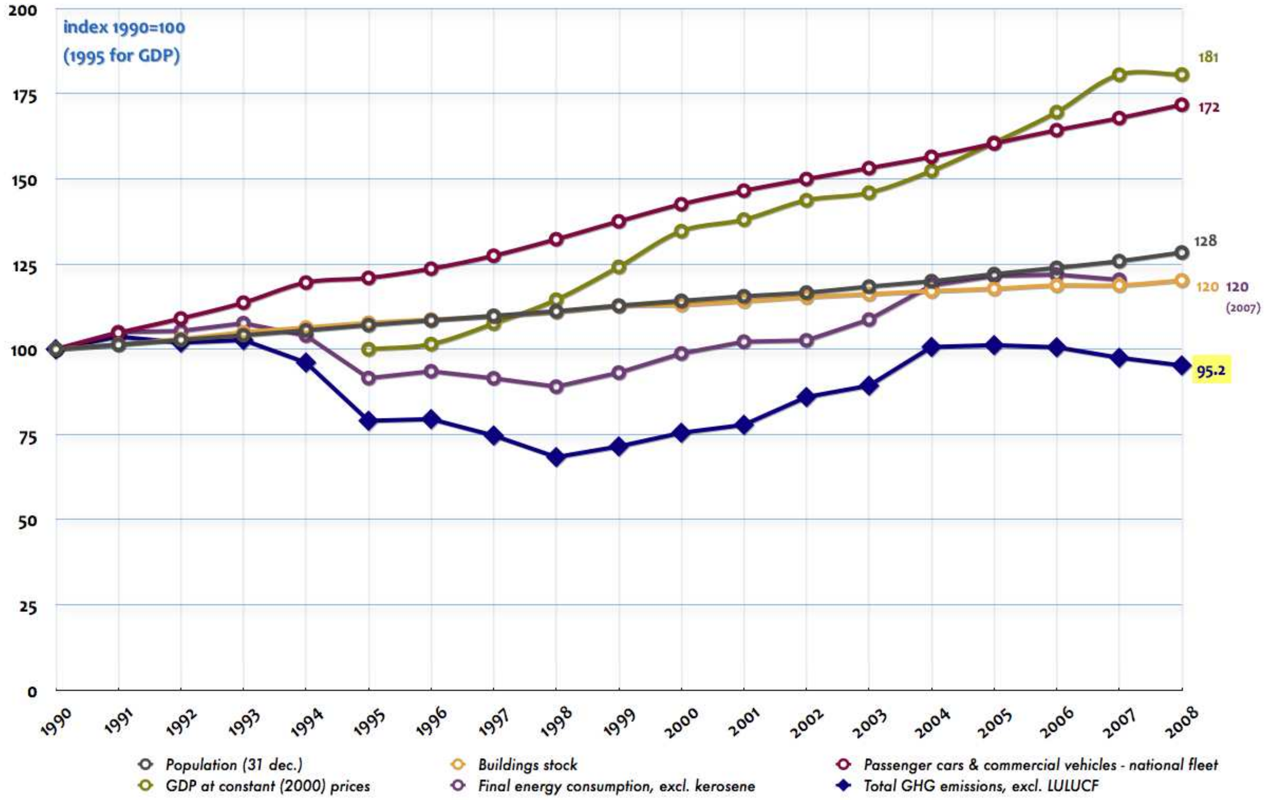
Figure 2-24, Figure 2-25 and Figure 2-26 provide a quick overview of the trends of some key variables since 1990.

Figure 2-24 – Key variables trends – 1: 1990-2008



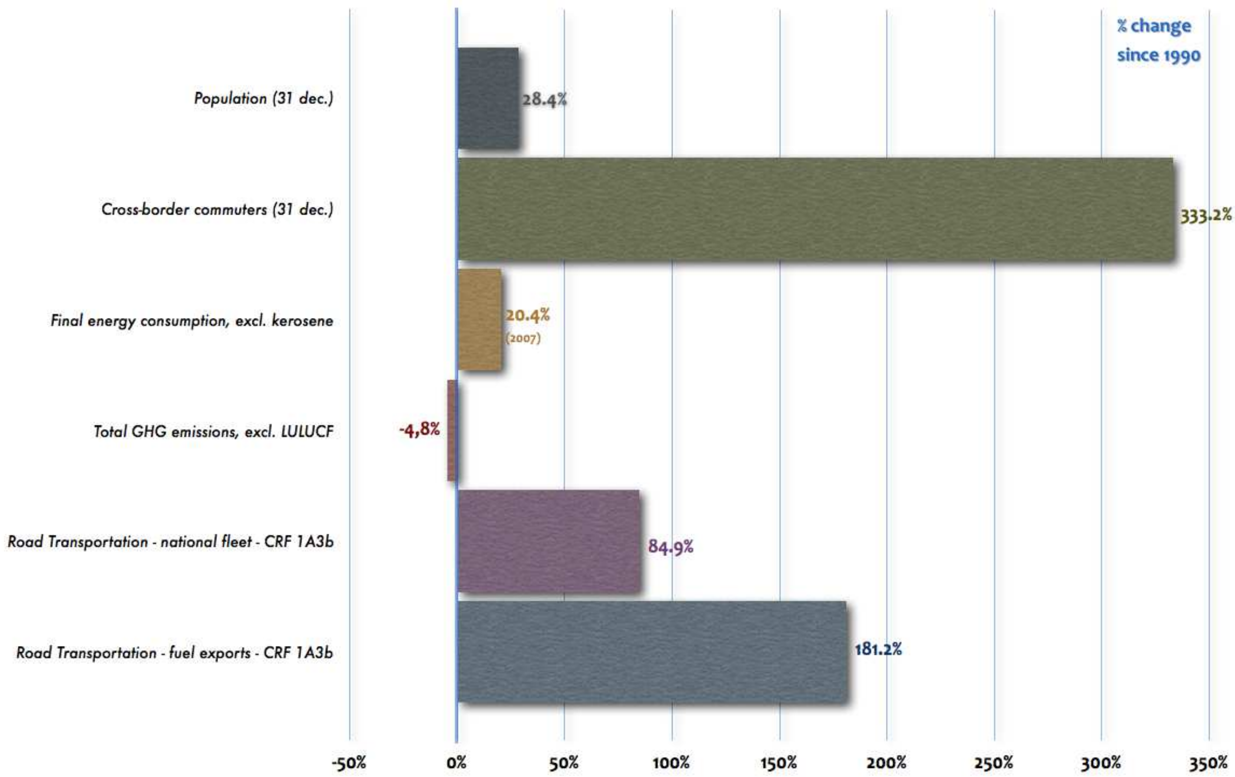
Sources: STATEC, Ministry of Economic Affairs and External Trade-Energy Department and FiFo Köln.

Figure 2-25 – Key variables trends – 1: 1990-2008 (excl. cross-border commuters)



Sources: STATEC, Ministry of Economic Affairs and External Trade-Energy Department, Environment Agency, MDDI-DEV and FiFo Köln.

Figure 2-26 – Key variables trends – 2: 1990 & 2008



Sources: STATEC, Ministry of Economic Affairs and External Trade-Energy Department, Environment Agency, MDDI-DEV and FiFo Köln.

2.2 Description of emission trends for aggregeated GHG emissions

Luxembourg ratified the United Nations Framework Convention on Climate Change in 1994, and the Kyoto Protocol in 2002. Pursuant to that Protocol and the terms of the European agreement distributing the burden among, at that time, the EU-15 Member States, Luxembourg undertook **to reduce its GHG emissions by 28% below their 1990 level over the period 2008-12**. This is the deepest cut of any agreed by the 15 Member States. When the Act approving the Kyoto Protocol was adopted in Luxembourg (2001), its GHG emissions were down by more than 30% between 1990 and 1998 (Table 2-10).

In 2009, carbon dioxide was the main source of GHG in Luxembourg. This source counted for a bit less than 91.7% of the total GHG emissions calculated in CO_2e – total excluding LULUCF.[73] The second source of GHG was nitrous oxide with 3.9% of the total emissions. Methane was the third source with 3.8%. Fluorinated gases only accounted for 0.6% of the total emissions, with hydrofluorocarbons representing 0.56% of the total and sulphur hexafluoride representing 0.06% of the total. Perfluorocarbons only accounted for 0.002% of the total.

In 2009, total GHG emissions amounted to 11.684 Mio. t CO_2e, 4.69% below their level for the base year.[74] As Figure 2-27 shows, several phases can clearly be distinguished over the period 1990 to 2009:

- 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, when they were down by more than 30%;
- from 1999 up to 2004, emissions augmented recurrently;
- from 2004 to 2006, a stabilisation peaking at 13.2 Mio. t CO_2e is observed;
- from 2006 to 2009, emissions experienced a relatively important decrease by more than 10%.

The evolution during those 20 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. During the last two years, the economic crisis, certainly also played a part.

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73 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.

74 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 2-10).

Table 2-10 – Luxembourg's GHG emissions and removals – overview by main gases and CRF Sectors: 1990-2009

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	2008	2009
CO_2 emissions, incl. net CO_2	**12215.72**	**12561.20**	**11970.55**	**11981.48**	**11333.03**	**8891.45**	**8766.83**	**8025.96**	**7398.40**	**7680.51**	**8383.13**	**8846.92**	**9605.80**	**10054.58**	**11464.63**	**11766.01**	**11752.45**	**11149.48**	**11002.30**	**10411.04**
from LULUCF (1)	*92.72%*	*92.77%*	*92.40%*	*92.46%*	*92.18%*	*90.13%*	*89.88%*	*89.11%*	*88.31%*	*88.56%*	*89.36%*	*90.06%*	*90.68%*	*91.19%*	*91.82%*	*92.16%*	*92.23%*	*91.96%*	*91.78%*	*91.42%*
CO_2 emissions, excl. net CO_2	**11870.82**	**12391.62**	**12169.15**	**12290.15**	**11471.84**	**9132.40**	**9180.32**	**8479.89**	**7596.75**	**8002.17**	**8771.36**	**9301.27**	**10059.83**	**10517.07**	**11881.84**	**12154.36**	**12030.71**	**11425.30**	**11277.25**	**10710.06**
from LULUCF	*92.54%*	*92.70%*	*92.54%*	*92.66%*	*92.28%*	*90.39%*	*90.31%*	*89.66%*	*88.61%*	*89.00%*	*89.81%*	*90.52%*	*91.09%*	*91.56%*	*92.11%*	*92.41%*	*92.42%*	*92.16%*	*91.99%*	*91.66%*
CH_4 (2) emissions, incl. net CH_4	**467.13**	**478.70**	**469.11**	**471.97**	**466.55**	**474.75**	**478.73**	**473.72**	**472.68**	**480.29**	**471.58**	**471.47**	**472.13**	**462.27**	**456.18**	**455.29**	**450.74**	**445.94**	**448.54**	**448.26**
from LULUCF (1)	*3.55%*	*3.54%*	*3.62%*	*3.64%*	*3.79%*	*4.81%*	*4.91%*	*5.26%*	*5.64%*	*5.54%*	*5.03%*	*4.80%*	*4.46%*	*4.19%*	*3.65%*	*3.57%*	*3.54%*	*3.68%*	*3.74%*	*3.94%*
CH_4 (2) emissions, excl. net CH_4	**467.13**	**478.70**	**469.11**	**471.97**	**466.55**	**474.75**	**478.73**	**473.72**	**472.68**	**480.29**	**471.58**	**471.47**	**472.13**	**462.27**	**456.18**	**455.29**	**450.74**	**445.94**	**448.54**	**448.26**
from LULUCF	*3.64%*	*3.58%*	*3.57%*	*3.56%*	*3.75%*	*4.70%*	*4.71%*	*5.01%*	*5.51%*	*5.34%*	*4.83%*	*4.59%*	*4.27%*	*4.02%*	*3.54%*	*3.46%*	*3.46%*	*3.60%*	*3.66%*	*3.84%*
N_2O (3) emissions, incl. net N_2O	**477.69**	**484.96**	**500.61**	**489.60**	**479.59**	**482.23**	**490.85**	**487.92**	**485.04**	**485.86**	**495.32**	**468.05**	**469.54**	**458.27**	**510.71**	**487.02**	**476.33**	**461.59**	**466.10**	**455.26**
from LULUCF (1)	*3.63%*	*3.58%*	*3.86%*	*3.78%*	*3.90%*	*4.89%*	*5.03%*	*5.42%*	*5.79%*	*5.60%*	*5.28%*	*4.76%*	*4.43%*	*4.16%*	*4.09%*	*3.81%*	*3.74%*	*3.81%*	*3.89%*	*4.00%*
N_2O (3) emissions, excl. net N_2O	**474.84**	**482.11**	**497.76**	**486.75**	**476.74**	**479.38**	**488.00**	**485.07**	**482.19**	**483.01**	**492.49**	**465.25**	**466.77**	**455.52**	**507.99**	**484.32**	**473.66**	**458.94**	**463.48**	**452.67**
from LULUCF	*3.70%*	*3.61%*	*3.78%*	*3.67%*	*3.84%*	*4.74%*	*4.80%*	*5.13%*	*5.62%*	*5.37%*	*5.04%*	*4.53%*	*4.23%*	*3.97%*	*3.94%*	*3.68%*	*3.64%*	*3.70%*	*3.78%*	*3.87%*
HFCs (4)	**13.54**	**13.54**	**13.54**	**13.83**	**14.32**	**15.62**	**16.02**	**17.32**	**20.14**	**24.12**	**28.79**	**34.38**	**42.09**	**47.00**	**49.40**	**53.23**	**57.15**	**61.33**	**63.68**	**65.78**
	0.11%	*0.10%*	*0.10%*	*0.10%*	*0.12%*	*0.15%*	*0.16%*	*0.18%*	*0.23%*	*0.27%*	*0.29%*	*0.33%*	*0.38%*	*0.41%*	*0.38%*	*0.40%*	*0.44%*	*0.49%*	*0.52%*	*0.56%*
PFCs (4)	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**0.01**	**0.01**	**0.01**	**0.02**	**0.11**	**0.15**	**0.17**	**0.21**	**0.24**	**0.22**
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
SF_6 (4)	**1.13**	**1.21**	**1.29**	**1.37**	**1.46**	**1.55**	**1.71**	**1.87**	**1.97**	**2.05**	**2.15**	**2.82**	**3.37**	**4.09**	**4.60**	**5.04**	**5.71**	**6.15**	**6.57**	**7.40**
	0.01%	*0.01%*	*0.01%*	*0.01%*	*0.01%*	*0.02%*	*0.02%*	*0.02%*	*0.02%*	*0.02%*	*0.02%*	*0.03%*	*0.03%*	*0.04%*	*0.04%*	*0.04%*	*0.04%*	*0.05%*	*0.05%*	*0.06%*
1. Energy	**10344.59**	**10952.79**	**10812.56**	**10961.55**	**10240.41**	**8257.42**	**8367.61**	**7780.81**	**7059.81**	**7428.35**	**8186.68**	**8775.84**	**9528.23**	**10064.17**	**11405.66**	**11684.01**	**11501.69**	**10884.07**	**10796.40**	**10284.96**
	80.64%	*81.94%*	*82.22%*	*82.64%*	*82.38%*	*81.73%*	*82.32%*	*82.27%*	*82.34%*	*82.61%*	*83.83%*	*85.41%*	*86.27%*	*87.62%*	*88.42%*	*88.84%*	*88.35%*	*87.79%*	*88.06%*	*88.02%*
2. Industrial Processes	**1623.03**	**1545.26**	**1475.28**	**1453.43**	**1361.97**	**1001.67**	**946.46**	**839.27**	**683.09**	**725.20**	**756.73**	**705.08**	**729.20**	**674.71**	**719.92**	**716.34**	**773.44**	**767.44**	**706.21**	**642.21**
	12.65%	*11.56%*	*11.22%*	*10.96%*	*10.96%*	*9.91%*	*9.31%*	*8.87%*	*7.97%*	*8.07%*	*7.75%*	*6.86%*	*6.60%*	*5.87%*	*5.58%*	*5.45%*	*5.94%*	*6.19%*	*5.76%*	*5.50%*
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**	**15.09**	**17.39**	**16.65**	**16.25**	**17.48**	**16.90**	**16.02**
	0.19%	*0.17%*	*0.17%*	*0.16%*	*0.16%*	*0.20%*	*0.19%*	*0.20%*	*0.21%*	*0.19%*	*0.16%*	*0.16%*	*0.15%*	*0.13%*	*0.13%*	*0.13%*	*0.12%*	*0.14%*	*0.14%*	*0.14%*
4. Agriculture	**745.87**	**754.16**	**748.70**	**735.64**	**718.60**	**737.15**	**746.91**	**734.48**	**728.82**	**738.46**	**724.11**	**697.23**	**690.41**	**650.49**	**680.78**	**660.63**	**652.39**	**656.42**	**669.63**	**674.09**
	5.81%	*5.64%*	*5.69%*	*5.55%*	*5.78%*	*7.30%*	*7.35%*	*7.77%*	*8.50%*	*8.21%*	*7.41%*	*6.79%*	*6.25%*	*5.66%*	*5.28%*	*5.02%*	*5.01%*	*5.29%*	*5.46%*	*5.77%*
5. LULUCF	**347.75**	**172.43**	**-195.75**	**-305.83**	**-135.96**	**-238.10**	**-410.64**	**-451.08**	**-195.50**	**-318.81**	**-385.41**	**-451.56**	**-451.26**	**-459.74**	**-414.49**	**-385.65**	**-275.59**	**-273.18**	**-272.34**	**-296.43**
	NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
6. Waste	**90.06**	**91.98**	**92.43**	**92.61**	**90.36**	**87.73**	**84.39**	**84.32**	**84.12**	**82.32**	**83.05**	**80.51**	**79.61**	**81.52**	**76.36**	**74.78**	**74.36**	**72.47**	**70.63**	**67.10**
	0.70%	*0.69%*	*0.70%*	*0.70%*	*0.73%*	*0.87%*	*0.83%*	*0.89%*	*0.98%*	*0.92%*	*0.85%*	*0.78%*	*0.72%*	*0.71%*	*0.59%*	*0.57%*	*0.57%*	*0.58%*	*0.58%*	*0.57%*
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*	*NA*	*NA*	*NA*	*NA*
Total GHG including LULUCF	**13175.21**	**13539.61**	**12955.10**	**12958.25**	**12294.96**	**9865.60**	**9754.15**	**9006.80**	**8378.22**	**8672.82**	**9380.97**	**9823.64**	**10592.94**	**11026.24**	**12485.62**	**12766.74**	**12742.55**	**12124.71**	**11987.43**	**11387.95**
	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%*	*100.00%*	*100.00%*
Total GHG excluding LULUCF	**12827.46**	**13367.18**	**13150.85**	**13264.08**	**12430.92**	**10103.70**	**10164.79**	**9457.88**	**8573.72**	**8991.63**	**9766.38**	**10275.20**	**11044.20**	**11485.97**	**12900.12**	**13152.40**	**13018.13**	**12397.88**	**12259.77**	**11684.38**
	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%*	*100.00%*	*100.00%*

Source: Environment Agency

Notes:

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

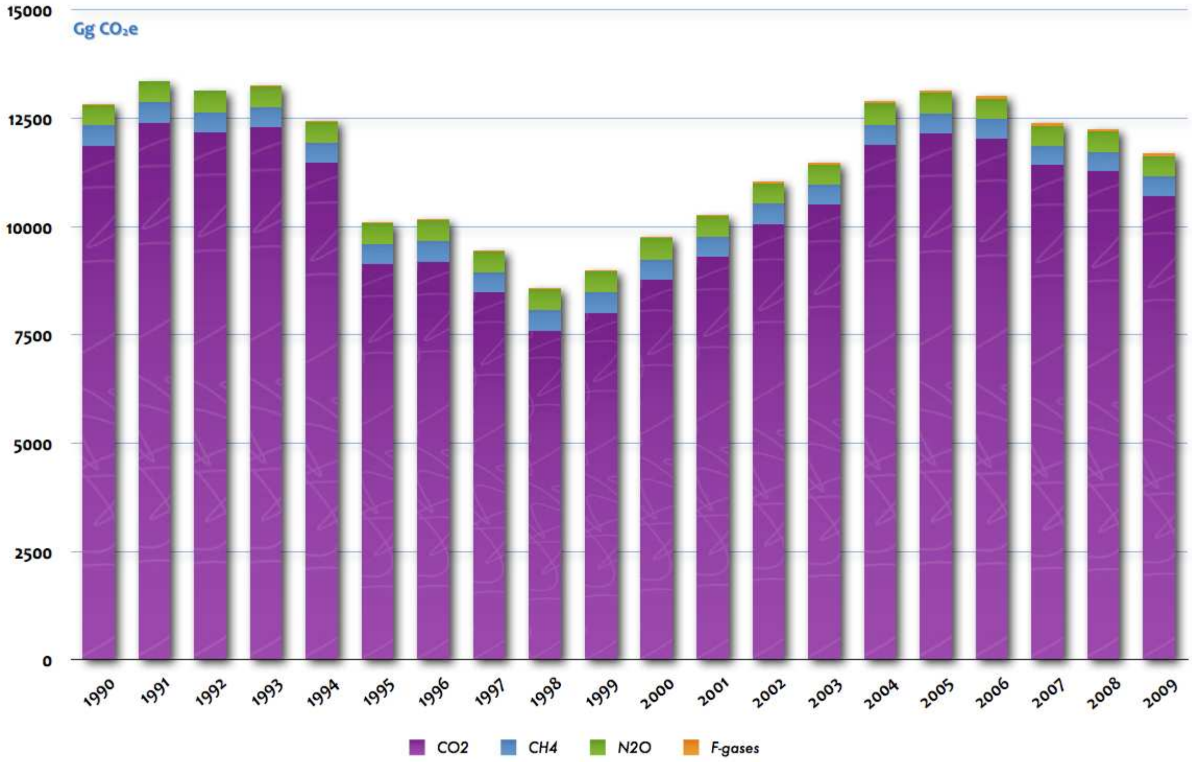
(2) the methane emissions are converted in CO_2 equivalents by multiplying the emissions by 21, i.e. the global warming potential (GWP) value for methane based on the effects of GHG over a 100-year time horizon.

(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 SF_6 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.

Figure 2-27 – Luxembourg's GHG emissions and removals (excl. LULUCF) – absolute values: 1990-2009

GHG



CRF Sectors

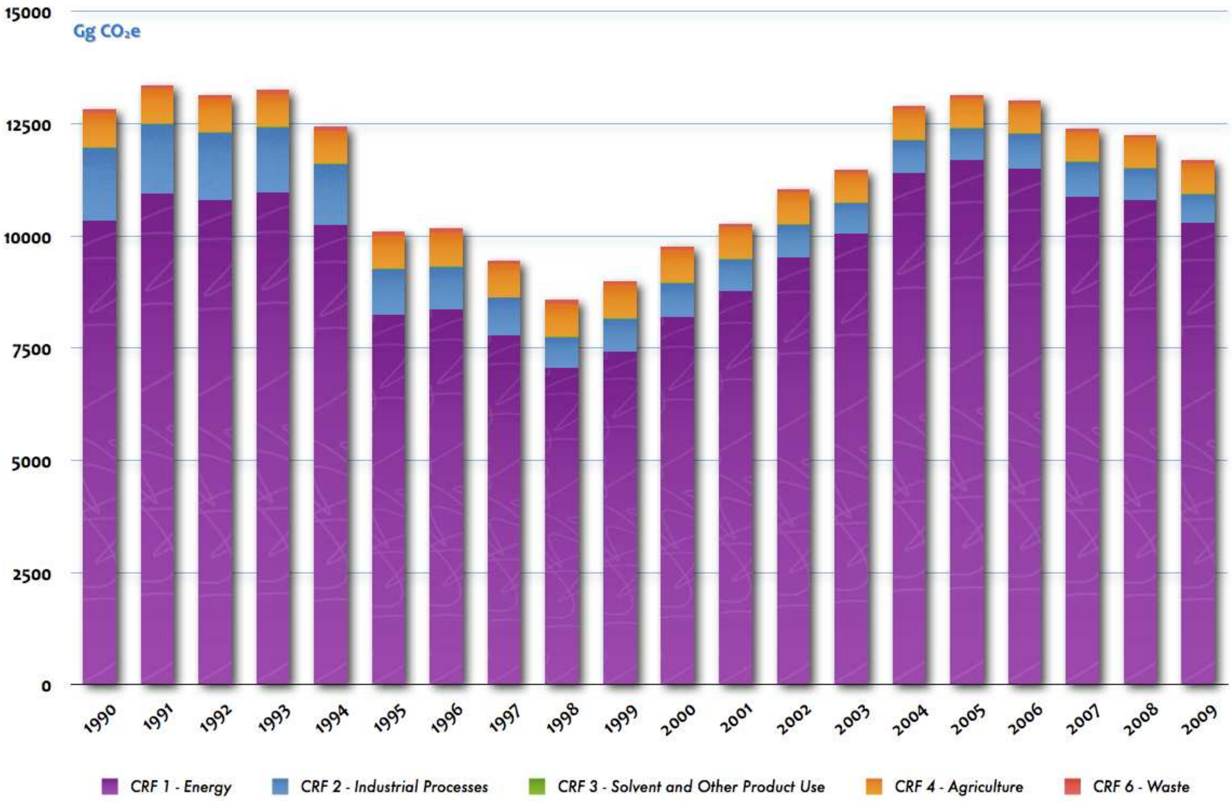
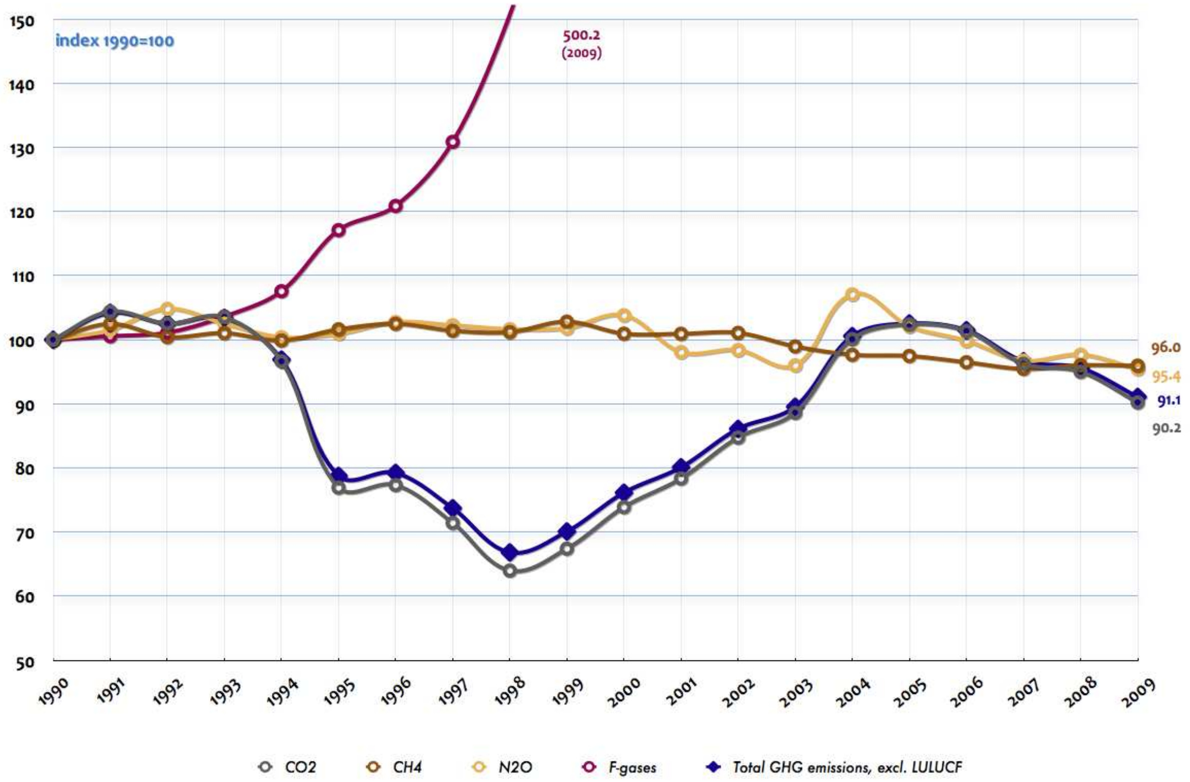
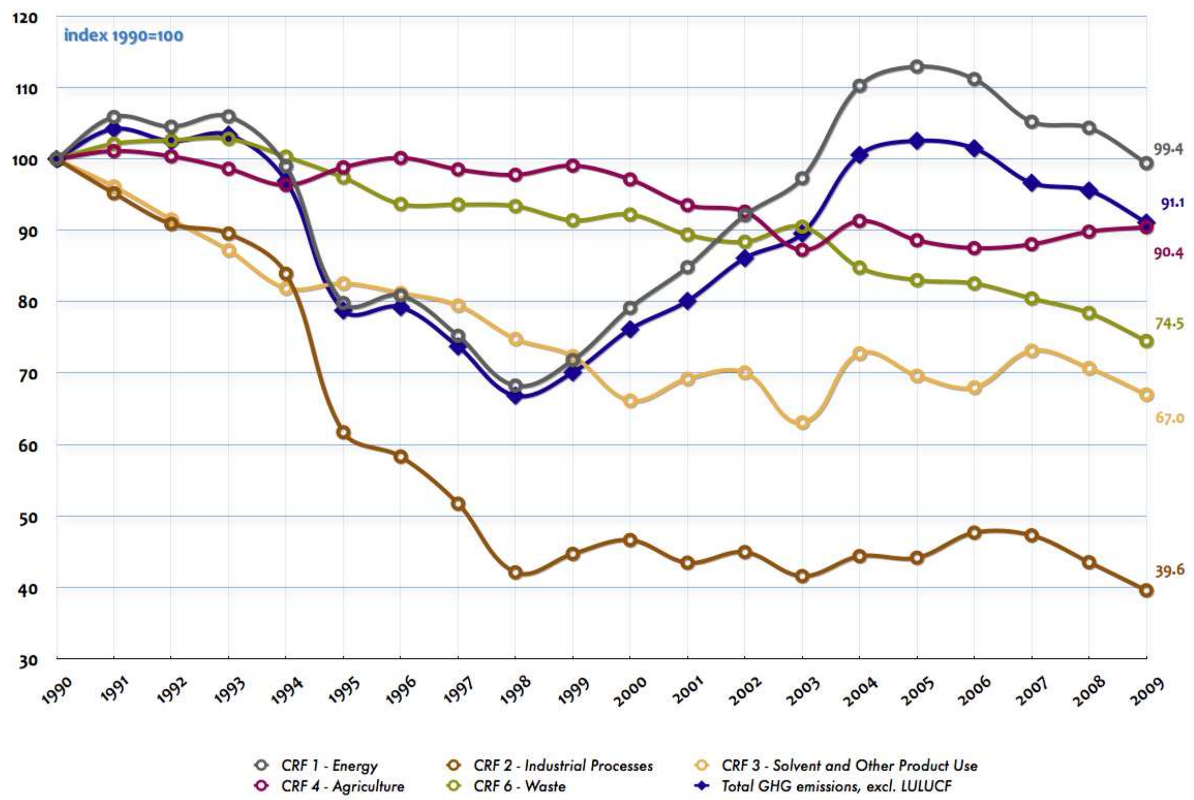


Figure 2-28 – Luxembourg's GHG emissions and removals (excl. LULUCF) – indexes: 1990-2009

GHG



CRF Sectors



A good 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. 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, gasoil) 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 2009 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 2.3 (dealing with gases) and 2.4 (on CRF Sectors), as well as in the analysis of emission trends for each sector (see the first section of CRF Sector 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 7.9 Mio. t in 1990, CO_2e emissions from industrial processes and fuel combustion in industry accounted for 61.2% of total GHG emissions. They could eventually be reduced to 1.7 Mio. t in 1998 – i.e. 14.8% 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. This plant started its operation in mid-2002 and, by 2009, was responsible of about

0.95 Mio. t CO_2, i.e. around 8% of the total GHG emissions.[75] These considerations can easily be identified in Table 2-8, which distributes, for each GHG, emissions amongst the main source categories.

2.3 Description of emission trends by gas

For the different GHG, trends over the period 1990-2009 (and 2008-2009) were as follows:

- CO_2: .... -9.78% (-5.03%)
- CH_4: .... -4.04% -0.06%)
- N_2O: ....-4.67% (-2.33%)
- F-gases: ....+400.26% (+4.11%)

For carbon dioxide, the relatively close values estimated in 1990 and 2009 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 combustion, increasing emissions from transport and natural gas fired power plants – as underlined in the previous section.

Methane emissions have declined over the period due to the conjunction of reduced methane emissions in agriculture (-0.1%) and in waste management (-40.4%) and with growing emissions in energy use (+31.1%), the latter being due to an upward trend in energy industries and fugitive emissions from natural gas distribution and use.

Nitrous oxide emissions development is closely linked to an increase of liquid fuels related emissions from combustion activities and the waste sector that could not be balanced by declining emissions from the agriculture and solvent and other product use sectors.

Finally, with regard to F-gases, HFC emissions were almost 4 times higher in 2009 than in the base year, whereas SF_6 emissions showed a 5 fold increase.

From Table 2-11, and its associated Figure 2-29 and Figure 2-30, emission trends for each of the gases can be analysed further.

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75 The highest emissions recorded for the TWINerg plant were 1.05 Mio t CO_2 in 2006, i.e. 8.0% of the total GHG emissions reported for that year.

Table 2-11 – Luxembourg's GHG emissions and removals – details by main gases: 1990-2009

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	2008	2009
CO_2 (excluding LULUCF)	**11870.82**	**12391.62**	**12169.15**	**12290.15**	**11471.84**	**9132.40**	**9180.32**	**8479.89**	**7596.75**	**8002.17**	**8771.36**	**9301.27**	**10059.83**	**10517.07**	**11881.84**	**12154.36**	**12030.71**	**11425.30**	**11277.25**	**10710.06**
	92.54%	*92.70%*	*92.54%*	*92.66%*	*92.28%*	*90.39%*	*90.31%*	*89.66%*	*88.61%*	*89.00%*	*89.81%*	*90.52%*	*91.09%*	*91.56%*	*92.11%*	*92.41%*	*92.42%*	*92.16%*	*91.99%*	*91.66%*
of which																				
CRF 1 - Energy	10247.82	10847.06	10695.39	10839.31	10113.98	8135.74	8239.41	7647.72	6924.43	7292.03	8035.58	8622.28	9364.83	9882.18	11202.78	11483.59	11308.15	10712.57	10629.33	10129.92
	79.89%	*81.15%*	*81.33%*	*81.72%*	*81.36%*	*80.52%*	*81.06%*	*80.86%*	*80.76%*	*81.10%*	*82.28%*	*83.91%*	*84.79%*	*86.04%*	*86.84%*	*87.31%*	*86.86%*	*86.41%*	*86.70%*	*86.70%*
CRF 1A1 - Fuel Combustion from	33.29	34.01	34.73	33.04	32.32	91.07	80.40	87.44	152.94	170.11	179.43	351.51	1059.99	1062.98	1272.59	1252.31	1321.37	1181.33	1006.74	1154.75
Energy Industries	*0.26%*	*0.25%*	*0.26%*	*0.25%*	*0.26%*	*0.90%*	*0.79%*	*0.92%*	*1.78%*	*1.89%*	*1.84%*	*3.42%*	*9.60%*	*9.25%*	*9.86%*	*9.52%*	*10.15%*	*9.53%*	*8.21%*	*9.88%*
CRF 1A2 - Fuel Combustion from	6278.42	6122.29	5794.69	5922.00	5201.87	3343.67	3201.23	2444.91	1410.59	1521.74	1607.04	1574.58	1456.41	1600.67	1817.84	1722.10	1750.11	1540.23	1422.10	1144.19
Manuf. Industries & Construction	*48.95%*	*45.80%*	*44.06%*	*44.65%*	*41.85%*	*33.09%*	*31.49%*	*25.85%*	*16.45%*	*16.92%*	*16.45%*	*15.32%*	*13.19%*	*13.94%*	*14.09%*	*13.09%*	*13.44%*	*12.42%*	*11.60%*	*9.79%*
CRF 1A3 - Fuel Combustion from	2600.11	3089.61	3388.06	3427.15	3481.31	3301.42	3398.83	3595.86	3760.11	4051.77	4596.13	4859.74	5068.00	5498.64	6387.53	6789.72	6501.36	6357.34	6515.18	6005.22
Transport	*20.27%*	*23.11%*	*25.76%*	*25.84%*	*28.01%*	*32.68%*	*33.44%*	*38.02%*	*43.86%*	*45.06%*	*47.06%*	*47.30%*	*45.89%*	*47.87%*	*49.52%*	*51.62%*	*49.94%*	*51.28%*	*53.14%*	*51.40%*
of which, road fuel export(1):																				
share in transport sector	65.82%	71.01%	67.88%	64.91%	65.41%	63.46%	66.42%	66.24%	66.05%	66.96%	68.05%	68.91%	70.65%	72.24%	77.14%	78.10%	75.90%	74.49%	74.02%	74.02%
estimated CO_2 emissions	1711.39	2193.93	2299.81	2224.56	2277.13	2095.08	2257.50	2381.90	2483.55	2713.06	3127.66	3348.85	3580.54	3972.22	4927.34	5302.77	4934.53	4735.59	4822.53	4445.07
	13.34%	*16.41%*	*17.49%*	*16.77%*	*18.32%*	*20.74%*	*22.21%*	*25.18%*	*28.97%*	*30.17%*	*32.02%*	*32.59%*	*32.42%*	*34.58%*	*38.20%*	*40.32%*	*37.91%*	*38.20%*	*39.34%*	*38.04%*
CRF 1A4 - Fuel Combustion from	1309.70	1574.84	1451.59	1433.96	1376.88	1389.12	1540.82	1497.06	1567.42	1505.17	1641.51	1813.63	1767.79	1716.88	1724.76	1719.38	1735.23	1633.60	1685.26	1825.69
Other Sectors	*10.21%*	*11.78%*	*11.04%*	*10.81%*	*11.08%*	*13.75%*	*15.16%*	*15.83%*	*18.28%*	*16.74%*	*16.81%*	*17.65%*	*16.01%*	*14.95%*	*13.37%*	*13.07%*	*13.33%*	*13.18%*	*13.75%*	*15.63%*
CRF 1A5 & 1B2 - Other Energy	26.30	26.32	26.33	23.17	21.60	10.47	18.14	22.45	33.38	43.25	11.47	22.82	12.65	3.02	0.07	0.07	0.07	0.07	0.07	0.07
Sources	*0.21%*	*0.20%*	*0.20%*	*0.17%*	*0.17%*	*0.10%*	*0.18%*	*0.24%*	*0.39%*	*0.48%*	*0.12%*	*0.22%*	*0.11%*	*0.03%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
CRF 2 - Industrial Processes	1608.36	1530.51	1460.44	1438.23	1346.19	984.50	928.72	820.07	660.99	699.04	725.78	667.88	683.72	623.60	665.82	657.91	710.42	699.74	635.71	568.81
	12.54%	*11.45%*	*11.11%*	*10.84%*	*10.83%*	*9.74%*	*9.14%*	*8.67%*	*7.71%*	*7.77%*	*7.43%*	*6.50%*	*6.19%*	*5.43%*	*5.16%*	*5.00%*	*5.46%*	*5.64%*	*5.19%*	*4.87%*
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	12.21	11.33
	0.11%	*0.11%*	*0.10%*	*0.10%*	*0.09%*	*0.12%*	*0.12%*	*0.13%*	*0.13%*	*0.12%*	*0.10%*	*0.11%*	*0.10%*	*0.10%*	*0.10%*	*0.10%*	*0.09%*	*0.10%*	*0.10%*	*0.10%*
CH_4 (3)	**467.13**	**478.70**	**469.11**	**471.97**	**466.55**	**474.75**	**478.73**	**473.72**	**472.68**	**480.29**	**471.58**	**471.47**	**472.13**	**462.27**	**456.18**	**455.29**	**450.74**	**445.94**	**448.54**	**448.26**
	3.64%	*3.58%*	*3.57%*	*3.56%*	*3.75%*	*4.70%*	*4.71%*	*5.01%*	*5.51%*	*5.34%*	*4.83%*	*4.59%*	*4.27%*	*4.02%*	*3.54%*	*3.46%*	*3.46%*	*3.60%*	*3.66%*	*3.84%*
of which																				
CRF 1 - Energy	45.36	49.62	49.70	48.36	47.85	47.37	50.14	48.91	48.79	49.55	50.40	53.50	64.59	64.44	69.03	67.09	67.89	62.50	60.11	59.46
	0.35%	*0.37%*	*0.38%*	*0.36%*	*0.38%*	*0.47%*	*0.49%*	*0.52%*	*0.57%*	*0.55%*	*0.52%*	*0.52%*	*0.58%*	*0.56%*	*0.54%*	*0.51%*	*0.52%*	*0.50%*	*0.49%*	*0.51%*
CRF 4A+4B - Enteric Fermentation and	341.05	346.61	336.67	341.51	339.22	350.64	354.45	351.74	352.36	361.42	353.61	352.96	343.25	333.36	328.57	331.85	327.99	330.44	337.25	340.72
Manure Management	*2.66%*	*2.59%*	*2.56%*	*2.57%*	*2.73%*	*3.47%*	*3.49%*	*3.72%*	*4.11%*	*4.02%*	*3.62%*	*3.44%*	*3.11%*	*2.90%*	*2.55%*	*2.52%*	*2.52%*	*2.67%*	*2.75%*	*2.92%*
Other Sources (4)	80.73	82.47	82.74	82.11	79.49	76.74	74.13	73.07	71.52	69.32	67.57	65.01	64.29	64.47	58.58	56.35	54.86	53.01	51.18	48.09
	0.63%	*0.62%*	*0.63%*	*0.62%*	*0.64%*	*0.76%*	*0.73%*	*0.77%*	*0.83%*	*0.77%*	*0.69%*	*0.63%*	*0.58%*	*0.56%*	*0.45%*	*0.43%*	*0.42%*	*0.43%*	*0.42%*	*0.41%*
N_2O (5)	**474.84**	**482.11**	**497.76**	**486.75**	**476.74**	**479.38**	**488.00**	**485.07**	**482.19**	**483.01**	**492.49**	**465.25**	**466.77**	**455.52**	**507.99**	**484.32**	**473.66**	**458.94**	**463.48**	**452.67**
	3.70%	*3.61%*	*3.78%*	*3.67%*	*3.84%*	*4.74%*	*4.80%*	*5.13%*	*5.62%*	*5.37%*	*5.04%*	*4.53%*	*4.23%*	*3.97%*	*3.94%*	*3.68%*	*3.64%*	*3.70%*	*3.78%*	*3.87%*
of which																				
CRF 1 - Energy	51.41	56.12	67.48	73.88	78.58	74.30	78.05	84.18	86.58	86.77	100.70	100.06	98.81	117.55	133.85	133.33	125.65	109.00	106.95	95.58
	0.40%	*0.42%*	*0.51%*	*0.56%*	*0.63%*	*0.74%*	*0.77%*	*0.89%*	*1.01%*	*0.97%*	*1.03%*	*0.97%*	*0.89%*	*1.02%*	*1.04%*	*1.01%*	*0.97%*	*0.88%*	*0.87%*	*0.82%*
CRF 4D - Agricultural Soils	363.55	372.01	379.63	362.18	348.75	354.91	360.44	352.54	347.84	352.89	346.91	320.70	324.73	294.32	329.51	306.72	303.35	300.19	306.82	308.16
	2.83%	*2.78%*	*2.89%*	*2.73%*	*2.81%*	*3.51%*	*3.55%*	*3.73%*	*4.06%*	*3.92%*	*3.55%*	*3.12%*	*2.94%*	*2.56%*	*2.55%*	*2.33%*	*2.33%*	*2.42%*	*2.50%*	*2.64%*
Other Sources (6)	59.88	53.98	50.65	50.15	48.79	49.39	48.83	46.86	45.28	40.76	40.24	40.17	38.00	36.94	38.06	37.27	36.84	42.29	41.43	41.16
	0.47%	*0.40%*	*0.39%*	*0.38%*	*0.39%*	*0.49%*	*0.48%*	*0.50%*	*0.53%*	*0.45%*	*0.41%*	*0.39%*	*0.34%*	*0.32%*	*0.30%*	*0.28%*	*0.28%*	*0.34%*	*0.34%*	*0.35%*
F-gases (7)	**14.67**	**14.75**	**14.83**	**15.20**	**15.78**	**17.18**	**17.73**	**19.20**	**22.11**	**26.16**	**30.95**	**37.20**	**45.47**	**51.11**	**54.11**	**58.43**	**63.02**	**67.69**	**70.50**	**73.40**
	0.11%	*0.11%*	*0.11%*	*0.11%*	*0.13%*	*0.17%*	*0.17%*	*0.20%*	*0.26%*	*0.29%*	*0.32%*	*0.36%*	*0.41%*	*0.44%*	*0.42%*	*0.44%*	*0.48%*	*0.55%*	*0.58%*	*0.63%*
Total GHG excluding LULUCF	**12827.46**	**13367.18**	**13150.85**	**13264.08**	**12430.92**	**10103.70**	**10164.79**	**9457.88**	**8573.72**	**8991.63**	**9766.38**	**10275.20**	**11044.20**	**11485.97**	**12900.12**	**13152.40**	**13018.13**	**12397.88**	**12259.77**	**11684.38**
	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%*	*100.00%*	*100.00%*
LULUCF (8)	**347.75**	**172.43**	**-195.75**	**-305.83**	**-135.96**	**-238.10**	**-410.64**	**-451.08**	**-195.50**	**-318.81**	**-385.41**	**-451.56**	**-451.26**	**-459.74**	**-414.49**	**-385.65**	**-275.59**	**-273.18**	**-272.34**	**-296.43**

Source: Environment Agency

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.

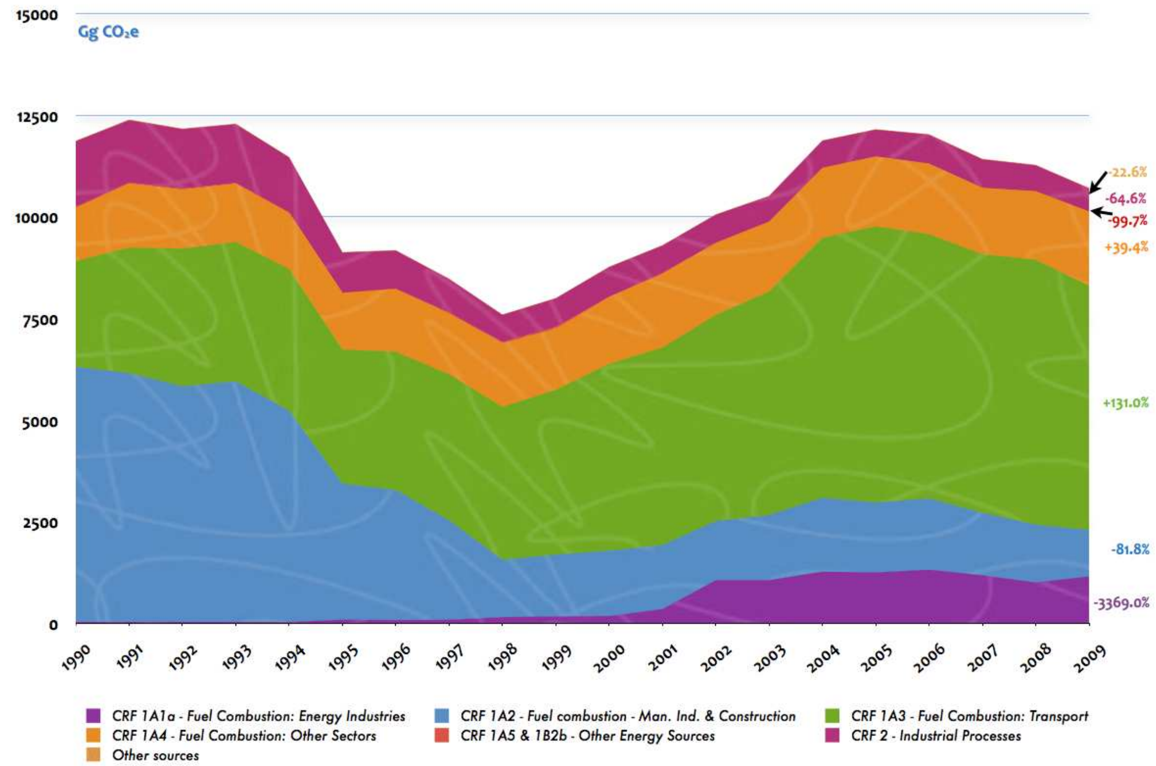
(6) the other N_2O sources are emissions from anasthesiae (CRF 3D), manure management (CRF 4B), waste water handling (CRF 6B) and composting (CRF 6D).

(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.

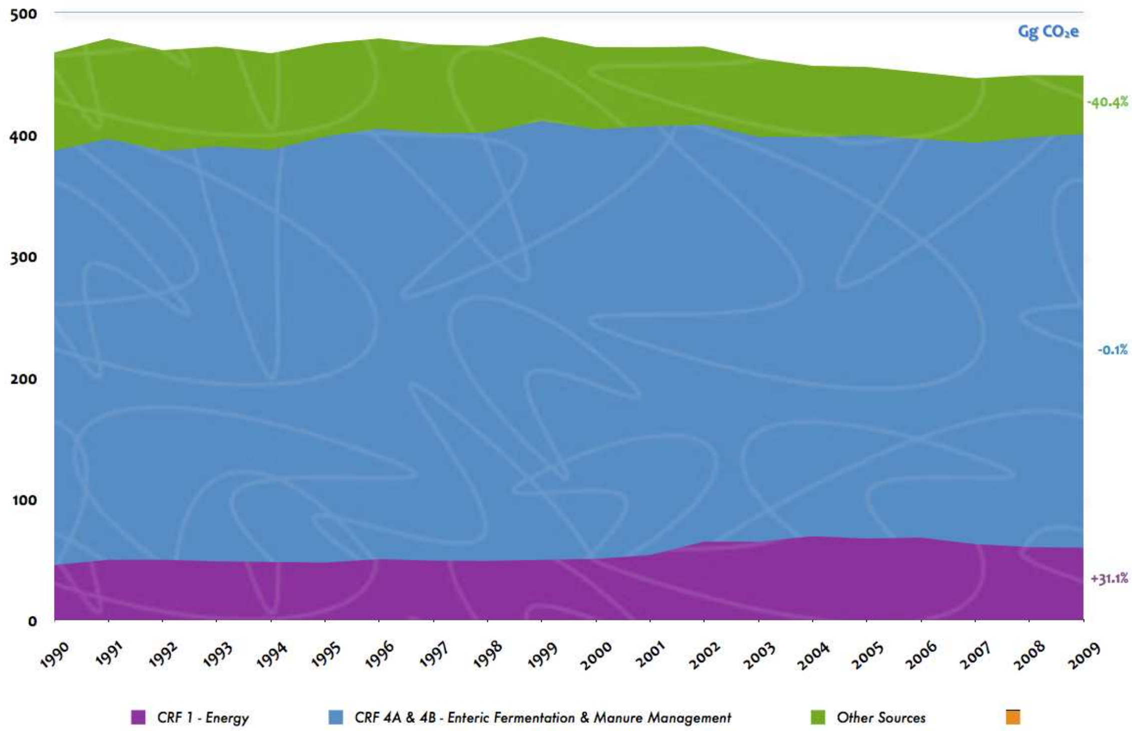
(8) the land use, land-use change and forestry emissions.

Figure 2-29 – Luxembourg's GHG emissions and removals (excl. F-gases & LULUCF) – details by main gases: 1990-2009

CO_2



CH_4



N_2O

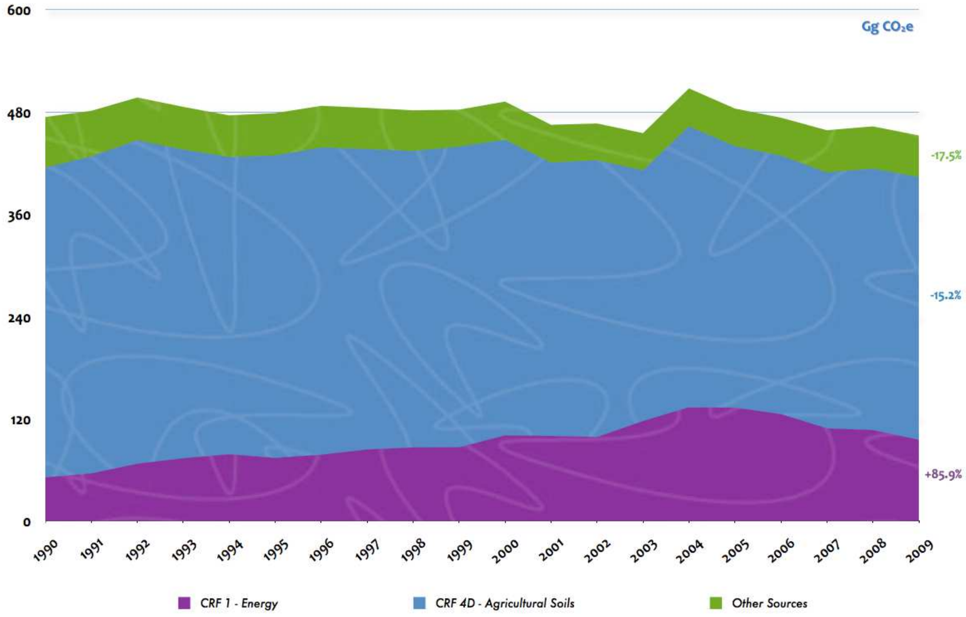
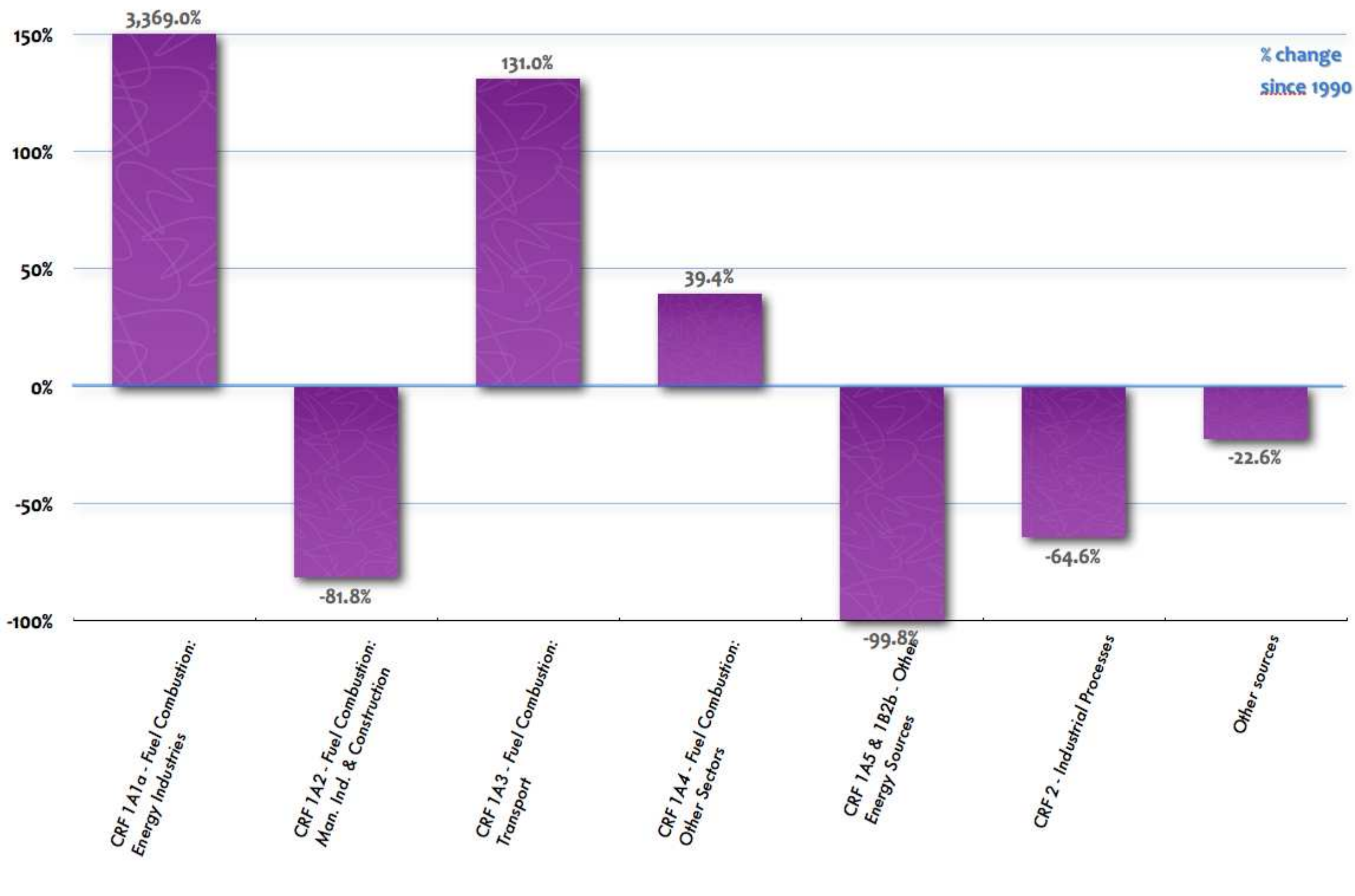
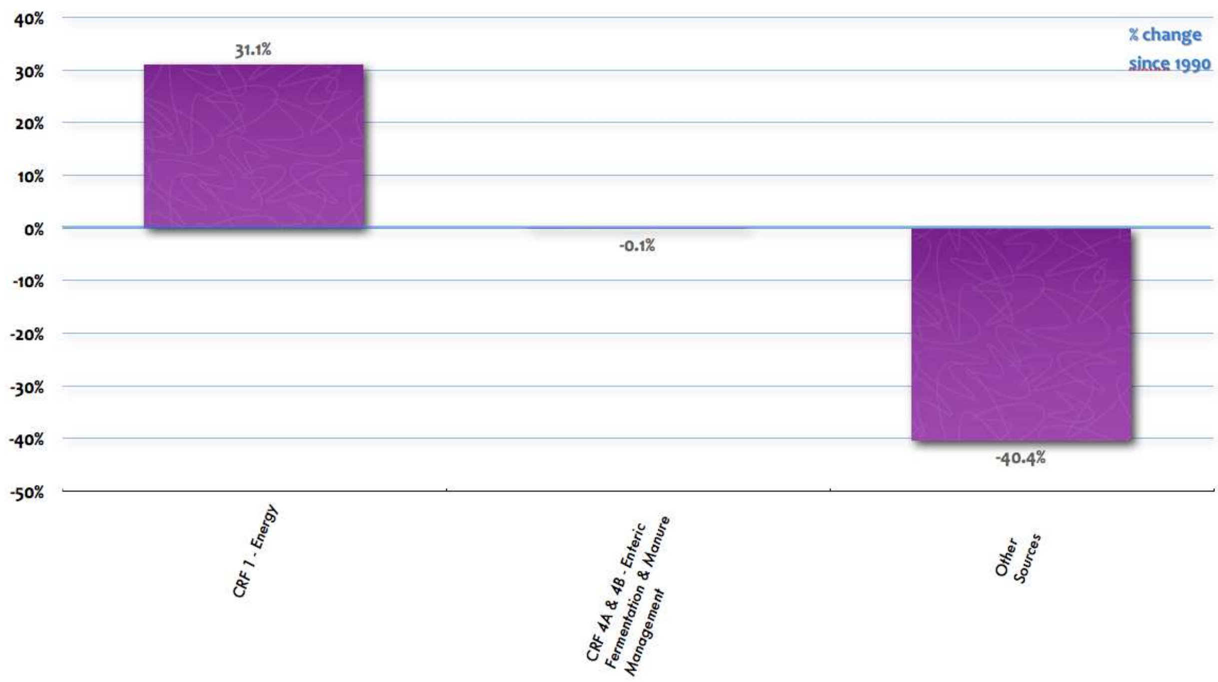


Figure 2-30 – Luxembourg's GHG emission and removal trends in % (excl. LULUCF) – details by main gases 1990-2009

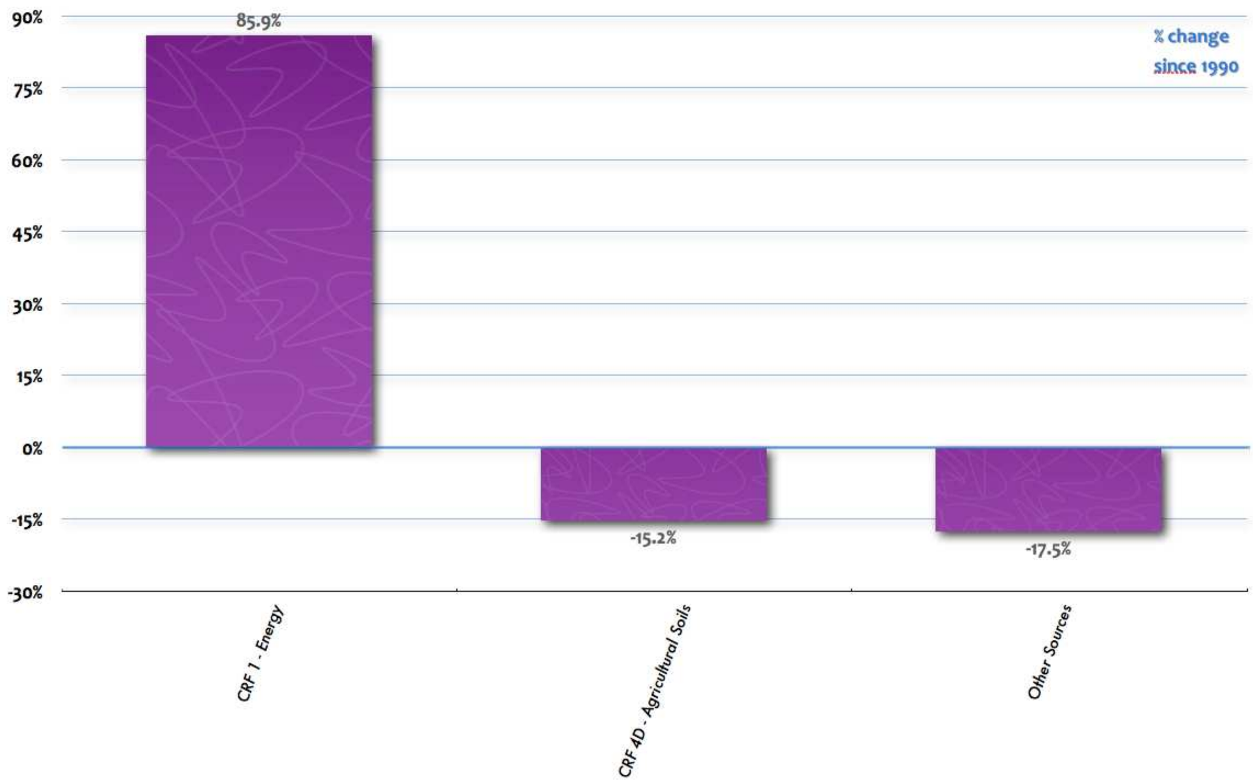
CO_2



CH_4



<u>N_2O</u>



2.3.1 Carbon dioxide – CO_2

CRF (sub-)categories covered	1A1a, 1A2, 1A3, 1A4, 1A5, 1B2b, 2A1, 2A7, 2C1, 3A, 3B, 3C & 3D

share in total GHG emissions, excl. LULUCF	***1990***	92.5% =11 870.82 Gg CO_2e
	2009	91.7% =10 710.06 Gg CO_2e

Throughout the period 1990-2009, the main GHG has remained carbon dioxide, which accounted between 89% 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 79.9% of total GHG emissions for the base year (1990) and climbed up to 86.7% in 2009, after having reached a maximum of 87.3% in 2005.

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 21.9% of total GHG emissions. Then, with 6.0 Mio. t CO_2, this percentage reached 56.1% in 2009.[76] CO_2 emissions (including CO_2 from biomass) due solely to "road fuel exports" amounted to about 1.7 Mio. t in 1990 and reached 4.5 Mio. t in 2009,[77] i.e. roughly a threefold increase (the same comparison shows only a twofold increase for road fuel consumed by the national vehicle fleet). In 2009, "road fuel exports" represented 72.2% of CO_2 emissions of the transport sector and 41.9% of the total CO_2 emissions.[78] In 1990, these percentages were, respectively, 66.0% and 14.5%.

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-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.

2.3.2 Methane – CH_4

CRF (sub-)categories covered	1A1a, 1A2, 1A3, 1A4, 1A5, 1B2b, 4A, 4B, 6A, 6B & 6D	
share in total GHG emissions, excl. LULUCF	***1990***	3.6% = 467.13 Gg CO_2e
	2009	3.8% = 448.26 Gg CO_2e

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 1990-2009, 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.

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76 The highest percentage was recorded for the year 2005: 6.79 Mio. t CO_2 and 51.6% of total GHG emissions.

77 5.4 Mio. t in 2005.

78 For 2005, these percentages were respectively 75.3% and 44.1%.

2.3.3 Nitrous oxide – N_2O

CRF (sub-)categories covered	1A1a, 1A2, 1A3, 1A4, 1A5, 3D, 4B, 4D, 6B & 6D		
share in total GHG emissions, excl. LULUCF	***1990***	3.7% =	474.84 Gg CO_2e
	2009	3.9% =	452.67 Gg CO_2e

A large part of nitrous oxide emissions is caused by agricultural soils. Other important sources, generating increasing N_2O emissions since 1990, are 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 1.5 over the period, following the increasing share of diesel vehicles on the roads, and secondly, combustion activities in the commercial and residential sectors.

2.3.4 Hydrofluorocarbons – HFCs, Polyfluorocarbons - PFCs and sulphur hexafluoride – SF_6

CRF (sub-)categories covered	2F		
share in total GHG emissions, excl. LULUCF	***1990***	0.1% =	14.67 Gg CO_2e
	2009	0.6% =	73.40 Gg CO_2e

The increase in HFC emissions between 1990 and 2009 is explained by a more wide spread use of mobile and stationary cooling equipments as well as of aerosols.

The use of PFCs only appeared in 2000 and accounts for 0.22 Gg CO_2e, in 2009.

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.

2.4 Description of emission trends by category

In 2009, the energy sector accounted for almost 88.0% of the total GHG emissions, excluding LULUCF. Two sectors represent between 5% and 6% of the total emissions, excluding LULUCF: industrial processes (5.5%) and agriculture (5.8%). The remaining sectors[79] (solvent and other product use (0.14%), waste[80] (0.57%)) were not even reaching 1% of the total GHG emitted in Luxembourg: see Table 2-10 and Figure 2-27 and Figure 2-28.

For the different sectors, trends over the period 1990-2009 (and 2007-2009) were as follows:

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79 The sector "other" is not reported for Luxembourg.

80 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).

- Energy: ....-0.58% (-4.7%)
- Industrial Processes: ....-60.4% (-9.1%)
- Solvent and Other Product Use: ....-33.0% (-5.22%)
- Agriculture: ....-9.6% (+0.67%)
- LULUCF:...-185.2% (+8.85%)
- Waste: ....-25.5% (-5.00%)

Emission reductions observed in all sectors could not balance the growth of energy use and production related emissions whose contribution to total GHG emissions, excluding LULUCF, ranged from 81% to 89% over the period 1990 to 2009.

2.4.1 CRF 1 – Energy

GHG covered	CO_2, CH_4 & N_2O	
share in total GHG emissions, excl. LULUCF	***1990***	80.6% =10 344.59 Gg CO_2e
	2009	88.0% =10 284.96 Gg CO_2e

Energy production and consumption related GHG emissions have decreased by 0.58% between 1990 and 2009 from 10.34 Mio. t CO_2e in 1990 to 10.28 Mio. t CO_2e in 2009. For carbon dioxide, methane and nitrous oxide, the changes over the period 1990-2009 were of -1.15%, +34.7% and +85.9%, respectively.

However, the overall trends at sector level hide very different developments at the CRF sub-category level. Within the energy sector, the fastest growing sub-sectors were energy industries (1A1) (due to the operational start of the Twinerg gas turbine in 2001) and transportation (1A3): +3159% and +130%, respectively between 1990 and 2009 (+14.6% and -7.8 from 2008 to 2009) with, as a result, a share in the total energy related GHG emissions rising from 0.34% to 11.3% and 25.6% to 59.4%, respectively. For the other sub-sectors, the observed trends between 1990 and 2009 are -81.6% for manufacturing industries (1A2), +39.8% for the other sectors (1A4), and +158.7% for fugitive emissions from fuels (1B).[81]

In fact, over the period, 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 CRF sub-categories 1A2 and 1A3 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

[81] Fugitive emission growth is closely linked to natural gas use in Luxembourg.

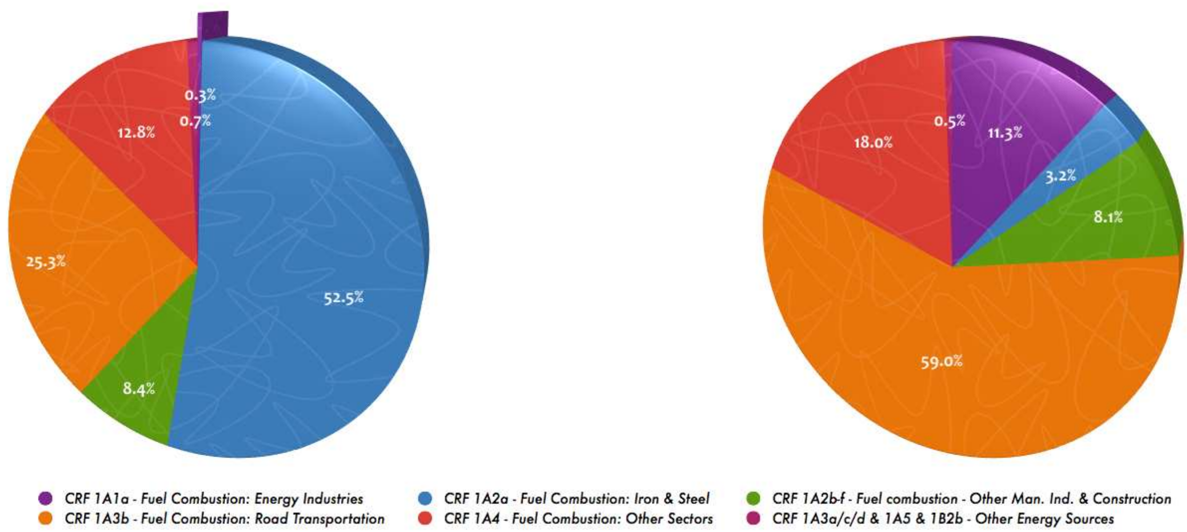
consumption, and even more so road fuel sales, have a very important weight in the national energy balance, and, consequently, have also a very important impact on the total GHG emissions.

In the iron and steel industry, the passage from blast furnaces to electric arc furnaces allowed to significantly reducing GHG emissions between 1994 and 1998. 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.

All these changes briefly presented in the previous paragraphs completely modified the pattern of the energy related GHG emissions with regard to CRF sub-categories share (Figure 2-31) and to the "energy-mix" or fuel usage for energy production and consumption (Tables 2-7 & 2-8, Figure 2-16 & Figure 2-17).

Figure 2-31 – CRF sub-categories share in GHG emissions for CRF 1 – Energy: 1990 & 2009

1990 *2009*



Sources: Environment Agency and MDDI-DEV.

2.4.2 CRF 2 – Industrial Processes

GHG covered	CO_2 & F-gases	
share in total GHG emissions, excl. LULUCF	***1990***	12.7% =1 623.03 Gg CO_2e
	2009	5.5% = 642.21 Gg CO_2e

Industrial processes are the third largest sector in Luxembourg with regard to GHG emissions. It includes emissions from industrial installations and from consumption of halocarbons and SF_6 (the fluorinated gases or F-gases).[82] Leaving F-gases out, in Luxembourg, only 3 companies and their various production installations are part of CRF sector 2:

- CRF sub-categories 2A1 & 2A7: one cement works unit and one flat glass manufacturing company;
- CRF sub-category 2C1: the iron and steel manufacturing company Arcelor-Mittal.

Industrial process emissions show a declining trend between 1990 and 1998, then a relative stabilisation. This evolution was mainly driven by process changes that occurred in the iron & steel industry. As indicated above, this industry moved from blast to electric arc furnaces between 1994 and 1998. As a consequence, steel industry porcess emissions in CO_2e decreased by 89.9% over the period 1990-2009. Overall sector emissions in CO_2e fell by about 60% between 1990 and 2009, reducing the weight of this sector in total GHG emissions from 12.7% to 5.5% over the period. Nevertheless, compared to 2008, emissions from industrial processes decreased by 9.06%, which is mainly the result of the financial and economic crisis which started in the second half of 2008. By gas, however, the picture is different. For carbon dioxide, the decrease over the period 1990-2009 was -64.6%: 2A1 = -33.7%, 2A7 = +15.9% and 2C1 = -86.9%. F-gases emissions, on the contrary, increased regularly: +400.3% over the period 1990-2009 but they are minor compared to the total emissions as Figure 2-20 shows.

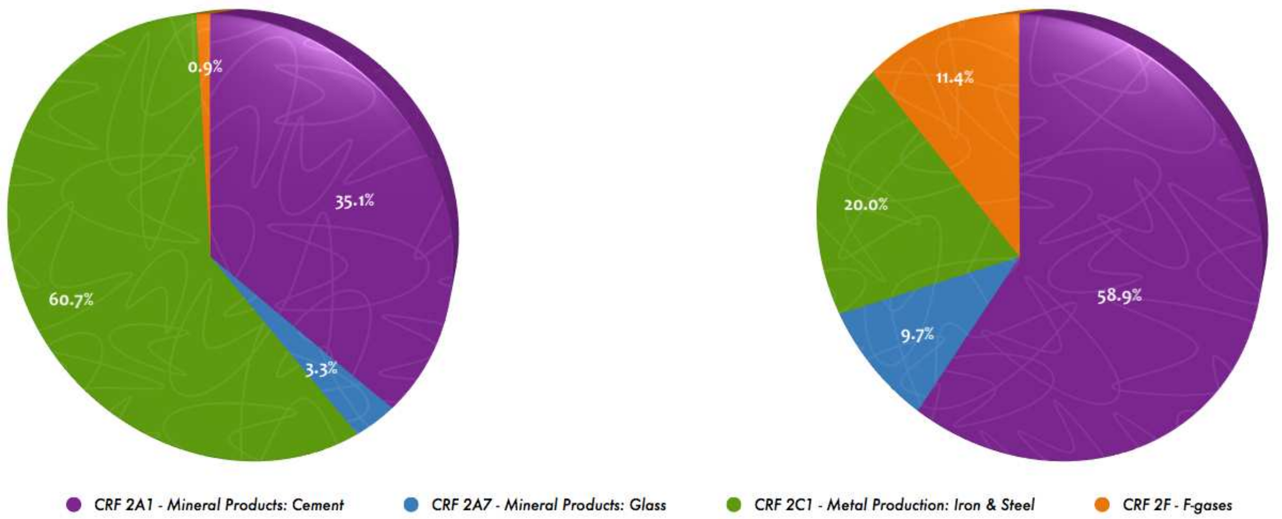
The striking increase of F-gases emissions is the consequence of supposedly growing use in the country, notably due to an increasing use of air conditioning and noise reduction windows (see Section 4.7).

The emission trends briefly described in the previous paragraphs led to a significant change in the composition of industrial processes' GHG emissions: see Figure 2-32.

82 No PFC application and emissions have been identified in Luxembourg so far.

Figure 2-32 – CRF sub-categories share in GHG emissions for CRF 2 – Industrial Processes: 1990 & 2009

1990 *2009*



Source: Environment Agency.

2.4.3 CRF 3 – Solvent and Other Product Use

GHG covered	CO_2 & N_2O		
share in total GHG emissions, excl. LULUCF	***1990***	0.2% =	23.90 Gg CO_2e
	2009	0.1% =	16.02 Gg CO_2e

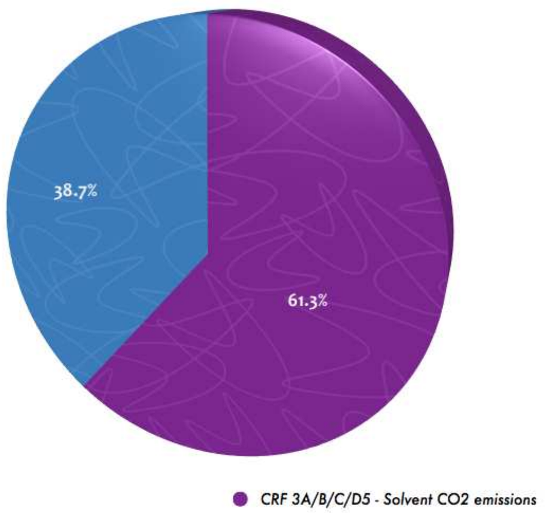
Carbon dioxide emissions from solvent use have been estimated from related NMVOC emissions. These NMVOC emanations have been calculated using both a bottom-up and a top-down approach. This is detailed in Chapter 5. Nitrous oxide emissions reported for this sector are exclusively stemming from anaesthesia usage (Section 5.3).

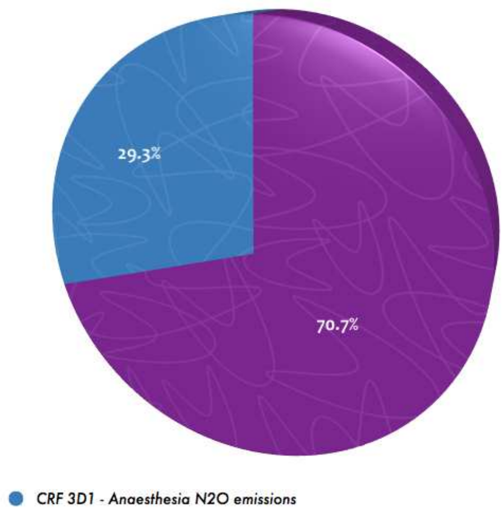
Emissions decreased by 33.0% between 1990 and 2009, due to decreasing solvent and N_2O emissions, as well as due to the positive impact of diverse enforced laws and regulations in Luxembourg.[83] The cut in emissions was sharper for anaesthesia (emissions almost divided by two) than for solvent leading to a reduced share of nitrous oxide emissions in the total emissions of CRF sector 3: see Figure 2-33.

83 These legal texts are listed in Section 5.1 of this report.

Figure 2-33 – CRF sub-categories share in GHG emissions for CRF 3 – Solvent and Other Product Use: 1990 & 2009

1990 *2008*





Source: Environment Agency.

2.4.4 CRF 4 – Agriculture

GHG covered	CH_4 & N_2O	
share in total GHG emissions, excl. LULUCF	***1990***	5.8% = 745.87 Gg CO_2e
	2009	5.8% = 674.09 Gg CO_2e

Trends in agriculture were also favourable between 1990 and 2009: GHG related to agricultural activities have decreased by 9.6% (-0.1% for methane and -17.7% for nitrous oxide). Enteric Fermentation (4A) saw its emissions falling by 5.8%, whereas for agricultural soils (4D), the decrease reaches a bit more than 15%. For manure management (4B), emissions remained quite stable between 1990 and 2009 (-1.0%), though opposite variations are observed for the two GHG emitted by this activity: methane increased by almost 19% and nitrous oxide declined by 39%.

However, the evolution of nitrous oxide emissions stemming from agricultural soils (4D) shapes the overall agriculture emission pattern. Indeed, for both the years 1990 and 2009, CRF category 4D is the biggest contributor to agriculture related emissions, though it is also, as for other Annex I Parties, the agriculture category that shows the highest uncertainty in the inventory. It is also worth noting that the shares of each CRF category under CRF sector 4 for which GHG emissions are reported have barely changed over the period: see Figure 2-34.

Looking at each CRF category in more detail, the decrease in **enteric fermentation** related **methane** emanations over the period is mainly the result from declining emissions generated by the main contributor to these emissions – with more than 95% – i.e. cattle: -17.8% for dairy cattle (but +1.8% for non-dairy cattle). With regard to cattle, its total population size declined throughout the period 1990-2008. 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 (+64.2%). 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). Another factor influencing cattle population is, of course, meat and milk prices (which, themselves are affected by agricultural policy changes and targets).[84] Finally, if the dairy cattle population decreased by 32% between 1990 and 2008, related methane emissions only declined by 17.8%. 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 and, consequently, of the methane implied emission factors.

Looking at **methane** emissions from **manure management**, an increase by a bit less than 17% can be observed for the period 1990-2008. Animals who did contribute the most to these emissions were cattle, swine and, to a lesser extent, chicken. As far as **nitrous oxide** emissions from **manure management** are concerned, a decrease of almost 38% is observed for the period 1990-2008.[85] These emissions are mainly due to cattle. However, if cattle were responsible for more than 94% of manure related N_2O emissions in 1990, this share dropped to 87% in 2008. This evolution is the result of a declining cattle population at the same time as other farm animal categories saw their number grow and as liquid system share in the animal waste management systems (AWMS) doubled at the expense of solid storage systems.

Finally, **nitrous oxide** emissions from **agricultural soils** are mainly driven by:

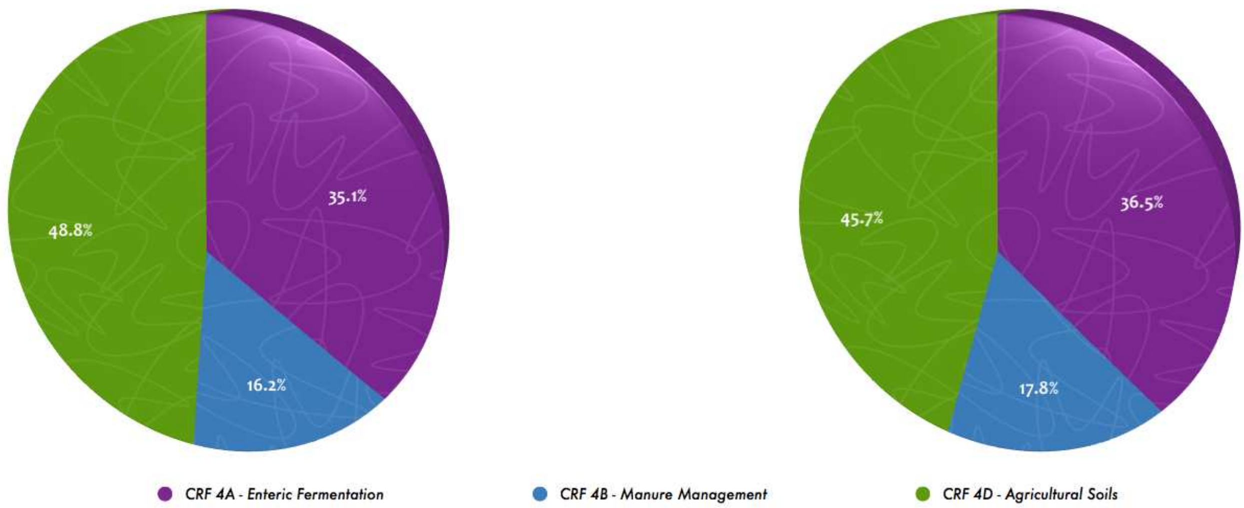
- nitrogen input to soils (such as application of synthetic fertilizers and manure) as well as nitrogen fixed by crops or crop residues (about 45% of category 4D emissions);
- nitrogen excretion on pasture, range and paddock (around 15%);
- by indirect soil emissions due to atmospheric deposition as well as to nitrogen from fertilizers and animals that is lost through leaching and run-off (about 40%).

84 As an example, the peak in the non-dairy cattle population observed in 1991 can be explained by a sharp price fall of the bovine meat price that year. This price fall led farmers to postpone slaughtering until early 1992.

85 Cf footnote 47.

Figure 2-34 – CRF sub-categories share in GHG emissions for CRF 4 – Agriculture: 1990 & 2009

1990 *2009*



Source: MDDI-DEV.

2.4.5 CRF 6 – Waste

GHG covered	CH_4 & N_2O		
share in total GHG emissions, excl. LULUCF	***1990***	0.7% =	90.06 Gg CO_2e
	2009	0.6% =	67.10 Gg CO_2e

In the waste sector, the main source of GHG was solid waste disposal on land (6A), but its weight decreased over the period 1990-2009 due to the combination of reduced amounts of waste disposed off in landfills and of increased emissions arising from composting activities (6D). However, GHG emission reduction for solid waste disposal on land between 1990 and 2009 (-50%) still drove a reduction for the overall waste sector despite composting rising emissions. Wastewater handling emissions (6B) experienced a 6.9% decline in emissions between 1990 and 2009. This decrease was driven by domestic and commercial wastewater treatment – and, more specifically methane related emissions - since industrial wastewater management remained fairly stable throughout the period.

For **solid waste disposal on land**, methane emissions have been reduced due to:

- a decrease in the quantity of waste being stored in authorised landfill sites (two as of today, three in the early 1990s), 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 storage in one of the two landfill sites;
- the recent installation of methane recovery systems at waste dumping sites.

Wastewater treatment plant (WWTP) capacities expressed in population-equivalents have steadily grown since 1990. However, methane and nitrous oxide emissions decreased by 6.9% since 1990. Therefore, technical changes, with regard to wastewater treatment, have had an unquestionable role too.

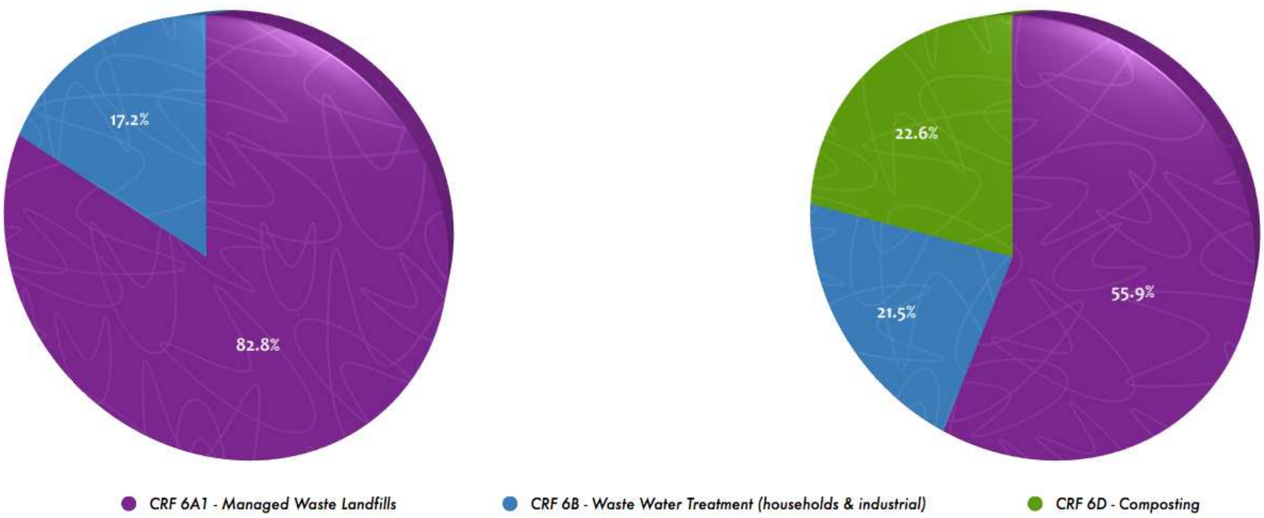
Concerning **compost production**, this activity started on an "industrial scale" only in the early 1990s. It experienced a steady growth from 1993 to 2003 and then more or less stabilizes. Nowadays, 7 composting installations operate in Luxembourg, plus one that co-compost sewage sludge. The latter uses active ventilation and fully operates aerobicly – without methane formation. The other plants operate in part under anaerobic conditions, with a residence time in the "composter" of a few weeks.

It is recalled that waste incineration related emissions are part of CRF sub-category 1A1a (public electricity and heat production) since energy is recovered in the sole incinerator of the country and injected in the network.

The emission trends briefly described in the previous paragraphs led to a significant change in the composition of waste related GHG emissions: see Figure 2-35.

Figure 2-35 – CRF sub-categories share in GHG emissions for CRF 6 – Waste: 1990 & 2009

1990 *2009*



Sources: Environment Agency, Water Agency and MDDI-DEV.

2.4.6 CRF sectors – overview

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. However, Figure 2-18 summarized analyzes presented in the previous sub-sections.

2.5 Description of emission 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 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.

2.6 Description of emission trends for the KP-LULUCF inventory in aggregate and by activity, and by gas

In Luxembourg, LULUCF was a net sink every year, except in 1990 and 1991.[86] An important subcategory is forest land, in particular its sub-source forest land remaining forest land (5A1). This sub-category, as well as the sub-category land converted to forest land (5A2), are net sinks for CO_2, whereas other categories and sub-categories reported in the inventory are generally sources of emissions (both CO_2 and N_2O).

Luxembourg has chosen **to account for the activities under Article 3.3** of the Kyoto Protocol for the whole commitment period but **does not plan to account for net emissions and removals from activities under Article 3.4** of the same Protocol since, for the moment, there is a lack of reliable data allowing to produce realistic estimates of the activities covered under Article 3.4. Nevertheless, it is anticipated – expert judgment by the Nature and Forest Administration - that land or, at least, forestry would not contribute to Luxembourg's means of meeting its Kyoto commitment. The latter would, therefore, be reached **only via national policies and measures and the use of "Kyoto flexible mechanisms"** and not via carbon sinks.

With regard to the KP-LULUCF activities, in 2009, CO_2 removals from AR in Luxembourg amounted to 78.00 Gg CO_2. 14.27 Gg CO_2 resulted from cropland converted to forest land, 18.14 Gg CO_2 from grassland, 4.40 Gg CO_2 from wetland, 27.88 Gg CO_2 from settlement and 13.31 Gg CO_2 from other land.

86 Net emissions these two years are the consequence of the important storms that touched the country in early 1989-90 severely hitting Luxembourg's forests.

Emissions from Deforestation activities amounted in 2009 to approximately 141.00 Gg CO_2. Forest land converted to cropland amounted to 9.27 Gg CO_2, to grassland 86.89 Gg CO_2, to wetland 3.60 Gg CO_2, to settlement 40.88 Gg CO_2 and to wetland 0.35 Gg CO_2.

Due to the nature and permanence of ARD areas, there is from 1990 on:

- a steady increase in ARD areas, and related to that,
- a steady increase of removals and emissions, respectively, at these areas.

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 2009.

CO_2 emissions from fossil fuel combustion are the main source of green house gas emissions in the Grand-Duchy of Luxembourg. In 2009, about 88.0% 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 (category 1A). Fugitive emissions only made up about 0.4% of the national total GHG emissions (excl. LULUCF)

Waste incineration related GHG emissions are allocated to IPCC sub-category *1A1a – Fuel Combustion Activities – Energy Industries – Public Electricity and Heat Production* (see Section 3.2.6) 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).

3.1.1 Emission Trends

Figure 3-1 and Table 3–1 show the GHG emission trends from 1990 to 2009 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 automatically reported under *Memory Items*. 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.

Fuel combustion activities (Category 1A) related GHG emissions have decreased by 0.83% between 1990 and 2009 from 10.33 million tonnes CO_2 equivalents in 1990 to 10.24 million tonnes CO_2 equivalents in 2009. For carbon dioxide and methane, the decrease was 1.2%, and 40.3% respectively, whereas for nitrous oxide, a growth of 85.9% was observed for the period 1990-2009.

Figure 3-1 – GHG emission trends for CRF Sector 1-Energy: 1990-2009

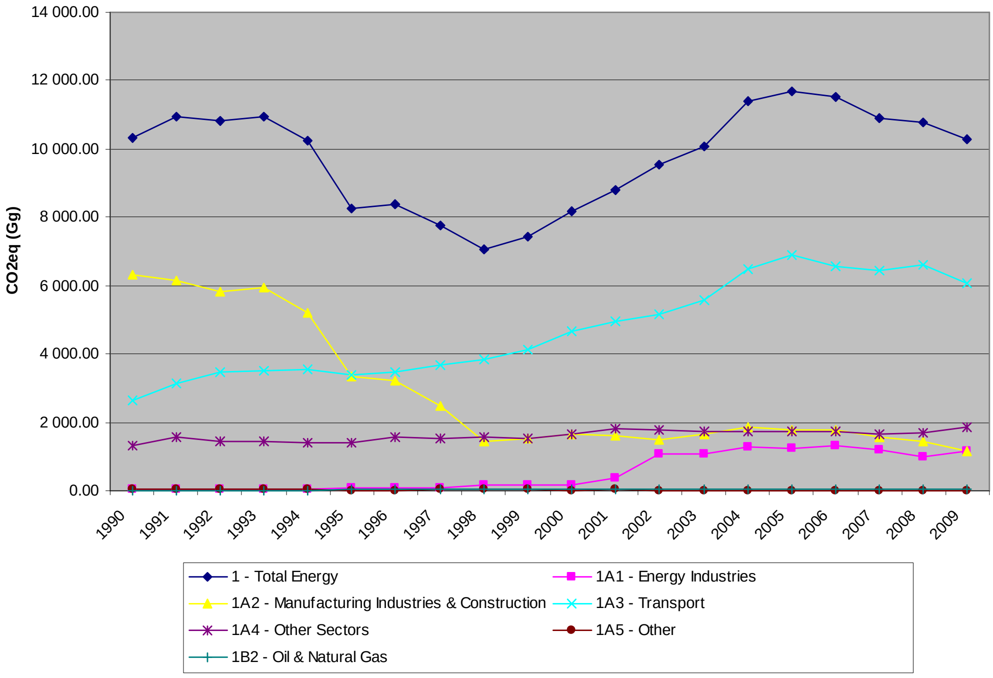


Figure 3-2 and Figure 3-3 clearly illustrate that the overall trend observed at sector level hides very different developments at the IPCC sub-category level. Indeed, between 1990 and 2009, GHG emissions have been strongly influenced by varying fuel consumption levels in industry, in particular in the 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,[87] 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 reduce GHG emissions significantly 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.

87 See Section 2.2.2 in Chapter 2.

Table 3–1 – GHG emission trends in $CO_{2\ eq}$ for CRF Sector 1 – Energy: 1990-2009

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	35.56	*33.29*	*0.04*	*0.00*	6 298.01	*6 278.42*	*0.16*	*0.05*	2 644.06	*2 600.11*	*0.84*	*0.09*	1 321.54	*1 309.70*	*0.35*	*0.01*
1991	36.33	*34.01*	*0.04*	*0.00*	6 141.66	*6 122.29*	*0.16*	*0.05*	3 140.56	*3 089.61*	*0.98*	*0.10*	1 588.19	*1 574.84*	*0.39*	*0.02*
1992	37.10	*34.73*	*0.04*	*0.01*	5 815.57	*5 794.69*	*0.15*	*0.06*	3 448.86	*3 388.06*	*0.97*	*0.13*	1 464.24	*1 451.59*	*0.37*	*0.02*
1993	35.29	*33.04*	*0.04*	*0.00*	5 942.34	*5 922.00*	*0.15*	*0.06*	3 493.73	*3 427.15*	*0.88*	*0.16*	1 446.26	*1 433.96*	*0.37*	*0.01*
1994	34.53	*32.32*	*0.04*	*0.00*	5 222.16	*5 201.87*	*0.15*	*0.06*	3 552.34	*3 481.31*	*0.86*	*0.17*	1 389.09	*1 376.88*	*0.36*	*0.02*
1995	93.23	*91.07*	*0.03*	*0.00*	3 360.60	*3 343.67*	*0.10*	*0.05*	3 370.09	*3 301.42*	*0.76*	*0.17*	1 401.09	*1 389.12*	*0.36*	*0.01*
1996	82.08	*80.40*	*0.03*	*0.00*	3 218.75	*3 201.23*	*0.10*	*0.05*	3 470.21	*3 398.83*	*0.79*	*0.18*	1 553.57	*1 540.82*	*0.38*	*0.02*
1997	89.42	*87.44*	*0.03*	*0.00*	2 462.96	*2 444.91*	*0.08*	*0.05*	3 670.64	*3 595.86*	*0.72*	*0.19*	1 509.94	*1 497.06*	*0.37*	*0.02*
1998	155.40	*152.94*	*0.04*	*0.01*	1 428.94	*1 410.59*	*0.06*	*0.05*	3 834.50	*3 760.11*	*0.70*	*0.19*	1 580.87	*1 567.42*	*0.39*	*0.02*
1999	172.92	*170.11*	*0.05*	*0.01*	1 538.90	*1 521.74*	*0.07*	*0.05*	4 127.83	*4 051.77*	*0.70*	*0.20*	1 517.13	*1 505.17*	*0.38*	*0.01*
2000	182.18	*179.43*	*0.04*	*0.01*	1 633.04	*1 607.04*	*0.08*	*0.08*	4 676.50	*4 596.13*	*0.70*	*0.21*	1 658.32	*1 641.51*	*0.38*	*0.03*
2001	354.39	*351.51*	*0.05*	*0.01*	1 598.25	*1 574.58*	*0.08*	*0.07*	4 940.26	*4 859.74*	*0.67*	*0.21*	1 832.06	*1 813.63*	*0.41*	*0.03*
2002	1 063.56	*1 059.99*	*0.06*	*0.01*	1 478.29	*1 456.41*	*0.07*	*0.07*	5 148.17	*5 068.00*	*0.64*	*0.21*	1 785.43	*1 767.79*	*0.39*	*0.03*
2003	1 066.66	*1 062.98*	*0.06*	*0.01*	1 637.22	*1 600.67*	*0.08*	*0.11*	5 581.79	*5 498.64*	*0.61*	*0.23*	1 734.84	*1 716.88*	*0.39*	*0.03*
2004	1 276.74	*1 272.59*	*0.07*	*0.01*	1 862.87	*1 817.84*	*0.09*	*0.14*	6 477.99	*6 387.53*	*0.58*	*0.25*	1 742.92	*1 724.76*	*0.40*	*0.03*
2005	1 256.17	*1 252.31*	*0.07*	*0.01*	1 765.40	*1 722.10*	*0.11*	*0.13*	6 880.77	*6 789.72*	*0.52*	*0.26*	1 737.25	*1 719.38*	*0.39*	*0.03*
2006	1 325.48	*1 321.37*	*0.07*	*0.01*	1 791.32	*1 750.11*	*0.12*	*0.12*	6 585.12	*6 501.36*	*0.44*	*0.24*	1 753.15	*1 735.23*	*0.39*	*0.03*
2007	1 185.39	*1 181.33*	*0.07*	*0.01*	1 567.27	*1 540.23*	*0.11*	*0.08*	6 436.74	*6 357.34*	*0.37*	*0.23*	1 651.07	*1 633.60*	*0.36*	*0.03*
2008	1 010.73	*1 006.74*	*0.07*	*0.01*	1 444.30	*1 422.10*	*0.10*	*0.06*	6 596.74	*6 515.18*	*0.33*	*0.24*	1 702.92	*1 685.26*	*0.38*	*0.03*
2009	1 158.77	*1 154.75*	*0.07*	*0.01*	1 156.96	*1 144.19*	*0.08*	*0.04*	6 080.13	*6 005.22*	*0.29*	*0.22*	1 846.96	*1 825.69*	*0.39*	*0.04*
Trend 1990-2009	*3158.96%*	*3369.03%*	*85.71%*	*72.52%*	*-81.63%*	*-81.78%*	*-48.08%*	*-32.11%*	*129.95%*	*130.96%*	*-65.54%*	*160.97%*	*39.76%*	*39.40%*	*10.58%*	*193.92%*

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	29.14	*26.28*	*0.002*	*0.009*	16.29	*0.03*	*0.77*	*NA, NO*	**10 344.59**	*10 247.82*	*2.16*	*0.17*
1991	29.15	*26.29*	*0.002*	*0.009*	16.90	*0.03*	*0.80*	*NA, NO*	**10 952.79**	*10 847.06*	*2.36*	*0.18*
1992	29.16	*26.30*	*0.002*	*0.009*	17.63	*0.03*	*0.84*	*NA, NO*	**10 812.56**	*10 695.39*	*2.37*	*0.22*
1993	25.62	*23.14*	*0.001*	*0.008*	18.30	*0.03*	*0.87*	*NA, NO*	**10 961.55**	*10 839.31*	*2.30*	*0.24*
1994	23.86	*21.57*	*0.001*	*0.007*	18.43	*0.03*	*0.88*	*NA, NO*	**10 240.41**	*10 113.98*	*2.28*	*0.25*
1995	11.39	*10.43*	*0.001*	*0.003*	21.02	*0.03*	*1.00*	*NA, NO*	**8 257.42**	*8 135.74*	*2.26*	*0.24*
1996	20.01	*18.10*	*0.001*	*0.006*	22.99	*0.04*	*1.09*	*NA, NO*	**8 367.61**	*8 239.41*	*2.39*	*0.25*
1997	24.33	*22.42*	*0.001*	*0.006*	23.51	*0.04*	*1.12*	*NA, NO*	**7 780.81**	*7 647.72*	*2.33*	*0.27*
1998	36.40	*33.34*	*0.002*	*0.010*	23.70	*0.04*	*1.13*	*NA, NO*	**7 059.81**	*6 924.43*	*2.32*	*0.28*
1999	47.04	*43.21*	*0.003*	*0.012*	24.53	*0.04*	*1.17*	*NA, NO*	**7 428.35**	*7 292.03*	*2.36*	*0.28*
2000	11.46	*11.43*	*0.001*	*0.000*	25.18	*0.04*	*1.20*	*NA, NO*	**8 186.68**	*8 035.58*	*2.40*	*0.32*
2001	22.82	*22.77*	*0.002*	*0.000*	28.06	*0.04*	*1.33*	*NA, NO*	**8 775.84**	*8 622.28*	*2.55*	*0.32*
2002	12.61	*12.58*	*0.001*	*0.000*	40.16	*0.06*	*1.91*	*NA, NO*	**9 528.23**	*9 364.83*	*3.08*	*0.32*
2003	2.96	*2.95*	*0.000*	*0.000*	40.71	*0.06*	*1.94*	*NA, NO*	**10 064.17**	*9 882.18*	*3.07*	*0.38*
2004	NO	*NO*	*NO*	*NO*	45.14	*0.07*	*2.15*	*NA, NO*	**11 405.66**	*11 202.78*	*3.29*	*0.43*
2005	NO	*NO*	*NO*	*NO*	44.42	*0.07*	*2.11*	*NA, NO*	**11 684.01**	*11 483.59*	*3.19*	*0.43*
2006	NO	*NO*	*NO*	*NO*	46.62	*0.07*	*2.22*	*NA, NO*	**11 501.69**	*11 308.15*	*3.23*	*0.41*
2007	NO	*NO*	*NO*	*NO*	43.61	*0.07*	*2.07*	*NA, NO*	**10 884.07**	*10 712.57*	*2.98*	*0.35*
2008	NO	*NO*	*NO*	*NO*	41.70	*0.07*	*1.98*	*NA, NO*	**10 796.40**	*10 629.33*	*2.86*	*0.35*
2009	NO	*NO*	*NO*	*NO*	42.15	*0.07*	*2.00*	*NA, NO*	**10 284.96**	*10 129.92*	*2.83*	*0.31*
Trend 1990-2009	*NA*	*NA*	*NA*	*NA*	*158.73%*	*158.73%*	*158.73%*	*NA*	*-0.58%*	*-1.15%*	*31.08%*	*85.90%*

Source: Environment Agency.

Notes: CH_4 emissions are converted in CO2e 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 (*GW*P) 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: 1990-2009

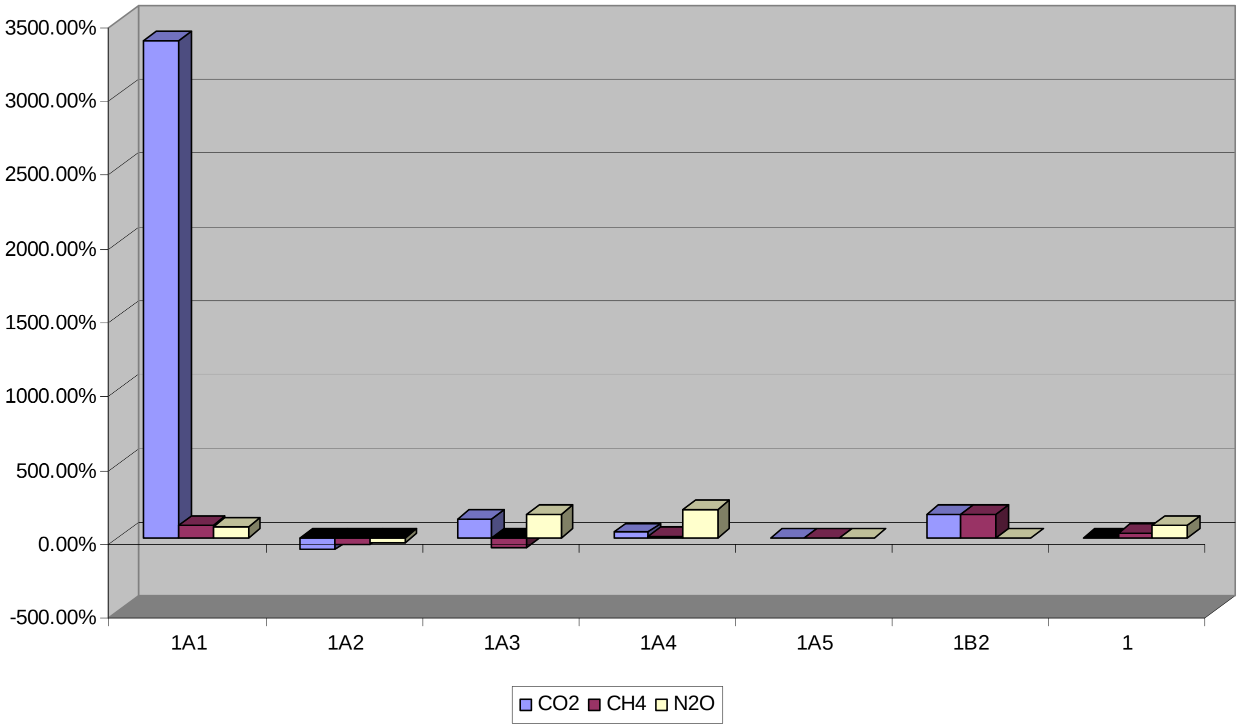
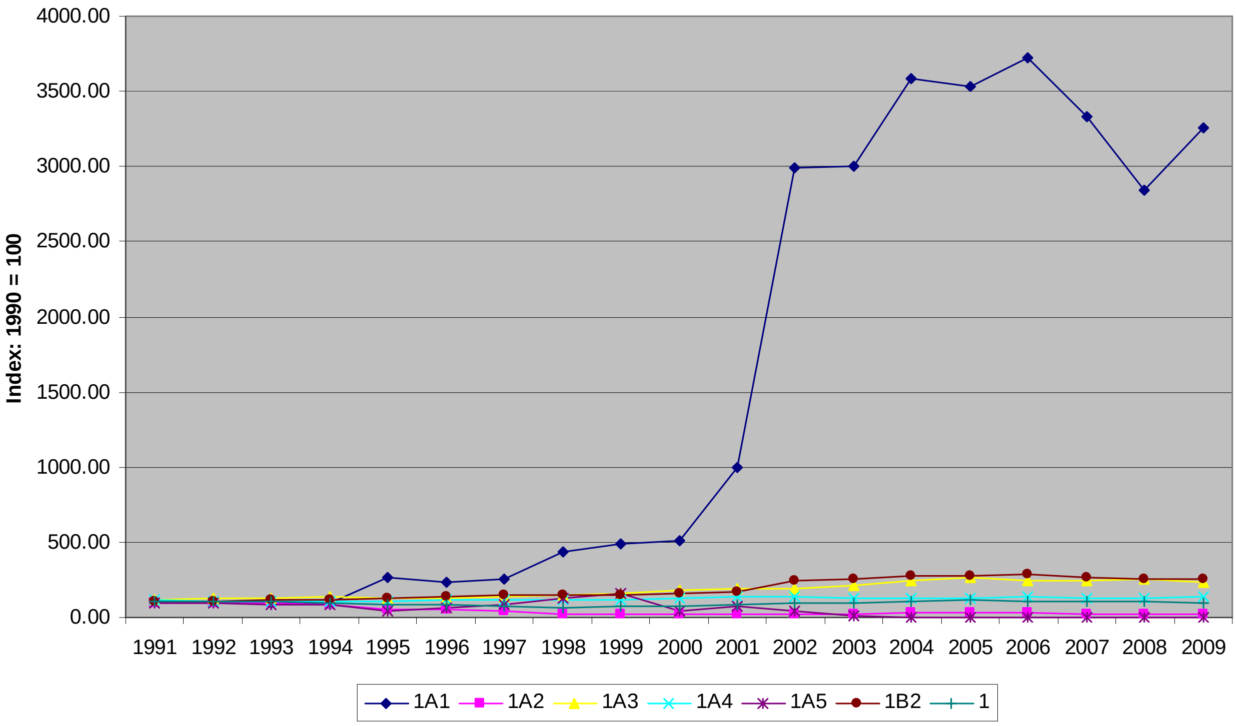


Figure 3-3 – GHG emission trend indexes for CRF Sector 1 – Energy: 1990-2009



All the changes briefly presented in the previous paragraphs – as well as in Chapter 2 - completely modified the pattern of the energy related GHG emissions between 1990 and 2009 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 2009

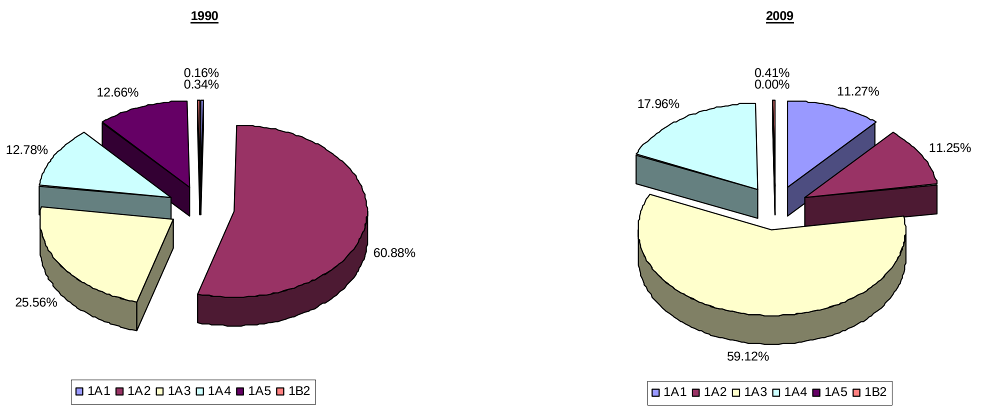


Table 3–2– Final energy consumption trends: 1970-2009

				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*	*NO*
1980	**3 407**	*1 342*	*346*	*1 049*	*360*	*310*	*NO*	*NO*
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	**3 543**	*107*	*NO*	*2 262*	*691*	*460*	*8*	*15*
2001	**3 744**	*117*	*NO*	*2 407*	*694*	*502*	*8*	*16*
2002	**3 791**	*72*	*NO*	*2 464*	*721*	*508*	*11*	*15*
2003	**4 001**	*55*	*NO*	*2 648*	*735*	*531*	*16*	*15*
2004	**4 439**	*78*	*NO*	*3 004*	*771*	*549*	*21*	*16*
2005	**4 531**	*76*	*NO*	*3 110*	*756*	*528*	*23*	*38*
2006	**4 459**	*91*	*NO*	*2 953*	*786*	*568*	*25*	*36*
2007	**4 400**	*76*	*NO*	*2 931*	*757*	*575*	*24*	*37*
2008	**4 438**	*73*	*NO*	*2 953*	*776*	*566*	*29*	*40*
2009	**4 145**	*65*	*NO*	*2 756*	*735*	*525*	*30*	*34*
Trend 1990-2009	***20.48%***	*-92.05%*	*NA*	*74.31%*	*58.31%*	*46.78%*	*NA*	*120.83%*
Share 1990	***100.00%***	*23.83%*	*5.87%*	*45.95%*	*13.49%*	*10.41%*	*NA*	*0.45%*
Share 2009	***100.00%***	*1.57%*	*NA*	*66.49%*	*17.72%*	*12.68%*	*0.72%*	*0.82%*

Sources: STATEC: Statistical Yearbook, Table A 4300: http://www.statistiques.public.lu/.

Notes: (1) including heat recovery from waste incineration.
(2) including blended biodiesel.
data extracted in January 2010 (subject to changes since that date)

Final energy consumption increased by 20.5% between 1990 and 2009. 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 2009 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 and biomass.

In 2009, with 66.5% 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 2009, almost 72.2% of road fuels are sold to vehicles registered abroad (see Table 3–49 in Section 3.2.8.3).

The importance of natural gas has increased constantly and significantly since 1990. In 2009, 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.[88] 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.[89] 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. 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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88 This cannot be seen in final energy consumption statistics but only in the primary energy consumption figures.

89 Later Arcelor, now Arcelor-Mittal.

Table 3–3 – Electricity production trends: 1990-2009

Year	Total	*Gross Electricity production (GWh)*						
		Thermic (1)		*Renewable Energy Sources (2)*				
		Total	*CHP plants*	*Total*	*small Hydro*	*Pumped Hydro*	*Solar*	*Wind*
1990	**1 377**	554	*0*	823	*70*	*753*	*0*	*0*
1991	**2 213**	617	*0*	798	*84*	*714*	*0*	*0*
1992	**1 806**	590	*0*	608	*70*	*538*	*0*	*0*
1993	**1 530**	604	*0*	463	*67*	*396*	*0*	*0*
1994	**1 803**	491	*0*	656	*86*	*570*	*0*	*0*
1995	**2 163**	399	*102*	831	*88*	*743*	*0*	*0*
1996	**2 246**	380	*114*	876	*60*	*816*	*0*	*0*
1997	**2 318**	320	*118*	940	*83*	*854*	*0*	*3*
1998	**2 545**	240	*195*	1 055	*115*	*929*	*0*	*11*
1999	**1 990**	255	*205*	765	*85*	*662*	*0*	*18*
2000	**2 316**	286	*234*	898	*124*	*747*	*0*	*27*
2001	**2 821**	744	*287*	895	*118*	*753*	*0*	*24*
2002	**5 013**	2 660	*327*	1 013	*100*	*889*	*0*	*24*
2003	**4 899**	2 654	*369*	938	*79*	*832*	*1*	*26*
2004	**5 475**	3 229	*442*	902	*104*	*750*	*9*	*39*
2005	**5 523**	3 182	*445*	948	*94*	*784*	*18*	*52*
2006	**5 800**	3 337	*471*	996	*111*	*806*	*21*	*58*
2007	**5 405**	2 998	*399*	1 004	*117*	*802*	*21*	*64*
2008	**5 025**	2 511	*422*	1 046	*132*	*833*	*20*	*61*
2009	**5 184**	2 962	*390*	916	*106*	*727*	*20*	*63*
Trend 1990-2009	***276.47%***	*434.66%*	*NA*	*11.30%*	*51.43%*	*-3.45%*	*NA*	*NA*
Share 1990	***100.00%***	*40.23%*	*0.00%*	*59.77%*	*5.08%*	*54.68%*	*0.00%*	*0.00%*
Share 2009	***100.00%***	*57.14%*	*7.52%*	*17.67%*	*2.04%*	*14.02%*	*0.39%*	*1.22%*

Sources: STATEC: IEA questionnaire on Electricity Production

Notes:

(1) includes all power plants where fuels ar combusted (public thermal power plants (TWINerg), autoproducer thermal power plants, MSW incineration and Biogas).

(2) RES = Renewable Energy Sources, includes pumped and small hydro-electric power plants, wind power and photovoltaic power.

data extracted in December 2010 (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 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	**X** (2000-2009)	**X** (2000-2009)	**X** (2000-2009)
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	NA	NA	NA
Memo Items	CO2 emissions from biomass	**X**		

Note: **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)

In 2009, GHG emissions of category *1A - Fuel Combustion* amounted to a total of 10.24 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* (52.0% 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 commercial and residential sector (*1A4 - Other Sectors*) was the second largest source of emissions with a share of 18.0% of the GHG emissions within category *1A* (15.8 of national total excl. LULUCF), followed by the energy sector (*1A1 - Energy*) and the industrial sector (*1A2 - Manufacturing Industries and Construction*) with shares of 11.31% and 11.30%, respectively (9.92% and 9.90% of national total excl. LULUCF , respectively). No emissions from sub-category *1A5 - Other*, which includes emissions from other non-specified sources, were recorded in 2009.

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 Sectors	1A5 Other	1A Fuel Combustion
1990	35.6	6 298.0	2 644.1	1 321.5	29.1	10 328.3
1991	36.3	6 141.7	3 140.6	1 588.2	29.1	10 935.9
1992	37.1	5 815.6	3 448.9	1 464.2	29.2	10 794.9
1993	35.3	5 942.3	3 493.7	1 446.3	25.6	10 943.2
1994	34.5	5 222.2	3 552.3	1 389.1	23.9	10 222.0
1995	93.2	3 360.6	3 370.1	1 401.1	11.4	8 236.4
1996	82.1	3 218.8	3 470.2	1 553.6	20.0	8 344.6
1997	89.4	2 463.0	3 670.6	1 509.9	24.3	7 757.3
1998	155.4	1 428.9	3 834.5	1 580.9	36.4	7 036.1
1999	172.9	1 538.9	4 127.8	1 517.1	47.0	7 403.8
2000	182.2	1 633.0	4 676.5	1 658.3	11.5	8 161.5
2001	354.4	1 598.3	4 940.3	1 832.1	22.8	8 747.8
2002	1 063.6	1 478.3	5 148.2	1 785.4	12.6	9 488.1
2003	1 066.7	1 637.2	5 581.8	1 734.8	3.0	10 023.5
2004	1 276.7	1 862.9	6 478.0	1 742.9	NO	11 360.5
2005	1 256.2	1 765.4	6 880.8	1 737.2	NO	11 639.6
2006	1 325.5	1 791.3	6 585.1	1 753.2	NO	11 455.1
2007	1 185.4	1 567.3	6 436.7	1 651.1	NO	10 840.5
2008	1 010.7	1 444.3	6 596.7	1 702.9	NO	10 754.7
2009	1 158.8	1 157.0	6 080.1	1 847.0	NO	10 242.8
Trend 1990-2009	3158.96%	-81.63%	129.95%	39.76%	NA	-0.83%
Share 1990	0.34%	60.98%	25.60%	12.80%	0.28%	100.00%
Share 2009	11.31%	11.30%	59.36%	18.03%	NA	100.00%

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, 97-09	01-09		
1A1a	Public Heat and Electricity Production	other	CO_2	98-09			X
1A2a	MIC - Iron & Steel	gaseous	CO_2	90-09	90-09	X	
1A2a	MIC - Iron & Steel	liquid	CO_2	90-01	91	X	X
1A2a	MIC - Iron & Steel	solid	CO_2	90-97	90-97		
1A2c	MIC - Chemicals	gaseous	CO_2	92, 94-09	98-09	X	X
1A2c	MIC - Chemicals	liquid	CO_2	90-97	90-91	X	X
1A2f	MIC - Other	gaseous	CO_2	90-09	90-09	X	X
1A2f	MIC - Other	liquid	CO_2	90-09	90-91, 98-08		
1A2f	MIC - Other	other	CO_2	01-06			
1A2f	MIC - Other	solid	CO_2	90-09	90-09	X	X
1A3b	Road Transportation	diesel oil	CO_2	90-09	90-09	X	X
1A3b	Road Transportation	gasoline	CO_2	90-09	90-09		X
1A3b	Road Transportation	diesel oil	N_2O			X	X
1A3b	Road Transportation	gasoline	N_2O	98-00			
1A4a	Commercial/Institutional	gaseous	CO_2	90-09	90-09	X	X
1A4a	Commercial/Institutional	liquid	CO_2	90-07	90-05	X	X
1A4b	Residential	gaseous	CO_2	90-09	90-09	X	X
1A4b	Residential	liquid	CO_2	90-09	90-09	X	X
1A4c	Agriculture/Forestry/Fisheries	liquid	CO_2	01-03, 07, 09		X	X

Sources: Environment Agency

Notes: LA = Level Assessement including respectively excluding LULUCF

TA = Trend Assessement including respectively excluding LULUCF

MIC = Manufacturing Industries and Construction

3.2.1 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. Table 3–7 presents CO_2 emissions of the sectoral and the reference approaches, whereas, Table 3–8 presents the difference of CO_2 emissions in percent between the reference and sectoral approaches.

Table 3–7 – 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	5 039	4 388	1 033	10 461	5 317	3 858	1 039	33	10 248
1991	4 752	5 175	1 075	11 002	5 077	4 660	1 076	34	10 847
1992	4 425	5 369	1 123	10 917	4 686	4 851	1 123	35	10 695
1993	4 563	5 369	1 167	11 099	4 813	4 826	1 168	33	10 839
1994	3 919	5 266	1 178	10 363	4 073	4 832	1 177	32	10 114
1995	2 247	4 717	1 344	8 309	2 239	4 519	1 347	31	8 136
1996	2 063	4 843	1 465	8 371	2 043	4 706	1 467	24	8 239
1997	1 349	4 955	1 492	7 797	1 247	4 876	1 496	28	7 648
1998	588	5 108	1 499	7 194	280	5 080	1 495	70	6 924
1999	626	5 367	1 545	7 537	296	5 373	1 546	77	7 292
2000	662	5 838	1 572	8 072	325	5 840	1 787	84	8 036
2001	696	6 200	1 749	8 644	317	6 204	1 991	111	8 622
2002	531	6 289	2 506	9 327	215	6 293	2 735	121	9 365
2003	482	6 839	2 543	9 864	187	6 820	2 758	117	9 882
2004	588	7 806	2 823	11 217	213	7 807	3 052	130	11 203
2005	550	8 191	2 803	11 544	224	8 119	3 015	125	11 484
2006	617	7 735	2 937	11 288	260	7 736	3 178	134	11 308
2007	572	7 573	2 731	10 876	204	7 434	2 955	119	10 713
2008	565	7 645	2 594	10 804	186	7 519	2 796	128	10 629
2009	629	7 108	2 657	10 394	211	6 960	2 853	106	10 130

Table 3–8 presents the difference of CO_2 emissions in percent between reference and sectoral approach.

Table 3–8 – Difference of CO_2 emissions by type of fuel

Difference of CO_2 emissions between sectoral and reference approach [%]				
Year	*Solid*	*Liquid*	*Gaseous*	Total
1990	- 5.23	13.75	- 0.55	2.08
1991	- 6.41	11.05	- 0.09	1.43
1992	- 5.56	10.67	- 0.07	2.07
1993	- 5.19	11.25	- 0.08	2.39
1994	- 3.78	8.98	0.14	2.46
1995	0.35	4.40	- 0.19	2.13
1996	0.98	2.92	- 0.10	1.60
1997	8.18	1.62	- 0.23	1.95
1998	110.13	0.54	0.27	3.90
1999	111.36	- 0.11	- 0.09	3.37
2000	103.72	- 0.04	- 12.00	0.45
2001	119.69	- 0.07	- 12.14	0.26
2002	146.58	- 0.06	- 8.36	- 0.40
2003	157.84	0.28	- 7.79	- 0.18
2004	176.10	- 0.02	- 7.51	0.13
2005	145.41	0.89	- 7.05	0.53
2006	137.55	- 0.01	- 7.60	- 0.17
2007	179.99	1.87	- 7.59	1.53
2008	203.41	1.68	- 7.25	1.64
2009	198.37	2.12	- 6.85	2.61

Sources: Environment Agency

Note: Positive numbers indicate that CO_2 emissions from the reference approach are higher than emissions from the sectoral approach.

3.2.1.1 Explanation of differences

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 extracted from the Questionnaires sent to the IEA by STATEC;
- 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;
- 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;
- 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.

3.2.1.2 Recalculations

Table 3–9 presents the main revisions and recalculations done since submission 2010v2.1 relevant to the *Reference Approach*.

Table 3–9 – Recalculations for the Reference Approach

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
All fuels	Streamlining of NCVs, EFs and oxidation factors (OF)between Reference Approach and Sectoral Approach.	updated NCVs, EFs and OFs
All fuels	AD was revised according to new energy balance and IEA Questionnaires as provided by STATEC	updated AD

3.2.1.3 Planned improvements

Following the findings of the last centralised review[90], all parameters of the reference approach will be verified and revised, as presented in Table 3–10.

Table 3–10 – Planned improvements for the Reference Approach

GHG source & sink category	Planned improvement
Biomass	Separate biogenic matter from fossil fuels in the Reference Approach.
Quantitative assessment	Provide a quantitative estimate of each separate discrepancy between RA and SA as outlined in Section 3.2.1.1.
International statistics	Investigate and explain any differences between data reported to international organisations.

3.2.2 International Bunker Fuels

In 2009, GHG emissions from International Bunkers amounted to 1 266 Gg CO_2 eq (see Table 3–11), an increase of approximately 218% compared to 1990.

Table 3–11 – 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	5 516 169	397.88	*394.41*	*0.003*	*0.011*	928	0.069	*0.068*	*0.000006*	*0.000002*	**5 517 097**	**398**
1991	5 765 550	415.87	*412.24*	*0.003*	*0.012*	1 007	0.075	*0.074*	*0.000007*	*0.000002*	**5 766 557**	**416**
1992	5 574 033	402.06	*398.54*	*0.003*	*0.011*	920	0.068	*0.068*	*0.000006*	*0.000002*	**5 574 953**	**402**
1993	5 512 762	397.64	*394.16*	*0.003*	*0.011*	1 291	0.096	*0.095*	*0.000009*	*0.000003*	**5 514 053**	**398**
1994	6 993 817	504.47	*500.06*	*0.003*	*0.014*	1 106	0.082	*0.081*	*0.000008*	*0.000002*	**6 994 923**	**505**
1995	7 927 783	571.83	*566.83*	*0.004*	*0.016*	1 114	0.083	*0.082*	*0.000008*	*0.000002*	**7 928 897**	**572**
1996	8 614 215	621.34	*615.91*	*0.004*	*0.017*	1 045	0.078	*0.077*	*0.000007*	*0.000002*	**8 615 261**	**621**
1997	10 305 632	743.35	*736.85*	*0.005*	*0.021*	1 027	0.076	*0.075*	*0.000007*	*0.000002*	**10 306 659**	**743**
1998	12 493 294	901.15	*893.27*	*0.006*	*0.025*	1 140	0.085	*0.084*	*0.000008*	*0.000002*	**12 494 434**	**901**
1999	14 095 591	1 016.72	*1 007.83*	*0.007*	*0.028*	1 252	0.093	*0.092*	*0.000009*	*0.000003*	**14 096 843**	**1 017**
2000	13 434 073	969.00	*960.53*	*0.007*	*0.027*	1 384	0.103	*0.102*	*0.000010*	*0.000003*	**13 435 457**	**969**
2001	14 530 054	1 048.06	*1 038.90*	*0.007*	*0.029*	1 387	0.103	*0.102*	*0.000010*	*0.000003*	**14 531 440**	**1 048**
2002	15 742 564	1 135.52	*1 125.59*	*0.008*	*0.031*	1 462	0.108	*0.107*	*0.000010*	*0.000003*	**15 744 026**	**1 136**
2003	16 399 902	1 182.93	*1 172.59*	*0.008*	*0.033*	1 490	0.111	*0.109*	*0.000010*	*0.000003*	**16 401 392**	**1 183**
2004	17 844 514	1 287.13	*1 275.88*	*0.009*	*0.036*	1 441	0.107	*0.106*	*0.000010*	*0.000003*	**17 845 955**	**1 287**
2005	18 131 067	1 307.80	*1 296.37*	*0.009*	*0.036*	1 933	0.144	*0.142*	*0.000014*	*0.000004*	**18 132 999**	**1 308**
2006	16 967 777	1 223.89	*1 213.19*	*0.008*	*0.034*	2 041	0.152	*0.150*	*0.000014*	*0.000004*	**16 969 818**	**1 224**
2007	18 238 604	1 315.56	*1 304.06*	*0.009*	*0.036*	1 699	0.126	*0.125*	*0.000012*	*0.000003*	**18 240 303**	**1 316**
2008	18 359 132	1 324.25	*1 312.68*	*0.009*	*0.037*	1 835	0.136	*0.135*	*0.000013*	*0.000004*	**18 360 967**	**1 324**
2009	17 556 880	1 266.38	*1 255.32*	*0.009*	*0.035*	1 471	0.109	*0.108*	*0.000010*	*0.000003*	**17 558 351**	**1 266**
Trend 1990-2009	*218.28%*	*218.28%*	*218.28%*	*218.28%*	*218.28%*	*58.54%*	*58.58%*	*58.58%*	*58.54%*	*58.54%*	*218.25%*	*218.25%*

Source: Environment Agency

3.2.2.1 Aviation Bunkers

As there is only one airport for commercial aviation in Luxembourg (Findel), all flights, either coming to Luxembourg or going out of Luxembourg, are international flights. Domestic flights are mainly leisure or urgency (medical, police) flights made with small-sized propellers airplanes 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

90 ARR 2009, §51-53.

and their related emissions are allocated to international bunkers (see also *1A3a – Civil Aviation*: section 3.2.8.2.2).

3.2.2.1.1 Activity data

Fuel consumptions of kerosene and aviation gasoline are obtained from official statistics (STATEC, IEA Joint Questionnaires) and from the sole vendor of aviation gasoline at the airport (Luxfuel S.A.) (see Table 3–11). Data on the number of Landings and Take-Offs (LTO) has been obtained from national statistics (STATEC)

3.2.2.1.2 Methodological issues

The 2006 IPCC Guidelines Tier 2 approach has been applied for jet flights combusting kerosene. 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.

3.2.2.1.3 Emission factors

The emission factors, used for calculating emissions from International Bunkers – Aviation, are listed in Table 3–12. Emission factors for jet kerosene are taken from the EMEP-EEA Guidebook 2009 (EMEP-EEA GB 2009) and correspond to the B737-400 aircraft type which pest represents the modern Luxemburgish fleet of commercial aircrafts.

Table 3–12 – Emission factors for International Bunkers - Aviation

International Bunkers - Aviation
Emission Factors for 2009

Fuel	Flight Phase	CO_2			CH_4			N_2O			Source
		EF	(unit)	type	EF	(unit)	type	EF	(unit)	type	
Jet Kerosene	LTO	2.600	(t/LTO)	D	0.0001	(t/LTO)	D	0.0001	(t/LTO)	D	EMEP-EEA GB 2009
	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

3.2.2.2 Marine Bunkers

As motorised 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 3–11.

For more details on activity data sources, methodological issues and emission factors used, please refer to Section 3.2.8.5.

3.2.2.3 Multilateral Operations

There are no multilateral operations in Luxembourg. Compared to submission 2010v2.1, notation keys were changed from IE to NO.

3.2.2.4 Recalculations

Table 3–13 presents the main revisions and recalculations done since submission 2010v2.1 relevant to *International Bunker Fuels*.

Table 3–13 – Recalculations for International Bunkers

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
Memo Items – International Bunkers - Aviation	revised aviation gasoline and jet kerosene consumption (2000-2009) due to revised energy balance from national statistics.	updated AD

3.2.2.5 Category specific QA/QC procedures

Standard QA/QC procedures were followed.

3.2.2.6 Planned Improvements

No planned improvements are being considered at this stage.

3.2.3 Feedstocks and non-energy use

Non-energy use of fuels is considered in the national energy balance. Below explanations for the reported non-energy use is provided together with information on where CO_2 emissions due to the manufacture, use and disposal of carbon containing products are considered.

For fraction of carbon stored the IPCC default values are applied for all.

3.2.3.1 Lubricants

Manufacturing: manufacturing of lubricants does not occur in Luxembourg.

Use: Emissions from the use of motor oil (by default 50% of the total quantity of lubricants sold) should be included in CO_2 emissions from transport. It is assumed that other uses of lubricants do not result in VOC or CO_2 emissions due to the low vapour pressure of lubricants.

Disposal: incineration of lubricants (waste oil) does not occur in Luxembourg. Waste oil is either recycled or exported.

3.2.3.2 Bitumen

Manufacturing: manufacturing of bitumen does not occur in Luxembourg.

Use: by default the carbon contained in bitumen is considered to be entirely stored in the product, i.e. asphalt for road paving.

Disposal: CO_2 emissions from the disposal of bitumen are assumed to be negligible. Recycling is not considered.

3.2.3.3 Coke oven coke

Manufacturing: not occurring. All coke used in the iron and steel industry was imported.

Use: CO_2 emissions from coke used in iron and steel industry are reported under *2.C.1 – Iron and Steel Production*.

Disposal: not applicable.

3.2.3.4 Other bituminous coal

Manufacturing: Manufacturing of electrodes from anthracite used in the electric arc furnaces does not occur in Luxembourg.

Use: Emissions from the use of electrodes in the iron and steel production are considered in category *2.C.1 – iron and steel production*.

Disposal: not applicable.

3.2.3.5 Other oil products

Manufacturing: not occurring. All products such as white spirits, etc. are imported.

Use: CO_2 emissions from solvent use are considered in sector 3.

Disposal: emissions from the disposal of plastics in landfills are considered in *6.A* and emissions from incineration of plastics in waste with energy recovery are considered in 1 A 1 a.

3.2.3.6 Planned improvements

Following the findings of the last centralised review[91], a general revision of this section will be undertaken.

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91 ARR 2009, § 56-58

3.2.4 CO_2 capture from flue gases and subsequent CO_2 storage

CO_2 capture from flue gases and CO_2 storage is not occurring in Luxembourg.

3.2.5 Country specific issues

3.2.5.1 Activity data

As Luxembourg's industrial sector is relatively small compared to larger countries, one has to keep in mind, that, when analysing trends in activity data, relatively large fluctuations may occur in between years simply due to the fact that a facility was temporally switched off for maintenance reasons, or shut-down for good. This may then be reflected by a sharp decrease in the activity data. On the other hand, the bringing into service of a single installation may lead to a sharp increase of activity data in a source category, and consequently also an increase in emissions (e.g. in 2001, when the Twinerg gas turbine began operating).

3.2.5.2 Methodological choices

In general, the IPCC methodologies were applied for IPCC category *1-Energy*, except for road transportation where the COPERT calculation model was used.

Methodologies used were mostly Tier 1 for solid fuels (except blast furnace gas) and liquid fuels (residual fuel oil, aviation gasoline, kerosene) and Tier 2 for liquid fuels (motor gasoline, diesel oil, gas oil and LPG), 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, IEA Joint Questionnaires), or obtained directly from plant operators, from the Ministry of Economic Affairs (Energy Directorate) and the Customs and Excise Administration. Activity data obtained through the Emission Trading System (ETS) were 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 were fixed to national values in agreement with national statistics (STATEC) and the "Office

Commercial du Ravitaillement) (OCRA) of the Ministry of Economic Affairs.[92] These are mostly country-specific values, however, were no such values were available, defaults from the 2006 IPCC Guidelines or the European Directive on Statistics (2006/32/EC) were used (see Table 3–14). For natural gas, please refer to Table 3–15.

Table 3–14 – Fuel Properties for 2009

Fuel Characteristics for 2009 *Country-specific Net Calorific values and Densities*						
Fuel	**Net calorific value**			**Density**		
	NCV	***Unit***	***Source***	***Density***	***Unit***	***Source***
Anthracite	26.70	GJ/t	*2006 IPCC GL*			
Bituminous Coal & Coking Coal	24.40	GJ/t	*Plant Operator*			
Patent Fuel ("boulets")	28.20	GJ/t	*2006 IPCC GL*			
Brown Coal Briquettes (incl. Lignite dust)	22.20	GJ/t	*Plant Operator*			
Coke Oven Coke	28.50	GJ/t	*EU-2006/32/EC*			
Residual Fuel Oil (low / high sulphur)	40.00	GJ/t	*EU-2006/32/EC*	0.92 / 0.96	kg/l	*Fuel Providers*
Gas Oil	42.49	GJ/t	*Fuel Providers*	0.85	kg/l	*Fuel Providers*
Diesel Oil	42.49	GJ/t	*Fuel Providers*	0.85	kg/l	*Fuel Providers*
Gasoline	43.05	GJ/t	*Fuel Providers*	0.76	kg/l	*Fuel Providers*
Liquefied Petroleum Gas (LPG)	46.00	GJ/t	*EU-2006/32/EC*	0.53	kg/l	*Fuel Providers*
Aviation Gasoline	43.50	GJ/t	*Fuel Provider*	0.71	kg/l	*Fuel Provider*
Jet Kerosene	43.11	GJ/t	*Fuel Provider*			
Other Kerosene	43.80	GJ/t	*2006 IPCC GL*			
Wood	7.15	GJ/m3	*Statec*			
Pellets	11.00	GJ/m3	*Statec*	0.65	kg/l	*Statec*
Wood chips	3.60	GJ/m3	*Statec*			
Biogaz	0.02	GJ/m3	*Statec*			
Biodiesel (pure)	39.76	GJ/t	*Fuel Providers*			
Lubricants	40.20	GJ/t	*2006 IPCC GL*			
Bitumen	40.20	GJ/t	*2006 IPCC GL*			

Source: Environment Agency

Emission factors are defaults from 2006 IPCC Guidelines for solid (except blast furnace gas) and some liquid fuels and country-specific for natural gas, motor gasoline, gas/diesel oil, and LPG.

3.2.5.3 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.[93] 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 0 for more details).

92 ARR 2010, § 21

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

Natural Gas

In Luxembourg, one operator, Creos S.A. (formerly SOTEG S.A.)[94], 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:

- 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/Nm^3) and gross calorific value (GCV: MJ/Nm^3);
- monthly import/consumption (Mio Nm^3). [95]

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 [96].

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.

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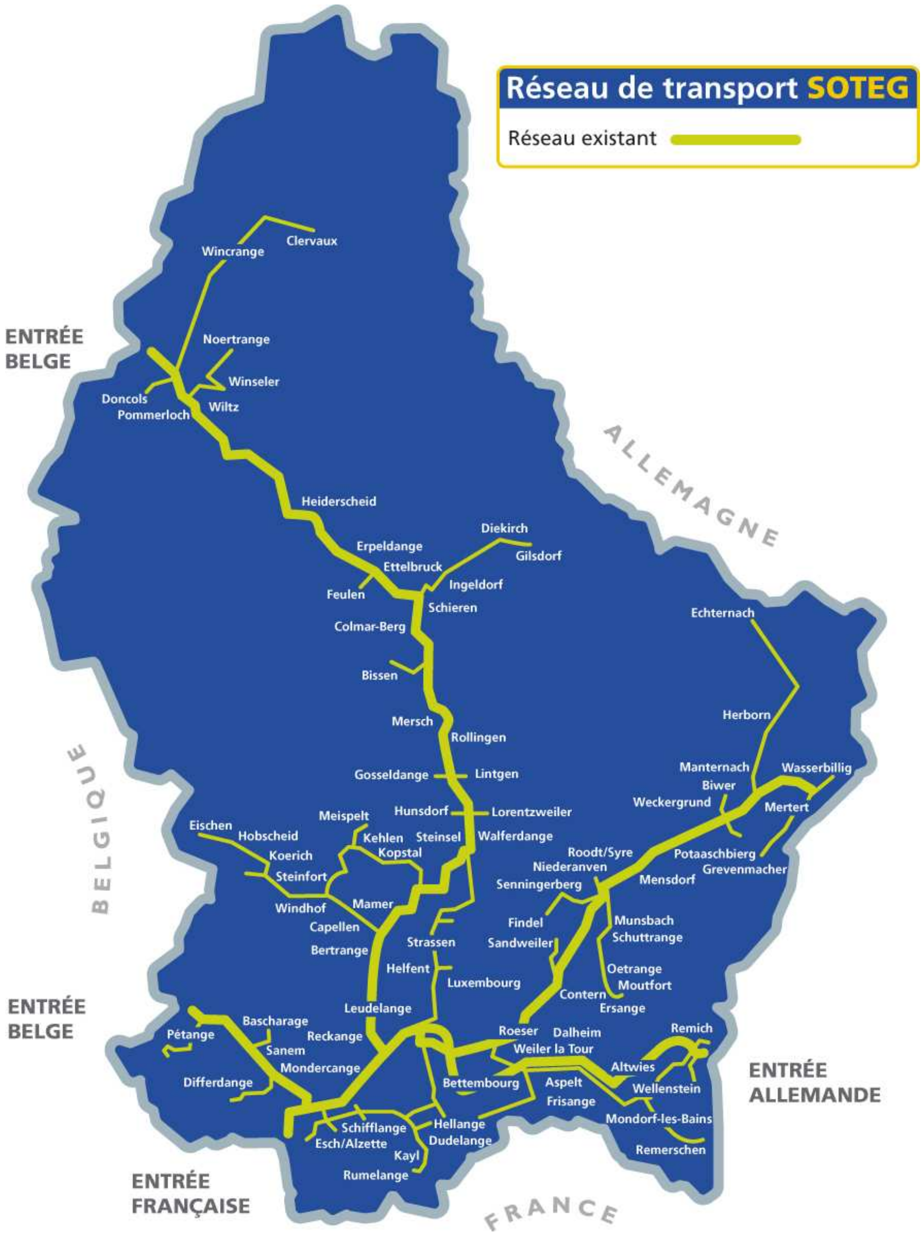
94 http://www.creos.lu

95 Nm^3 is defined at a pressure of 1035 mbar and 0 degree Celsius.

96 IEA Energy Statistics Manual, 2005, Table A3.12, p.183

Figure 3-5 - Natural gas network



Source: Creos

Country-specific NCVs and emission factors have, thus, been obtained for the years 1991, 1995, 2000, 2005-2009 (Table 3–15). For the years in-between, the values have been interpolated.

Table 3–15 - Country-specific NCV and Emission Factors for Natural Gas: 1990-2009

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
EF (t CO_2/TJ)	57.76	57.74	57.85	57.89	57.94	57.93	57.55	57.20	56.86	56.52
NCV (MJ/Nm^3)	36.58	36.67	36.62	36.64	36.66	36.75	36.85	36.92	36.99	37.06
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
EF (t CO_2/TJ)	56.22	56.26	56.40	56.53	56.67	56.91	57.01	56.79	56.66	57.06
NCV (MJ/Nm^3)	37.10	37.01	36.96	36.91	36.86	36.85	36.72	36.64	36.48	36.72

Source: Environment Agency

Motor Gasoline, Gas/Diesel Oil, Liquefied Petroleum Gas

In Luxembourg, refined oil products such as motor gasoline, gasoil, diesel oil and liquefied petroleum gas (LPG) are exclusively imported from the neighbouring countries Belgium, the Netherlands and Germany, and to a minor extent from France. As the Luxembourgish association of mineral oil companies (Groupement Pétrolier Luxembourgeois a.s.b.l.) was not able to provide country-specific carbon contents of the before-mentioned fuels to the Environment Agency, country-specific emission factors for motor gasoline, gas/diesel oil and LPG were derived from the emission factors of the corresponding import countries in relation with the yearly quantities imported.[97] Thus, country-specific emission factors have been obtained for the entire time-series (Table 3–16).

Table 3–16 - Country-specific Emission Factors for Gas/Diesel Oil, Motor Gasoline and LPG: 1990-2009 (tCO_2/TJ)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Gas/Diesel Oil	73.45	73.48	73.53	73.45	73.40	73.39	73.41	73.41	73.42	73.42
Motor Gasoline	68.79	68.86	69.46	69.34	69.26	69.17	69.13	69.00	69.04	68.99
LPG	62.92	63.05	62.89	62.44	62.44	62.44	62.44	62.44	62.61	63.25
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Gas/Diesel Oil	73.37	73.37	73.37	73.43	73.47	73.49	73.48	73.48	73.50	73.47
Motor Gasoline	68.89	69.00	68.98	68.95	68.72	68.76	69.01	68.96	68.94	68.89
LPG	62.53	62.52	62.65	62.82	62.58	62.60	62.64	62.44	62.44	62.53

Source: Environment Agency

3.2.6 Energy Industries (1A1): Public Electricity and Heat Production (1A1a)

3.2.6.1 Source category description

This section describes GHG emissions resulting from fuel combustion activities in energy industries, which, in Luxembourg, only originate from public electricity and heat production plants. There are no manufacturing solid fuels plants, nor petroleum refining plants. Hence, IPCC Sub-Category *1A1 – Energy Industries* = 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 plant (SIDOR) where heat and electricity are distributed to the urban district network. Therefore, the emissions are reported as fuel combustion emissions.

97 ARR 2009, § 48

In 2009, this source category was responsible for 11.3% of GHG emissions from fuel combustion activities (0.34% in 1990) and represented 9.45% of the national total GHG emissions in CO_2e, excluding LULUCF (0.28% in 1990). Table 3–17 summarizes GHG emissions for IPCC Sub-category 1A1. Compared to 2008, GHG emissions increased by 14.6%, mainly due to the increased electricity production level by the Twinerg gas turbine, which was on a maintenance stop for several months in 2008.

With regard to CO_2 emissions, *1A1a - Public electricity and heat production* is a key category, in 2009. It has been a key source for gaseous fuels in 1995 and from 1997 onwards and for other solid fuels (MSW) from 1998 onwards: see Table 3–6 in Section 3.2.

Table 3–17 – GHG emission trends in CO_2e for IPCC Sub-category 1A1 – Fuel Combustion Activities – Energy Industries: 1990-2009

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	35.56	*33.29*	*0.036*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1991	36.33	*34.01*	*0.037*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1992	37.10	*34.73*	*0.038*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1993	35.29	*33.04*	*0.036*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1994	34.53	*32.32*	*0.035*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1995	93.23	*91.07*	*0.035*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1996	82.08	*80.40*	*0.027*	*0.004*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1997	89.42	*87.44*	*0.032*	*0.004*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1998	155.40	*152.94*	*0.040*	*0.005*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
1999	172.92	*170.11*	*0.045*	*0.006*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2000	182.18	*179.43*	*0.044*	*0.006*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2001	354.39	*351.51*	*0.047*	*0.006*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2002	1 063.56	*1 059.99*	*0.060*	*0.007*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2003	1 066.66	*1 062.98*	*0.062*	*0.008*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2004	1 276.74	*1 272.59*	*0.070*	*0.009*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2005	1 256.17	*1 252.31*	*0.065*	*0.008*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2006	1 325.48	*1 321.37*	*0.070*	*0.009*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2007	1 185.39	*1 181.33*	*0.068*	*0.008*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2008	1 010.73	*1 006.74*	*0.067*	*0.008*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
2009	1 158.77	*1 154.75*	*0.068*	*0.008*	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*
Trend 1990-2009	*3158.96%*	*3369.03%*	*85.71%*	*72.52%*	*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.

3.2.6.2 Methodological issues

3.2.6.2.1 Activity data

Activity data of various installations are considered in *1A1a*:

- 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 or wood & wood wastes. The activity rates are based on information received from the operators and from energy statistics (STATEC).
- a CHP gas turbine (350MW) running on natural gas and operated since 2002 by Twinerg S.A. Since heat is not yet recovered, this unit is counted as a thermal power plant and not as a cogeneration plant 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.
- one 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 which is deposited on land[98]). No industrial and hazardous waste is incinerated because it is exported. Activity data on municipal waste composition are taken from the following studies and for the years in-between an interpolation has been carried out. From 1990-2001, the composition is calculated based on :
  - Waste Division of the Environment Agency, "Restabfallanalyse 2004/05 im Großherzogtum Luxemburg, Band 1: Kompendium", Luxembourg, 2005;
  - Waste Division of the Environment Agency, "Restabfallanalyse 2001 im SIDOR", Luxembourg, 2002;
  - Waste Division of the Environment Agency, "Restabfallanalyse 1992/1994", Luxembourg, 2002.

  From 2002-2009, MSW fractions are calculated similarly based on the following waste composition analysis:
  - Waste Division of the Environment Agency, "Restabfallanalyse 2009/10 im Großherzogtum Luxemburg, Band 1: Kompendium", Luxembourg, 2010;
  - Waste Division of the Environment Agency, "Restabfallanalyse 2004/05 im Großherzogtum Luxemburg, Band 1: Kompendium", Luxembourg, 2005;

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

However, one part of the waste originates from a pre-treatment plant (MBA Fridhaff), which pre-treats waste before being disposed on land. The composition of this high calorific faction which is not disposed on land but brought to the incinerator, is calculated based on the following study:

- Air & Noise Division of the Environment Agency, "Abschätzung emittierter Klimagase durch die MBA Fridhaff abgeschiedene und verbrannte heizwertreiche Fraktion", Luxembourg, 2010

Table 3–18 gives an overview of the energy consumptions by fuel type in *1A1a – Public Electricity and Heat Production*.

Table 3–18 - Activity data for IPCC Sub-category 1A1a – Public Electricity and Heat Production: 1990-2009

1A1a - Public Electricity & Heat Production *Activity Data by fuel type (GJ)*					
		Liquid	Gaseous	Biomass	Other
Year	Activity Total (incl. biomass)	*Gas Oil*	*Natural Gas*	*Biogas, Wood & MSW (biogenic fraction)*	*MSW (fossil fraction)*
1990	1 213 293	*NO*	*NO*	*877 003*	*336 290*
1991	1 239 536	*NO*	*NO*	*895 973*	*343 564*
1992	1 282 780	*NO*	*NO*	*931 942*	*350 838*
1993	1 221 173	*NO*	*NO*	*887 411*	*333 762*
1994	1 195 144	*NO*	*NO*	*868 596*	*326 548*
1995	2 183 370	*NO*	*1 039 222*	*832 290*	*311 859*
1996	1 871 328	*900*	*980 942*	*648 213*	*241 274*
1997	2 074 746	*18 919*	*1 009 659*	*760 358*	*285 810*
1998	3 008 245	*30 783*	*1 701 649*	*691 092*	*584 722*
1999	3 366 146	*31 593*	*1 876 345*	*788 767*	*669 441*
2000	3 547 556	*20 688*	*2 097 900*	*778 629*	*650 338*
2001	6 657 227	*35 178*	*5 149 800*	*830 119*	*642 130*
2002	19 227 642	*29 574*	*17 689 933*	*855 424*	*652 711*
2003	19 342 934	*19 538*	*17 682 035*	*1 005 646*	*635 714*
2004	23 031 545	*20 625*	*21 181 176*	*1 096 503*	*733 241*
2005	22 694 542	*20 818*	*20 893 903*	*1 145 552*	*634 269*
2006	23 929 187	*15 513*	*21 966 145*	*1 244 485*	*703 044*
2007	21 608 824	*17 189*	*19 562 997*	*1 315 201*	*713 437*
2008	18 569 835	*31 857*	*16 448 005*	*1 338 974*	*750 999*
2009	21 114 810	*43 194*	*18 953 727*	*1 382 096*	*735 792*
Trend 1990-2009	*1640.29%*	*NA*	*NA*	*57.59%*	*118.80%*

Source: Environment Agency.

3.2.6.2.2 Methodological choices

The 2006 IPCC Guidelines Tier 1 approach has been applied for bimoass burning (biogaz & wood and wood wastes), except for the biogenic fraction of MSW. For natural gas and gasoil, the methodological approach is classified as Tier 2 methodology as country-specific emission factors were 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.[99]

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 3–19).[100]

Table 3–19 – Calorific values for MSW components

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

99 2006 IPCC Guidelines, Vol. 5, Chap. 2, Tab. 2.4, p2.14

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

MSW component	Heating value [GJ/t]	MSW component	Heating value [GJ/t]
Nappies	10	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 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).

3.2.6.2.3 Emission factors

Default emission factors are derived from IPCC 2006 Guidelines (Table 3–20). Country-specific emission factors were determined by the Environment Agency and were calculated from specific data accessible to the Environment Agency (see section 3.2.5.3).

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 3.2.6.2.2, 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 one of the next submissions, 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 3–20 gives an overview of the different emission factors used for 2009.

Table 3–20 – Emission factors for IPCC Sub-category 1A1a – Public Electricity and Heat Production

1A1a - Public Electricity & Heat Production *Emission Factors for 2009 (kg/TJ)*								
Fuel	Fuel Type	CO_2 EF	CO_2 type	CH_4 EF	CH_4 type	N_2O EF	N_2O type	Source
Gas Oil	liquid	*73 470*	*CS*	*3.00*	*D*	*0.60*	*D*	*AEV; 2006 IPCC GL*
Natural Gas	gaseous	*57 056*	*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*
Wood & wood wastes	biomass	*112 000*	*D*	*30.00*	*D*	*4.00*	*D*	*2006 IPCC GL*
MSW (biogenic)	biomass	*94 813*	*IEF*	*30.00*	*D*	*4.00*	*D*	*AEV, 2006 IPCC GL*
MSW (fossil)	other	*95 344*	*IEF*	*30.00*	*D*	*4.00*	*D*	*AEV, 2006 IPCC GL*

Source: Environment Agency.

Notes: AEV: IEFs and CS EFs were determined by the Environment Agency.

Table 3–21 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3–21 – Implied emission factors for IPCC Sub-category 1A1a – Public Electricity and Heat Production

1A1a - Public Electricity & Heat Production *Implied Emission Factors (kg/TJ)*												
Year	Liquid *Gas Oil*			Gaseous *Natural Gas*			Biomass *Biogas, Wood & 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
1990	NO	NO	NO	NO	NO	NO	98 984	30.00	4.00	98 984	30.00	4.00
1991	NO	NO	NO	NO	NO	NO	98 984	30.00	4.00	98 984	30.00	4.00
1992	NO	NO	NO	NO	NO	NO	98 175	29.47	3.93	98 984	30.00	4.00
1993	NO	NO	NO	NO	NO	NO	98 134	29.44	3.93	98 984	30.00	4.00
1994	NO	NO	NO	NO	NO	NO	98 116	29.43	3.92	98 984	30.00	4.00
1995	NO	NO	NO	57 929	1.00	0.10	97 971	29.34	3.91	98 984	30.00	4.00
1996	73 410	3.00	0.60	57 546	1.00	0.10	97 684	29.15	3.89	98 984	30.00	4.00
1997	73 408	3.00	0.60	57 205	1.00	0.10	98 109	29.43	3.92	98 984	30.00	4.00
1998	73 424	3.00	0.60	56 863	1.00	0.10	91 480	29.43	3.92	92 215	30.00	4.00
1999	73 421	3.00	0.60	56 522	1.00	0.10	91 668	29.56	3.94	92 215	30.00	4.00
2000	73 369	3.00	0.60	56 221	1.00	0.10	91 155	29.14	3.88	92 215	30.00	4.00
2001	73 370	3.00	0.60	56 258	1.00	0.10	88 456	27.07	3.61	92 215	30.00	4.00
2002	73 374	3.00	0.60	56 396	1.00	0.10	88 067	26.75	3.56	92 202	30.00	4.00
2003	73 435	3.00	0.60	56 533	1.00	0.10	90 126	25.01	3.33	97 396	30.00	4.00
2004	73 470	3.00	0.60	56 671	1.00	0.10	88 295	24.47	3.26	96 441	30.00	4.00
2005	73 492	3.00	0.60	56 910	1.00	0.10	85 917	22.13	2.94	97 300	30.00	4.00
2006	73 483	3.00	0.60	57 008	1.00	0.10	84 166	21.31	2.83	96 690	30.00	4.00
2007	73 482	3.00	0.60	56 793	1.00	0.10	83 483	20.78	2.76	96 753	30.00	4.00
2008	73 501	3.00	0.60	56 665	1.00	0.10	83 182	20.75	2.76	96 366	30.00	4.00
2009	73 470	3.00	0.60	57 056	1.00	0.10	80 214	19.13	2.54	95 344	30.00	4.00

Source: Environment Agency.

3.2.6.3 Uncertainties and time-series consistency

For uncertainties on activity data and emission factors, please refer to section 1.7.

The time-series are considered to be consistent with the data reported in the energy balance. The increase of natural gas consumption between 2008 and 2009, and the resulting increase of GHG emissions, is explained by the increased electricity production level by the Twinerg gas turbine. Indeed, in 2008, the turbine was shut down for about 3 month for maintenance.

3.2.6.4 Source-specific QA/QC and verification

Activity data 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. Thus, completeness can be checked on a more systematic basis.

Additionally, cross checks with other relevant sectors, mainly 6 – Waste, are performed to avoid double counting.

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

3.2.6.5 Source-specific recalculations

Table 3–22 presents the main revisions and recalculations done since submission 2010v2.1 relevant to IPCC sub-category *1A1a - Public Electricity and Heat Production*.

Table 3–22 – Recalculations done since submission 2010v2.1

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
1A1a	Emissions from iron & steel auto producers were reallocate from 1A1a to 1A2a[101]	updated AD
1A1a	Waste incineration: MSW composition was revised by integrating nesand streamlined with data on waste deposited on land (see Waste sector), especially for high calorific waste fraction.	updated AD
1A1a	Emissions from wood & wood waste burning with energy recovery are considered, due to revised energy balance from national statistics.	added wood burning
1A1a	Fuel consumption data for all fuels was revised due to revised energy balance and updated fuel properties (densities, NCVs) from national statistics	updated AD, NCVs, densi-ties

3.2.6.6 Source-specific planned improvements

No planned improvements are being considered at this stage.

3.2.7 Manufacturing Industries and Construction (1A2)

3.2.7.1 Source category description

This section describes GHG emissions resulting from fuel combustion activities in manufacturing industries and construction.

The 2011 GHG inventory includes emissions from IPCC Sub-categories *1A2a – Iron and Steel*, *1A2b – Non-Ferrous Metals*, *1A2c – Chemicals*, *1A2d – Pulp, Paper and Print*, *1A2e – Food Processing, Beverages and Tobacco* and *1A2f – Other*. Compared to the previous submission, submission 2011v1.3 does also record GHG emissions for the IPCC Sub-category *1A2d – Pulp, Paper and Print* from 2000-2009, due the availability of new data from the revised energy balance from national statistics (SATEC).

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101 ARR 2009, § 59; ARR 2010, §38

Table 3–23 – GHG emission trends in CO_2e for IPCC Sub-category 1A2 – Fuel Combustion Activities – Manufacturing Industries and Construction: 1990-2009

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	5 426.47	*5 417.96*	*0.110*	*0.020*	27.89	*27.87*	*0.0005*	*0.0000*	179.65	*178.20*	*0.006*	*0.004*	IE	*IE*	*IE*	*IE*
1991	5 167.60	*5 159.15*	*0.105*	*0.020*	28.97	*28.95*	*0.0005*	*0.0000*	197.66	*195.94*	*0.007*	*0.005*	IE	*IE*	*IE*	*IE*
1992	4 768.36	*4 760.57*	*0.098*	*0.019*	29.21	*29.19*	*0.0005*	*0.0000*	184.91	*183.29*	*0.006*	*0.005*	IE	*IE*	*IE*	*IE*
1993	4 943.31	*4 934.65*	*0.105*	*0.021*	28.57	*28.54*	*0.0005*	*0.0000*	192.29	*190.65*	*0.006*	*0.005*	IE	*IE*	*IE*	*IE*
1994	4 085.59	*4 078.06*	*0.087*	*0.018*	34.67	*34.64*	*0.0006*	*0.0001*	209.95	*208.47*	*0.006*	*0.004*	IE	*IE*	*IE*	*IE*
1995	2 337.87	*2 332.65*	*0.050*	*0.013*	35.85	*35.82*	*0.0006*	*0.0001*	208.46	*206.59*	*0.006*	*0.006*	IE	*IE*	*IE*	*IE*
1996	2 125.64	*2 120.45*	*0.046*	*0.014*	58.20	*58.15*	*0.0010*	*0.0001*	213.08	*211.04*	*0.006*	*0.006*	IE	*IE*	*IE*	*IE*
1997	1 358.37	*1 354.28*	*0.029*	*0.011*	41.79	*41.75*	*0.0007*	*0.0001*	198.92	*197.29*	*0.005*	*0.005*	IE	*IE*	*IE*	*IE*
1998	331.27	*328.38*	*0.007*	*0.009*	43.59	*43.55*	*0.0008*	*0.0001*	194.87	*193.99*	*0.004*	*0.003*	IE	*IE*	*IE*	*IE*
1999	365.15	*363.54*	*0.008*	*0.005*	42.48	*42.44*	*0.0007*	*0.0001*	183.40	*182.83*	*0.004*	*0.002*	IE	*IE*	*IE*	*IE*
2000	428.97	*425.40*	*0.009*	*0.011*	41.24	*41.20*	*0.0007*	*0.0001*	200.35	*198.82*	*0.004*	*0.005*	20.27	*19.83*	*0.0005*	*0.0014*
2001	419.95	*417.31*	*0.009*	*0.008*	41.83	*41.79*	*0.0007*	*0.0001*	210.51	*209.19*	*0.004*	*0.004*	12.10	*11.68*	*0.0004*	*0.0013*
2002	410.29	*408.05*	*0.009*	*0.007*	40.36	*40.32*	*0.0007*	*0.0001*	206.32	*205.01*	*0.004*	*0.004*	16.47	*16.05*	*0.0005*	*0.0013*
2003	386.54	*384.74*	*0.007*	*0.005*	46.20	*46.16*	*0.0008*	*0.0001*	219.19	*217.41*	*0.005*	*0.005*	36.97	*36.60*	*0.0008*	*0.0012*
2004	519.25	*515.94*	*0.010*	*0.010*	52.65	*52.60*	*0.0009*	*0.0001*	232.25	*230.16*	*0.005*	*0.006*	35.04	*34.55*	*0.0008*	*0.0015*
2005	462.92	*460.16*	*0.009*	*0.008*	51.32	*51.28*	*0.0009*	*0.0001*	226.65	*224.64*	*0.005*	*0.006*	28.22	*27.75*	*0.0007*	*0.0015*
2006	526.84	*523.36*	*0.010*	*0.011*	56.45	*56.39*	*0.0010*	*0.0001*	217.51	*216.09*	*0.004*	*0.004*	16.85	*16.47*	*0.0004*	*0.0012*
2007	517.68	*515.39*	*0.010*	*0.007*	52.85	*52.80*	*0.0009*	*0.0001*	192.86	*192.04*	*0.004*	*0.002*	12.33	*12.14*	*0.0003*	*0.0006*
2008	498.54	*496.79*	*0.009*	*0.005*	51.37	*51.32*	*0.0009*	*0.0001*	183.92	*183.25*	*0.003*	*0.002*	13.42	*13.26*	*0.0003*	*0.0005*
2009	326.42	*325.71*	*0.006*	*0.002*	45.00	*44.95*	*0.0008*	*0.0001*	136.14	*135.77*	*0.002*	*0.001*	16.18	*16.09*	*0.0003*	*0.0003*
Trend 1990-2009	*-93.98%*	*-93.99%*	*-94.67%*	*-90.52%*	*61.30%*	*61.30%*	*70.54%*	*70.54%*	*-24.22%*	*-23.81%*	*-57.84%*	*-75.54%*	*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	16.78	*16.26*	*0.001*	*0.002*	647.22	*638.13*	*0.043*	*0.026*	**6 298.01**	*6 278.42*	*0.160*	*0.052*
1991	25.23	*24.22*	*0.001*	*0.003*	722.20	*714.03*	*0.042*	*0.024*	**6 141.66**	*6 122.29*	*0.156*	*0.052*
1992	22.39	*21.40*	*0.001*	*0.003*	810.70	*800.24*	*0.047*	*0.031*	**5 815.57**	*5 794.69*	*0.152*	*0.057*
1993	15.56	*15.05*	*0.001*	*0.002*	762.61	*753.11*	*0.041*	*0.028*	**5 942.34**	*5 922.00*	*0.153*	*0.055*
1994	22.41	*21.42*	*0.001*	*0.003*	869.53	*859.28*	*0.053*	*0.029*	**5 222.16**	*5 201.87*	*0.148*	*0.055*
1995	22.61	*21.61*	*0.001*	*0.003*	755.82	*747.00*	*0.044*	*0.025*	**3 360.60**	*3 343.67*	*0.101*	*0.048*
1996	19.13	*18.38*	*0.001*	*0.002*	802.71	*793.22*	*0.051*	*0.027*	**3 218.75**	*3 201.23*	*0.104*	*0.049*
1997	23.49	*22.25*	*0.001*	*0.004*	840.39	*829.35*	*0.048*	*0.032*	**2 462.96**	*2 444.91*	*0.084*	*0.053*
1998	20.67	*19.67*	*0.001*	*0.003*	838.55	*824.99*	*0.052*	*0.040*	**1 428.94**	*1 410.59*	*0.065*	*0.055*
1999	21.90	*21.10*	*0.001*	*0.003*	925.97	*911.82*	*0.055*	*0.042*	**1 538.90**	*1 521.74*	*0.068*	*0.051*
2000	41.43	*39.66*	*0.001*	*0.006*	900.78	*882.12*	*0.061*	*0.056*	**1 633.04**	*1 607.04*	*0.077*	*0.079*
2001	29.24	*27.74*	*0.001*	*0.005*	884.61	*866.87*	*0.068*	*0.053*	**1 598.25**	*1 574.58*	*0.084*	*0.071*
2002	31.86	*30.48*	*0.001*	*0.004*	773.00	*756.48*	*0.059*	*0.049*	**1 478.29**	*1 456.41*	*0.074*	*0.066*
2003	24.75	*23.82*	*0.001*	*0.003*	923.57	*891.95*	*0.063*	*0.098*	**1 637.22**	*1 600.67*	*0.078*	*0.113*
2004	27.66	*26.40*	*0.001*	*0.004*	996.02	*958.20*	*0.071*	*0.117*	**1 862.87**	*1 817.84*	*0.089*	*0.139*
2005	27.12	*25.70*	*0.001*	*0.005*	969.16	*932.58*	*0.098*	*0.111*	**1 765.40**	*1 722.10*	*0.115*	*0.132*
2006	21.26	*20.08*	*0.001*	*0.004*	952.41	*917.72*	*0.100*	*0.105*	**1 791.32**	*1 750.11*	*0.117*	*0.125*
2007	16.75	*16.05*	*0.001*	*0.002*	774.79	*751.80*	*0.092*	*0.068*	**1 567.27**	*1 540.23*	*0.108*	*0.080*
2008	14.59	*14.07*	*0.000*	*0.002*	682.46	*663.41*	*0.088*	*0.055*	**1 444.30**	*1 422.10*	*0.103*	*0.065*
2009	17.35	*17.01*	*0.000*	*0.001*	615.87	*604.66*	*0.073*	*0.031*	**1 156.96**	*1 144.19*	*0.083*	*0.036*
Trend 1990-2009	*3.41%*	*4.62%*	*-21.54%*	*-35.04%*	*-4.84%*	*-5.24%*	*70.36%*	*18.15%*	*-81.63%*	*-81.78%*	*-48.08%*	*-32.11%*

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.

In 2009, this source category was responsible for 11.3% of GHG emissions from fuel combustion activities (this share was 61.0% in 1990) and represented 9.4% of the total GHG emissions in CO_2e, excluding LULUCF (49.1% in 1990). Compared to 2008, emissions of 1A2 decreased by 19.9%, mainly due to the economic crisis.

Table 3–23 summarizes GHG emissions for *1A2 – Manufacturing Industries and Construction* and the relevant sub-categories.

3.2.7.2 Iron and Steel (1A2a)

3.2.7.2.1 Source category description

In 2009, fuel combustion in iron and steel was responsible for 3.2% of GHG emissions from fuel combustion activities (this share was 52.5% in 1990) and represented 2.66% of the total GHG emissions in CO_2e, excluding LULUCF (42.3% in 1990). Compared to 2008, this was a decrease of 34.5%.

Fuel combustion in *1A2a - iron and steel* is a key category 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 1990 and 2001: see Table 3–6 in Section 3.2.

3.2.7.2.2 Methodological issues

3.2.7.2.2.1 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 3–24 gives a summary of which combustion activities are included for estimating GHG emissions pertaining from IPCC Sub-category 1A2a.

Table 3–24 – Iron and steel combustion activities included in the GHG inventory

Combustion activity	SNAP code
Combustion plants 50-300 MW	030102
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

<u>Combustion plants 50-300 MW</u>

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[102] and from a study (TÜV (1990)). The electricity produced was used in the installations of the iron and steel industry (autoproducer). Overproduction was fed into the public electricity network.

<u>Combustion plants <50 MW</u>

Various combustion plants were operated 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.

<u>Blast furnace cowpers</u>

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.

<u>Sinter and pelletizing plants</u>

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

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 - 2009. 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 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 national statistics (STATEC).

Mobile Sources and Machinery in Industry

Activity data on the consumption of diesel oil, used in mobile sources and machinery was derived from national statistics (STATEC).

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

Table 3–25 gives a summary of the amount of energy used in IPCC Sub-category 1A2a.

Table 3–25 – Activity data for IPCC Sub-category 1A2a – Iron and Steel: 1990-2009

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	32 004 496	*24 297 184*	*776 779*	*6 930 533*	*NO*	*NO*
1991	30 054 974	*23 212 906*	*1 246 935*	*5 595 133*	*NO*	*NO*
1992	28 249 954	*21 153 539*	*1 687 177*	*5 409 238*	*NO*	*NO*
1993	29 281 141	*22 278 448*	*1 554 173*	*5 448 521*	*NO*	*NO*
1994	24 910 480	*18 169 300*	*1 434 674*	*5 306 506*	*NO*	*NO*
1995	16 409 228	*9 509 657*	*856 087*	*6 043 485*	*NO*	*NO*
1996	15 666 583	*8 471 037*	*784 887*	*6 410 658*	*NO*	*NO*
1997	11 712 254	*4 700 381*	*731 517*	*6 280 357*	*NO*	*NO*
1998	5 541 521	*NO*	*745 085*	*4 796 436*	*NO*	*NO*
1999	6 154 002	*NO*	*890 043*	*5 263 959*	*NO*	*NO*
2000	7 316 063	*NO*	*801 144*	*6 514 918*	*NO*	*NO*
2001	7 195 723	*NO*	*711 971*	*6 483 752*	*NO*	*NO*
2002	7 041 351	*NO*	*625 678*	*6 415 673*	*NO*	*NO*
2003	6 714 648	*NO*	*294 180*	*6 420 468*	*NO*	*NO*
2004	8 964 376	*NO*	*471 286*	*8 493 090*	*NO*	*NO*
2005	7 979 291	*NO*	*365 351*	*7 613 940*	*NO*	*NO*
2006	9 059 791	*NO*	*417 175*	*8 642 616*	*NO*	*NO*
2007	8 993 333	*NO*	*277 768*	*8 715 566*	*NO*	*NO*
2008	8 717 402	*NO*	*167 699*	*8 549 703*	*NO*	*NO*
2009	5 694 240	*NO*	*49 870*	*5 644 370*	*NO*	*NO*
Trend 1990-2009	*-82.21%*	*NA*	*-93.58%*	*-18.56%*	*NA*	*NA*

Source: Environment Agency.

3.2.7.2.2.2 Methodological choices

The 2006 IPCC Guidelines Tier 1 approach has been applied for residual fuel oil and solid fuels except for blast furnace gas (recorded under solid fuels according to the 2006 IPCC Guidelines). For natural gas, gas oil, diesel oil and blast furnace gas, the methodological approach is classified as a Tier 2 methodology as country-specific emissions factor were used.

Special care was taken with solid fuels to avoid double counting with IPCC sub-category *2C1 - Iron and Steel Production*. As already stated (§ 3.2.7.2.2.1), the use of natural gas and BFG is 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.

3.2.7.2.2.3 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

(TÜV 1990) or were calculated from specific data accessible to the Environment Agency from the operator (Table 3–26).

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 of BFG composition (see also section 3.2.5.3). 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.[93] 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 3–26 gives an overview of the different emission factors used for 2009.

Table 3–26 – Emission factors for IPCC Sub-category 1A2a – Iron and Steel

1A2a Iron & Steel *Emission Factors for 2009 (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	73 470	CS	3.00	D	0.60	D	AEV 2006 IPCC GL
Diesel Oil	liquid	73 470	CS	4.15	D	28.60	D	AEV 2006 IPCC GL
Natural Gas	gaseous	57 056	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 – 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	204 087	4.13	0.59	75 884	3.24	6.54	57 755	1.00	0.10
1991	204 235	4.11	0.58	76 329	3.17	4.82	57 743	1.00	0.10
1992	204 137	4.11	0.58	76 718	3.11	3.33	57 848	1.00	0.10
1993	202 008	4.24	0.60	76 428	3.16	4.41	57 894	1.00	0.10
1994	201 498	4.27	0.61	76 335	3.17	4.72	57 940	1.00	0.10
1995	201 690	4.27	0.61	75 411	3.32	8.28	57 929	1.00	0.10
1996	199 816	4.37	0.62	75 030	3.38	9.79	57 546	1.00	0.10
1997	200 038	4.37	0.62	74 849	3.41	10.48	57 205	1.00	0.10
1998	NO	NO	NO	74 679	3.43	11.18	56 863	1.00	0.10
1999	NO	NO	NO	74 169	3.16	4.61	56 522	1.00	0.10
2000	NO	NO	NO	73 803	3.50	12.78	56 221	1.00	0.10
2001	NO	NO	NO	73 812	3.39	10.19	56 258	1.00	0.10
2002	NO	NO	NO	73 899	3.37	9.59	56 396	1.00	0.10
2003	NO	NO	NO	73 998	3.63	15.83	56 533	1.00	0.10
2004	NO	NO	NO	73 470	3.77	19.36	56 671	1.00	0.10
2005	NO	NO	NO	73 492	3.82	20.60	56 910	1.00	0.10
2006	NO	NO	NO	73 483	3.93	23.18	57 008	1.00	0.10
2007	NO	NO	NO	73 482	3.84	21.00	56 793	1.00	0.10
2008	NO	NO	NO	73 501	4.00	24.84	56 665	1.00	0.10
2009	NO	NO	NO	73 470	4.07	26.76	57 056	1.00	0.10

Source: Environment Agency.

3.2.7.3 Non-Ferrous Metals (1A2b)

3.2.7.3.1 Source category description

In Luxembourg, non-ferrous metals activities cover basically secondary aluminium production from aluminium scrap.

In 2009, fuel combustion due to non-ferrous metal processing or production was responsible for 0.44% of GHG emissions from fuel combustion activities (0.27% in 1990) and represented 0.37% of the total GHG emissions in CO_2e, excluding LULUCF (0.22% in 1990).

Fuel combustion from non-ferrous metal processing or production is not a key category.

3.2.7.3.2 Methological issues

3.2.7.3.2.1 Activity data

Liquefied petroleum gas (*LPG*) was an important fuel used in the secondary aluminium production. It was 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 3–28.

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 national statistics as no such data is reported for this category. Due to confidentiality reasons, this data is reported under the iron & steel industry by national statistics. However, to avoid double counting, the bottom-up data was subtracted from the top-down data from official statistics reported for IPCC sub-category *1A2a - Iron and Steel*.

Table 3–28 - Activity data for IPCC sub-category 1A2b - Non-Ferrous Metals: 1990-2009

1A2b - Non-Ferrous Metals *Activity Data by fuel type (GJ)*						
Year	**Activity Total**	**Solid**	**Liquid** *LPG*	**Gaseous** *Natural Gas*	**Biomass**	**Other**
1990	462 005	*NO*	*230 000*	*232 005*	*NO*	*NO*
1991	480 174	*NO*	*230 000*	*250 174*	*NO*	*NO*
1992	484 471	*NO*	*230 000*	*254 471*	*NO*	*NO*
1993	474 992	*NO*	*230 000*	*244 992*	*NO*	*NO*
1994	574 091	*NO*	*307 372*	*266 719*	*NO*	*NO*
1995	593 787	*NO*	*314 594*	*279 193*	*NO*	*NO*
1996	983 700	*NO*	*314 594*	*669 106*	*NO*	*NO*
1997	724 596	*NO*	*56 951*	*667 645*	*NO*	*NO*
1998	757 076	*NO*	*87 447*	*669 629*	*NO*	*NO*
1999	740 541	*NO*	*86 796*	*653 745*	*NO*	*NO*
2000	722 935	*NO*	*88 251*	*634 683*	*NO*	*NO*
2001	733 199	*NO*	*86 796*	*646 403*	*NO*	*NO*
2002	715 027	*NO*	*NO*	*715 027*	*NO*	*NO*
2003	816 432	*NO*	*NO*	*816 432*	*NO*	*NO*
2004	928 110	*NO*	*NO*	*928 110*	*NO*	*NO*
2005	900 989	*NO*	*NO*	*900 989*	*NO*	*NO*
2006	989 225	*NO*	*NO*	*989 225*	*NO*	*NO*
2007	929 759	*NO*	*NO*	*929 759*	*NO*	*NO*
2008	905 641	*NO*	*NO*	*905 641*	*NO*	*NO*
2009	787 899	*NO*	*NO*	*787 899*	*NO*	*NO*
Trend 1990-2009	*70.54%*	*NA*	*NA*	*239.60%*	*NA*	*NA*

Source: Environment Agency.

3.2.7.3.2.2 Methodological choices

The 2006 IPCC Guidelines Tier 2 approach has been applied for liquid (LPG) and gaseous fuels (natural gas).

3.2.7.3.2.3 Emission factors

Country-specific EFs for CO_2 from LPG and natural gas were used. Default EFs from the 2006 IPCC Guidelines have been applied for CH_4 and N_2O (Table 3–29).

Table 3–29 – Emission factors for Sub-category 1A2b – Non-Ferrous Metals

1A2b - Non-Ferrous Metals *Emission Factors for 2009 (kg/TJ)*								
Fuel	**Fuel Type**	***CO_2***		***CH_4***		***N_2O***		***Source***
		EF	***type***	***EF***	***type***	***EF***	***type***	
LPG	liquid	*62 653*	*CS*	*1.00*	*D*	*0.10*	*D*	*AEV* *2006 IPCC GL*
Natural Gas	gaseous	*57 056*	*CS*	*1.00*	*D*	*0.10*	*D*	*AEV* *2006 IPCC GL*

Source: Environment Agency.

3.2.7.4 Chemicals (1A2c)

3.2.7.4.1 Source category description

In Luxembourg, chemical activities cover mainly the production of tyres, 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 industry for heat and electricity production (autoproducers).

In 2009, fuel combustion from the chemical industry was responsible for 1.3% of GHG emissions from fuel combustion activities (1.7% in 1990) and represented 1.1% of the total GHG emissions in CO_2e, excluding LULUCF (1.4% in 1990).

With regard to CO_2 emissions, combustion in *1A2c – Chemicals* is a key category. It has been a key category for gaseous fuels for 1992, and between 1994 and 2009 and for liquid fuels between 1990 and 1997.

3.2.7.4.2 Methodological issues

3.2.7.4.2.1 Activity data

Annual fuel consumption data of residual fuel oil, gas oil, 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, between 1990 and 1999, could not be matched to the top-down data from national statistics as no such data is reported for this category. To avoid double counting, the bottom-up data for this period was subtracted from the top-down data from official statistics reported for IPCC subcategory *1A2f - Other* (category Non-Specified Industry in the IEA Joint Questionnaires). For natural gas (2000-2009) and 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 by national statistics. Activity data for the chemical industry are listed in Table 3–30.

Fluctuations in activity data may occur, due to temporal shut-down of installations (e.g. for maintenance). This may then be reflected in the activity data by a sharp decrease as happened in 2007 in comparison to the year 2006: a decrease of about 9% occurred due to maintenance on one of the gas turbines operated by the chemical industry.[103] The downwards trend in the years 2008 and 2009 is explained by the global economic downturn due to the financial crisis.

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103 ARR 2009, § 61.

Table 3–30- Activity data for IPCC sub-category 1A2c - Chemicals: 1990-2009

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	2 570 754	*NO*	*1 576 031*	*994 723*	*NO*	*NO*
1991	2 697 255	*NO*	*2 109 986*	*587 269*	*NO*	*NO*
1992	2 653 980	*NO*	*1 587 701*	*1 066 279*	*NO*	*NO*
1993	2 731 382	*NO*	*1 729 118*	*1 002 264*	*NO*	*NO*
1994	3 079 696	*NO*	*1 605 240*	*1 474 456*	*NO*	*NO*
1995	3 240 983	*NO*	*1 040 314*	*2 200 668*	*NO*	*NO*
1996	3 326 788	*NO*	*1 065 442*	*2 261 347*	*NO*	*NO*
1997	3 234 243	*NO*	*669 892*	*2 564 350*	*NO*	*NO*
1998	3 346 868	*NO*	*209 173*	*3 137 695*	*NO*	*NO*
1999	3 180 654	*NO*	*169 370*	*3 011 284*	*NO*	*NO*
2000	3 421 566	*NO*	*370 031*	*3 051 534*	*NO*	*NO*
2001	3 601 548	*NO*	*378 846*	*3 222 702*	*NO*	*NO*
2002	3 530 060	*NO*	*344 323*	*3 185 737*	*NO*	*NO*
2003	3 739 714	*NO*	*347 436*	*3 392 277*	*NO*	*NO*
2004	3 937 951	*NO*	*408 099*	*3 529 852*	*NO*	*NO*
2005	3 835 571	*NO*	*375 863*	*3 459 708*	*NO*	*NO*
2006	3 725 392	*NO*	*220 197*	*3 505 195*	*NO*	*NO*
2007	3 336 854	*NO*	*148 971*	*3 187 883*	*NO*	*NO*
2008	3 210 020	*NO*	*78 355*	*3 131 665*	*NO*	*NO*
2009	2 369 638	*NO*	*33 300*	*2 336 338*	*NO*	*NO*
Trend 1990-2009	*-7.82%*	*NA*	*-97.89%*	*134.87%*	*NA*	*NA*

Source: Environment Agency.

3.2.7.4.2.2 Methodological issues

The 2006 IPCC Guidelines Tier 1 approach has been applied for residual fuel oil, whereas the 2006 IPCC Guidelines Tier 2 approach was applied for, gas oil, diesel oil and natural gas.

3.2.7.4.2.3 Emission factors

The 2006 IPCC Guidelines default EFs have been applied for CO_2 for residual fuel oil, whereas for gas oil, diesel oil, natural gas country-specific EFs were used. Default EFs have been applied for CH_4 and N_2O (Table 3–31).

Table 3–31 – Emission factors for Sub-category 1A2c – Chemicals

1A2c - Chemicals *Emission Factors for 2009 (kg/TJ)*								
Fuel	Fuel Type	CO_2 EF	CO_2 type	CH_4 EF	CH_4 type	N_2O EF	N_2O type	Source
Residual Fuel Oil	liquid	*77 400*	*D*	*3.00*	*D*	*0.60*	*D*	*2006 IPCC GL*
Gas Oil	liquid	*73 470*	*CS*	*3.00*	*D*	*0.60*	*D*	*AEV 2006 IPCC GL*
Diesel Oil	liquid	*73 470*	*CS*	*4.15*	*D*	*28.60*	*D*	*AEV 2006 IPCC GL*
Natural Gas	gaseous	*57 056*	*CS*	*1.00*	*D*	*0.10*	*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 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	76 619	3.08	2.64	57 755	1.00	0.10
1991	76 792	3.07	2.38	57 743	1.00	0.10
1992	76 596	3.10	2.96	57 848	1.00	0.10
1993	76 699	3.09	2.77	57 894	1.00	0.10
1994	76 649	3.08	2.60	57 940	1.00	0.10
1995	76 044	3.19	5.23	57 929	1.00	0.10
1996	75 936	3.21	5.61	57 546	1.00	0.10
1997	75 532	3.26	7.00	57 205	1.00	0.10
1998	74 416	3.42	10.84	56 863	1.00	0.10
1999	74 574	3.29	7.63	56 522	1.00	0.10
2000	73 660	3.46	11.76	56 221	1.00	0.10
2001	73 605	3.37	9.62	56 258	1.00	0.10
2002	73 628	3.40	10.42	56 396	1.00	0.10
2003	73 770	3.58	14.71	56 533	1.00	0.10
2004	73 792	3.59	14.89	56 671	1.00	0.10
2005	73 816	3.61	15.53	56 910	1.00	0.10
2006	73 865	3.71	17.94	57 008	1.00	0.10
2007	73 778	3.55	13.98	56 793	1.00	0.10
2008	73 929	3.82	20.59	56 665	1.00	0.10
2009	74 004	3.97	24.33	57 056	1.00	0.10

Source: Environment Agency.

3.2.7.5 Pulp, Paper and Print (1A2d)

3.2.7.5.1 Source category description

In Luxembourg, this source category only covers the printing industry. No pulp nor paper production occurs in Luxembourg. Included in this sub-category are the emissions from combustion plants (<50 MW) and from mobile sources and machinery operated by the printing industry.

In 2009, fuel combustion from the, paper and print industry was responsible for 0.16% of GHG emissions from fuel combustion activities and represented 0.13% of the total GHG emissions in CO_2e, excluding LULUCF.

Fuel combustion from *1A2d - Pulp, Paper and Print* is not a key category.

3.2.7.5.2 Methodological issues

3.2.7.5.2.1 Activity data

Annual fuel consumption data for gas oil, diesel oil and natural gas were derived from national statistics for the period 2000-2009. Diesel oil is mainly used by mobile sources and machinery, whereas the remaining fuels are mainly combusted in stationary units. For 1990-1999, no activity data is available from national statistics, hence the notation key IE was used in the CRF tables. For these years the data is included in IPCC subcategory *1A2f-Other*.

Activity data for the pulp, paper and print industry are listed in Table 3–36.

Table 3–33- Activity data for IPCC sub-category 1A2d - Pulp, Paper and Print: 1990-2009

1A2d - Pulp, Paper & Print *Activity Data by fuel type (GJ)*						
Year	**Activity Total**	**Solid**	**Liquid** *Gas Oil, Diesel Oil*	**Gaseous** *Natural Gas*	**Biomass**	**Other**
1990	IE	*NO*	*IE*	*IE*	*NO*	*NO*
1991	IE	*NO*	*IE*	*IE*	*NO*	*NO*
1992	IE	*NO*	*IE*	*IE*	*NO*	*NO*
1993	IE	*NO*	*IE*	*IE*	*NO*	*NO*
1994	IE	*NO*	*IE*	*IE*	*NO*	*NO*
1995	IE	*NO*	*IE*	*IE*	*NO*	*NO*
1996	IE	*NO*	*IE*	*IE*	*NO*	*NO*
1997	IE	*NO*	*IE*	*IE*	*NO*	*NO*
1998	IE	*NO*	*IE*	*IE*	*NO*	*NO*
1999	IE	*NO*	*IE*	*IE*	*NO*	*NO*
2000	331 691	*NO*	*67 091*	*264 600*	*NO*	*NO*
2001	183 921	*NO*	*75 921*	*108 000*	*NO*	*NO*
2002	261 437	*NO*	*75 137*	*186 300*	*NO*	*NO*
2003	629 937	*NO*	*56 637*	*573 300*	*NO*	*NO*
2004	587 702	*NO*	*72 002*	*515 700*	*NO*	*NO*
2005	468 153	*NO*	*64 951*	*403 201*	*NO*	*NO*
2006	274 371	*NO*	*48 470*	*225 901*	*NO*	*NO*
2007	205 867	*NO*	*25 866*	*180 000*	*NO*	*NO*
2008	228 252	*NO*	*18 553*	*209 699*	*NO*	*NO*
2009	279 451	*NO*	*8 552*	*270 899*	*NO*	*NO*
Trend 1990-2009	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

Source: Environment Agency.

3.2.7.5.2.2 Methodological choices

The 2006 IPCC Guidelines Tier 2 approach was applied for gas oil, diesel oil and natural gas.

3.2.7.5.2.3 Emission factors

Country-specific CO_2 EFs were used for gasoil, diesel oil natural gas, whereas 2006 IPCC default EFs have been applied for CH_4 and N_2O (Table 3–37).

Table 3–34 – Emission factors for Sub-category 1A2d - Pulp, Paper and Print

1A2d - Pulp, Paper & Print *Emission Factors for 2009 (kg/TJ)*								
Fuel	**Fuel Type**	***CO_2***		***CH_4***		***N_2O***		***Source***
		EF	***type***	***EF***	***type***	***EF***	***type***	
Gas Oil	liquid	*73 470*	*CS*	*3.00*	*D*	*0.60*	*D*	*AEV* *2006 IPCC GL*
Diesel Oil	liquid	*73 470*	*CS*	*4.15*	*D*	*28.60*	*D*	*AEV* *2006 IPCC GL*
Natural Gas	gaseous	*57 056*	*CS*	*1.00*	*D*	*0.10*	*D*	*AEV* *2006 IPCC GL*

Source: Environment Agency

Table 3–38 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3–35 – Implied emission factors for Sub-category 1A2d - Pulp, Paper and Print

Year	Liquid CO_2	Liquid CH_4	Liquid N_2O	Gaseous CO_2	Gaseous CH_4	Gaseous N_2O
1990	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA	NA
1996	NA	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	NA	NA
2000	73 879	3.80	20.12	56 221	1.00	0.10
2001	73 810	3.69	17.48	56 258	1.00	0.10
2002	73 802	3.68	17.11	56 396	1.00	0.10
2003	73 886	3.78	19.61	56 533	1.00	0.10
2004	73 919	3.82	20.53	56 671	1.00	0.10
2005	73 960	3.89	22.17	56 910	1.00	0.10
2006	74 015	3.99	24.75	57 008	1.00	0.10
2007	73 978	3.92	23.09	56 793	1.00	0.10
2008	74 046	4.05	26.09	56 665	1.00	0.10
2009	74 076	4.11	27.53	57 056	1.00	0.10

1A2d - Pulp, Paper & Print — *Implied Emission Factors (kg/TJ)*

Source: Environment Agency

3.2.7.6 Food Processing, Beverages and Tobacco (1A2e)

3.2.7.6.1 Source category description

In Luxembourg, this source category covers 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.

In 2009, fuel combustion from the food processing, beverages and tobacco industry was responsible for 0.17% of GHG emissions from fuel combustion activities (0.16% in 1990) and represented 0.14% of the total GHG emissions in CO_2e, excluding LULUCF (0.13% in 1990).

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

3.2.7.6.2 Methodological issues

3.2.7.6.2.1 Activity data

Annual fuel consumption data of residual fuel oil, gas oil, 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, for 1990-1999, could not be matched to the top-down data from nationall 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 national statistics reported for IPCC sub-category *1A2f - Other* (category Non-Specified Industry in the IEA Joint Questionnaires). For natural gas (2000-2009) and 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 national statistics. Activity data for the food processing, beverages and tobacco industry are listed in Table 3–36.

Table 3–36- Activity data for IPCC sub-category 1A2e - Food Processing, Beverages and Tobacco: 1990-2009

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	231 128	*NO*	*165 316*	*65 812*	*NO*	*NO*
1991	345 782	*NO*	*250 327*	*95 455*	*NO*	*NO*
1992	310 308	*NO*	*209 840*	*100 468*	*NO*	*NO*
1993	223 719	*NO*	*124 988*	*98 731*	*NO*	*NO*
1994	310 796	*NO*	*210 062*	*100 734*	*NO*	*NO*
1995	314 215	*NO*	*209 846*	*104 369*	*NO*	*NO*
1996	270 421	*NO*	*167 257*	*103 164*	*NO*	*NO*
1997	326 203	*NO*	*219 735*	*106 468*	*NO*	*NO*
1998	292 346	*NO*	*181 469*	*110 877*	*NO*	*NO*
1999	309 453	*NO*	*213 353*	*96 100*	*NO*	*NO*
2000	616 307	*NO*	*292 307*	*324 000*	*NO*	*NO*
2001	405 214	*NO*	*288 806*	*116 408*	*NO*	*NO*
2002	458 977	*NO*	*270 877*	*188 100*	*NO*	*NO*
2003	372 052	*NO*	*165 052*	*207 000*	*NO*	*NO*
2004	404 158	*NO*	*207 958*	*196 200*	*NO*	*NO*
2005	388 745	*NO*	*215 945*	*172 801*	*NO*	*NO*
2006	306 298	*NO*	*159 086*	*147 211*	*NO*	*NO*
2007	252 219	*NO*	*103 550*	*148 668*	*NO*	*NO*
2008	225 402	*NO*	*77 249*	*148 153*	*NO*	*NO*
2009	272 760	*NO*	*88 261*	*184 499*	*NO*	*NO*
Trend 1990-2009	*18.01%*	*NA*	*-46.61%*	*180.34%*	*NA*	*NA*

Source: Environment Agency.

3.2.7.6.2.2 Methodological choices

The 2006 IPCC Guidelines Tier 1 approach has been applied for residual fuel oil whereas the 2006 IPCC Guidelines Tier 2 approach was applied for gas oil, diesel oil and natural gas.

3.2.7.6.2.3 Emission factors

The 2006 IPCC Guidelines default EFs have been applied for CO_2 from residual fuel oil, whereas for gasoil, diesel oil natural gas, country specific EFs were used. Default EFs have been applied for CH_4 and N_2O (Table 3–37).

Table 3–37 – Emission factors for Sub-category 1A2e – Food Processing, Beverages and Tobacco

1A2e - Food Processing, Beverages & Tobacco *Emission Factors for 2009 (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	73 470	CS	3.00	D	0.60	D	AEV 2006 IPCC GL
Diesel Oil	liquid	73 470	CS	4.15	D	28.60	D	AEV 2006 IPCC GL
Natural Gas	gaseous	57 056	CS	1.00	D	0.10	D	AEV 2006 IPCC GL

Source: Environment Agency

Table 3–38 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3–38 – 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	75 365	3.38	9.78	57 755	1.00	0.10
1991	74 732	3.50	12.71	57 743	1.00	0.10
1992	74 268	3.59	15.01	57 848	1.00	0.10
1993	74 715	3.50	12.70	57 894	1.00	0.10
1994	74 167	3.59	15.00	57 940	1.00	0.10
1995	74 155	3.59	15.02	57 929	1.00	0.10
1996	74 367	3.56	14.13	57 546	1.00	0.10
1997	73 540	3.71	17.82	57 205	1.00	0.10
1998	73 676	3.68	17.27	56 863	1.00	0.10
1999	73 435	3.46	11.76	56 522	1.00	0.10
2000	73 380	3.76	19.07	56 221	1.00	0.10
2001	73 372	3.65	16.47	56 258	1.00	0.10
2002	73 374	3.63	16.05	56 396	1.00	0.10
2003	73 435	3.70	17.59	56 533	1.00	0.10
2004	73 470	3.76	19.16	56 671	1.00	0.10
2005	73 492	3.83	20.77	56 910	1.00	0.10
2006	73 483	3.94	23.41	57 008	1.00	0.10
2007	73 482	3.85	21.23	56 793	1.00	0.10
2008	73 501	3.84	21.14	56 665	1.00	0.10
2009	73 470	3.46	11.73	57 056	1.00	0.10

Source: Environment Agency

3.2.7.7 Other (1A2f)

3.2.7.7.1 Source category description

Source category *1A2f – Other* covers all the remaining industrial activities not previously mentioned.

In 2009, fuel combustion emissions reported under *1A2f - Other* manufacturing industries and construction were responsible for 6.0% of GHG emissions from fuel combustion activities (this share was 6.3% in 1990) and represented 5.0% of the total GHG emissions in CO_2e, excluding LULUCF (5.0% in 1990).

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 fuels – without interruption since 1990, and for other solid fuels from 2001-2006.

3.2.7.7.2 Methodological issues

3.2.7.7.2.1 Activity data

Under other manufacturing industries and construction, the following activities have been considered (Table 3–39):

Table 3–39 – Combustion activities included in 1A2f - Other

Description	SNAP code
Combustion plants < 50 MW	030103
Gas Turbines	030104
Cement (Clinker)	030311
Asphalt concrete plants	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 kind 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 is taken into consideration when estimating the emissions. The consumption data of these fuels are transmitted annually to the Environment Agency by the operator.

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 in the past, 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 was closed down in 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 national statistics (STATEC).

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 from 1990-1999) was then matched with the top-down data from national statistics (STATEC). 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 3–40 and Table 3–41.

Table 3–40 – Activity data by fuel type of IPCC Sub-category 1A2f – Other: 1990-2009

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	8 526 861	3 508 728	1 122 570	3 895 562	NO	NO
1991	9 965 260	3 228 615	1 232 389	5 504 257	NO	NO
1992	11 111 676	3 622 510	1 577 910	5 911 256	NO	NO
1993	10 721 289	3 011 902	1 432 137	6 277 251	NO	NO
1994	11 801 933	4 161 046	1 461 741	6 179 147	NO	NO
1995	10 519 642	3 160 692	1 411 184	5 947 765	NO	NO
1996	11 098 010	3 558 907	1 445 452	6 093 651	NO	NO
1997	11 989 591	3 111 167	1 736 899	7 141 525	NO	NO
1998	11 777 885	2 858 064	2 061 549	6 858 272	NO	179 572
1999	13 145 196	3 037 234	2 539 992	7 567 971	NO	175 064
2000	12 264 637	3 360 272	2 595 648	6 308 717	NO	268 442
2001	11 579 777	3 288 849	2 456 240	5 834 688	NO	583 715
2002	10 205 203	2 231 529	2 301 420	5 672 254	13 783	688 646
2003	12 292 380	1 939 682	4 298 759	6 053 939	41 709	626 431
2004	13 006 571	2 218 787	4 831 108	5 956 676	86 405	674 388
2005	12 526 599	2 335 518	4 304 569	5 886 512	976 529	722 346
2006	12 071 587	2 714 635	3 846 578	5 510 373	942 055	756 579
2007	10 236 721	2 131 648	2 582 537	5 522 536	1 231 212	572 010
2008	8 900 407	1 945 021	1 897 158	5 058 228	1 250 238	649 169
2009	8 233 027	2 200 120	1 040 568	4 992 339	973 574	433 991
Trend 1990-2009	-3.45%	-37.30%	-7.30%	28.15%	NA	NA

Source: Environment Agency

Table 3–41 – Activity data by fuel type and source categories of IPCC Sub-category 1A2f – Other: 1990-2009

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	8 529 548	3 302 589	187 680	3 612 175	NO	NO	NO	NO	NO	NO	198 557	553 951	NO	7 583	383 626	283 387
1991	9 968 500	3 028 845	348 686	3 119 032	NO	NO	NO	NO	NO	NO	193 628	212 805	NO	6 141	674 139	2 385 225
1992	11 115 253	3 404 630	438 661	3 107 842	NO	84 955	NO	NO	NO	NO	211 766	254 864	NO	6 114	803 008	2 803 414
1993	10 724 936	2 850 457	462 266	3 157 476	NO	84 987	NO	NO	NO	NO	154 556	339 946	NO	6 889	548 585	3 119 774
1994	11 805 580	3 840 609	536 518	3 275 872	NO	84 976	NO	NO	NO	NO	313 575	382 390	NO	6 862	461 505	2 903 275
1995	10 523 133	3 000 573	532 727	3 372 564	NO	84 985	NO	NO	NO	NO	153 180	339 942	NO	6 939	457 021	2 575 201
1996	11 101 661	3 303 931	520 981	3 408 405	NO	84 772	NO	NO	NO	NO	248 862	296 703	NO	6 114	546 646	2 685 246
1997	11 993 526	2 886 032	569 896	3 306 618	NO	85 003	NO	NO	NO	NO	221 023	340 012	NO	4 112	745 923	3 834 907
1998	11 961 704	2 853 690	517 921	2 949 911	NO	84 992	NO	NO	16 837	1 060 321	177 644	552 449	NO	6 301	893 597	2 848 040
1999	13 362 773	2 994 191	498 366	3 449 122	NO	85 025	NO	NO	291	1 085 333	213 941	510 152	NO	4 165	1 488 671	3 033 516
2000	11 208 279	3 396 337	220 026	3 645 901	NO	112 788	NO	NO	295	1 137 316	232 377	1 273 776	137 700	NO	988 763	63 000
2001	11 132 092	3 703 606	186 993	3 653 100	NO	125 369	NO	NO	13 756	1 073 688	168 958	1 181 474	51 300	NO	948 646	25 200
2002	9 771 832	2 795 754	163 331	3 532 500	NO	114 746	NO	NO	17 591	868 054	138 204	1 157 914	92 700	NO	847 839	43 200
2003	11 893 120	2 461 930	107 731	3 741 300	NO	58 759	NO	NO	17 591	894 239	145 892	3 233 893	189 000	NO	880 785	162 000
2004	12 723 364	2 831 670	134 313	3 567 600	NO	80 399	NO	NO	18 955	1 034 576	147 911	3 748 574	126 000	NO	848 866	184 500
2005	12 235 769	2 964 573	103 182	3 563 112	NO	70 723	NO	NO	15 748	1 003 096	144 819	3 351 164	97 200	NO	763 751	158 401
2006	11 970 917	3 419 439	88 695	3 286 321	NO	74 186	NO	NO	14 826	1 110 833	136 831	3 053 528	70 115	NO	615 342	100 800
2007	10 064 441	2 874 457	78 676	3 372 178	NO	50 076	NO	NO	15 635	899 984	142 414	1 859 017	61 486	NO	579 133	131 386
2008	8 881 120	2 724 763	65 399	3 340 782	NO	35 964	NO	NO	15 078	593 353	139 665	1 426 055	67 500	NO	354 663	117 899
2009	8 096 296	2 695 772	40 388	3 314 606	NO	19 378	NO	NO	17 591	640 038	156 912	675 616	116 099	NO	287 595	132 299
Trend 1990-2009	-5.08%	-18.37%	-78.48%	-8.24%	NA	NA	NA	NA	NA	NA	-20.97%	21.96%	NA	NA	-25.03%	-53.31%

Source: Environment Agency

3.2.7.7.2.2 Methodological choices

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

3.2.7.7.2.3 Emission factors

The 2006 IPCC Guidelines default CO_2 EFs have been applied for residual fuel oil and for solid fuels except for tires and fluff, where plant-specific emission factors were used. For natural gas, gas oil, diesel oil and LPG country specific EFs were used. IPCC default EFs have been applied for CH_4 and N_2O (Table 3–42).

Table 3–42 – Emission factors for IPCC Sub-category 1A2f – Other

1A2f - Other
Emission Factors for 2009 (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	73 470	CS	3.00	D	0.60	D	AEV 2006 IPCC GL
Diesel Oil	liquid	73 470	CS	4.15	D	28.60	D	AEV 2006 IPCC GL
Gasoline	liquid	68 890	CS	50.00	D	2.00	D	AEV 2006 IPCC GL
LPG	liquid	62 653	CS	1.00	D	0.10	D	AEV 2006 IPCC GL
Natural Gas	gaseous	57 056	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
Tires	other/biomass	88 000	PS	30.00	D	4.00	D	ETS 2006 IPCC GL
Fluff	other/biomass	73 790	PS	30.00	D	4.00	D	ETS 2006 IPCC GL

Source: Environment Agency

Table 3–43 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3–43 – Implied emission factors for Sub-category 1A2f – Other

1A2f - Other *Implied Emission Factors (kg/TJ)*															
Year	Solid			Liquid			Gaseous			Biomass			Other		
	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	94 764	10.00	1.50	71 832	3.40	18.51	57 755	1.00	0.10	NO	NO	NO	NO	NO	NO
1991	94 774	10.00	1.50	73 197	3.43	14.69	57 743	1.00	0.10	NO	NO	NO	NO	NO	NO
1992	94 770	10.00	1.50	72 873	3.39	15.53	57 848	1.00	0.10	NO	NO	NO	NO	NO	NO
1993	94 749	10.00	1.50	72 841	3.41	15.86	57 894	1.00	0.10	NO	NO	NO	NO	NO	NO
1994	94 819	10.00	1.50	73 005	3.41	15.49	57 940	1.00	0.10	NO	NO	NO	NO	NO	NO
1995	94 741	10.00	1.50	72 994	4.79	14.24	57 929	1.00	0.10	NO	NO	NO	NO	NO	NO
1996	94 803	10.00	1.50	72 750	6.20	14.70	57 546	1.00	0.10	NO	NO	NO	NO	NO	NO
1997	94 806	10.00	1.50	72 464	5.74	15.53	57 205	1.00	0.10	NO	NO	NO	NO	NO	NO
1998	94 780	10.00	1.50	71 945	5.35	16.75	56 863	1.00	0.10	NO	NO	NO	88 000	30.00	4.00
1999	94 804	10.00	1.50	71 150	4.74	14.13	56 522	1.00	0.10	NO	NO	NO	88 000	30.00	4.00
2000	94 801	10.00	1.50	71 376	4.89	19.00	56 221	1.00	0.10	NO	NO	NO	88 000	30.00	4.00
2001	94 749	10.00	1.50	71 507	4.97	18.22	56 258	1.00	0.10	NO	NO	NO	88 000	30.00	4.00
2002	94 780	10.00	1.50	71 472	4.19	18.50	56 396	1.00	0.10	100 000	30.00	4.00	88 000	30.00	4.00
2003	94 818	10.00	1.50	72 267	4.07	21.29	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	72 645	4.15	22.82	56 671	1.00	0.10	100 000	30.00	4.00	88 000	30.00	4.00
2005	94 780	10.00	1.50	72 633	4.22	23.34	56 910	1.00	0.10	111 367	30.00	4.00	88 000	30.00	4.00
2006	94 746	10.00	1.50	72 776	4.35	24.36	57 008	1.00	0.10	110 580	30.00	4.00	87 821	30.00	4.00
2007	94 794	10.00	1.50	72 180	4.41	22.05	56 793	1.00	0.10	106 436	30.00	4.00	86 870	30.00	4.00
2008	94 808	10.00	1.50	72 046	3.65	23.43	56 665	1.00	0.10	107 083	30.00	4.00	85 796	30.00	4.00
2009	94 807	10.00	1.50	72 444	3.56	20.95	57 056	1.00	0.10	107 742	30.00	4.00	82 596	30.00	4.00

Source: Environment Agency

3.2.7.8 Uncertainties and time-series consistency

For uncertainties on activity data and emission factors, please refer to section 1.7.

Generally, the time-series, as reported in category *1A2 - Manufacturing Industries and Construction* are considered to be consistent. Between 2008 and 2009, a relatively sharp decrease of emissions is observed, especially in sub-categories 1A2a, 1A2b, 1A2c and to a minor extent in 1A2f, which is due to the economic crisis. Indeed, in a small country like Luxembourg, this can be quite significant, as many of these sub-categories, only include one or two companies. During 2009, many of the manufacturing industries only worked short-time which was financially supported Luxembourg's Government.

However, at a deeper level, and especially for categories 1A2d and 1A2f, time series seem to be less consistent. This is either due to the lack of specific activity data (for example for 1A2d, no category-specific AD is available for the years 1990-1999, so that notation key *IE* is used, and the corresponding emissions are reported under 1A2f), or due to the industrial composition of sub-category. This is especially true for sub-category 1A2f, which is dominated by the cement and flat glass industry (3 plants) and to a minor extent by asphalt concrete plants (3 plants). Fluctuations in fuel consumption can occur due to short-term switches in the energy mix (rotation of gasoil stocks), maintenance stops, closure or start-up of new facilities, etc.[104]

3.2.7.9 Source-specific QA/QC and verification

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

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104 ARR 2010, §40

been compiled and enables the Single National Entity to quickly cross-check this data with the EU-ETS data. 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.

3.2.7.10 Source-specific recalculations

Table 3–44 presents the main revisions and recalculations done since submission 2010v2.1 and relevant to IPCC sub-category *1A2 - Manufacturing Industries and Construction*.

Table 3–44 – Recalculations done since submission 2010v2.1

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
1A2	Fuel consumption data for all fuels was revised due to revised energy balance and updated fuel properties (densities, NCVs) from national statistics	updated AD, NCVs, densities
1A2a	reallocation of emissions of a power plant operated by the iron and steel industry from 1A1a to 1A2a.[105]	reallocation
1A2d	New category: AD (2000-2009) for gaseous and liquid fuels was derived from the revised energy balance from national statistics. Notation key IE is used for the years 1990-1999, as no data on fuel consumption for this category is available. It is assumed that the consumption is included in 1A2f by the energy balance. In the previous submissions the notation key NO was used, as previous energy balances did not declare a consumption in this category.	reallocation
1A2f	Emissions from wood & wood waste burning with energy recovery are considered, due to revised energy balance from national statistics.	added wood burning
1A2b, 1A2f	Some plant-specific AD (fuel consumption data fro the years 2007 and 2008) was updated, due to revised annual reports.	updated AD

3.2.7.11 Source-specific 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 1A2 – Manufacturing Industries and Construction

GHG source & sink category	Planned improvement
1A2 – Manufacturing Industries and Construction	Reallocate emissions from off-road vehicles and other machinery from the respective subcategories 1A2a – 1A2e to category 1A2f - Other[106]
1A2b – Non-Ferrous Metals	Include other non-ferrous activities if relevant (copper processing and production from copper scrap) which are now included in 1A2f.

105 ARR 2010, §38

106 ARR 2009, § 62

3.2.8 Transport (1A3)

3.2.8.1 Source category description

This section describes GHG emissions resulting from fuel combustion activities in the transport sector.

The 2011 GHG inventory includes emissions from IPCC Sub-categories *1A3a – Civil Aviation*, *1A3b – Road Transportation*, *1A2c – Railways* and *1A2d– Navigation*. Submission 2011v1.3 does not record any GHG emissions for the IPCC Sub-category *1A2e – Other Transportation*.

In 2009, this source category was responsible for a bit more than 59.3% of GHG emissions from fuel combustion activities (this share was only 25.6% in 1990) and represented 49.6% of the total GHG emissions in CO_2e, excluding LULUCF (coming from 20.6% in 1990).

Table 3–46 summarizes GHG emissions for IPCC Sub-category 1A3.

Table 3–46 – GHG emission trends in CO_2e for IPCC Sub-category 1A3 – Transport: 1990-2009

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*	2 615.02	*2 574.09*	*0.83*	*0.08*	27.58	*24.58*	*0.0014*	*0.0096*
1991	0.33	*0.32*	*0.000002*	*0.000009*	3 111.22	*3 063.29*	*0.98*	*0.09*	27.59	*24.59*	*0.0014*	*0.0096*
1992	0.46	*0.46*	*0.000003*	*0.000013*	3 419.48	*3 361.70*	*0.97*	*0.12*	27.61	*24.61*	*0.0014*	*0.0096*
1993	0.60	*0.59*	*0.000004*	*0.000017*	3 464.18	*3 400.62*	*0.87*	*0.15*	27.58	*24.58*	*0.0014*	*0.0096*
1994	0.70	*0.70*	*0.000005*	*0.000020*	3 523.60	*3 455.50*	*0.86*	*0.16*	26.76	*23.85*	*0.0013*	*0.0093*
1995	0.76	*0.75*	*0.000005*	*0.000022*	3 346.54	*3 280.25*	*0.76*	*0.16*	21.66	*19.31*	*0.0011*	*0.0075*
1996	0.77	*0.77*	*0.000006*	*0.000022*	3 444.10	*3 375.38*	*0.79*	*0.17*	24.21	*21.58*	*0.0012*	*0.0084*
1997	0.79	*0.78*	*0.000006*	*0.000022*	3 644.89	*3 572.72*	*0.72*	*0.18*	23.80	*21.21*	*0.0012*	*0.0083*
1998	0.68	*0.67*	*0.000005*	*0.000019*	3 808.87	*3 737.09*	*0.69*	*0.18*	23.81	*21.22*	*0.0012*	*0.0083*
1999	0.69	*0.69*	*0.000005*	*0.000020*	4 102.03	*4 028.58*	*0.69*	*0.19*	23.81	*21.22*	*0.0012*	*0.0083*
2000	0.66	*0.65*	*0.000005*	*0.000019*	4 651.16	*4 573.38*	*0.70*	*0.20*	23.54	*20.98*	*0.0012*	*0.0082*
2001	0.65	*0.65*	*0.000005*	*0.000019*	4 912.97	*4 835.24*	*0.67*	*0.21*	25.37	*22.61*	*0.0013*	*0.0088*
2002	0.61	*0.60*	*0.000004*	*0.000017*	5 123.79	*5 046.08*	*0.64*	*0.21*	22.42	*19.98*	*0.0011*	*0.0078*
2003	0.71	*0.70*	*0.000005*	*0.000020*	5 560.06	*5 479.06*	*0.61*	*0.22*	19.56	*17.43*	*0.0010*	*0.0068*
2004	0.62	*0.61*	*0.000004*	*0.000018*	6 460.48	*6 371.73*	*0.58*	*0.25*	15.56	*13.87*	*0.0008*	*0.0054*
2005	0.61	*0.61*	*0.000004*	*0.000018*	6 868.85	*6 778.91*	*0.51*	*0.26*	9.88	*8.81*	*0.0005*	*0.0034*
2006	0.52	*0.52*	*0.000004*	*0.000015*	6 575.89	*6 492.96*	*0.44*	*0.24*	7.37	*6.57*	*0.0004*	*0.0026*
2007	0.55	*0.55*	*0.000004*	*0.000016*	6 433.05	*6 353.87*	*0.37*	*0.23*	1.77	*1.58*	*0.0001*	*0.0006*
2008	0.53	*0.52*	*0.000004*	*0.000015*	6 574.77	*6 495.40*	*0.33*	*0.23*	19.96	*17.79*	*0.0010*	*0.0069*
2009	0.54	*0.54*	*0.000004*	*0.000015*	6 066.73	*5 993.10*	*0.29*	*0.22*	11.59	*10.33*	*0.0006*	*0.0040*
Trend 1990-2009	*152.18%*	*152.18%*	*152.18%*	*152.18%*	*132.00%*	*132.82%*	*-65.57%*	*188.82%*	*-57.97%*	*-57.97%*	*-57.98%*	*-57.98%*

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	1.25	*1.23*	*0.000314*	*0.000042*	NA	*NA*	*NA*	*NA*	**2 644.06**	*2 600.11*	*0.84*	*0.09*
1991	1.43	*1.40*	*0.000432*	*0.000047*	NA	*NA*	*NA*	*NA*	**3 140.56**	*3 089.61*	*0.98*	*0.10*
1992	1.31	*1.29*	*0.000394*	*0.000043*	NA	*NA*	*NA*	*NA*	**3 448.86**	*3 388.06*	*0.97*	*0.13*
1993	1.37	*1.35*	*0.000394*	*0.000044*	NA	*NA*	*NA*	*NA*	**3 493.73**	*3 427.15*	*0.88*	*0.16*
1994	1.28	*1.26*	*0.000361*	*0.000041*	NA	*NA*	*NA*	*NA*	**3 552.34**	*3 481.31*	*0.86*	*0.17*
1995	1.13	*1.11*	*0.000322*	*0.000036*	NA	*NA*	*NA*	*NA*	**3 370.09**	*3 301.42*	*0.76*	*0.17*
1996	1.12	*1.10*	*0.000304*	*0.000036*	NA	*NA*	*NA*	*NA*	**3 470.21**	*3 398.83*	*0.79*	*0.18*
1997	1.16	*1.14*	*0.000302*	*0.000037*	NA	*NA*	*NA*	*NA*	**3 670.64**	*3 595.86*	*0.72*	*0.19*
1998	1.15	*1.13*	*0.000284*	*0.000037*	NA	*NA*	*NA*	*NA*	**3 834.50**	*3 760.11*	*0.70*	*0.19*
1999	1.31	*1.29*	*0.000333*	*0.000042*	NA	*NA*	*NA*	*NA*	**4 127.83**	*4 051.77*	*0.70*	*0.20*
2000	1.13	*1.12*	*0.000253*	*0.000036*	NA	*NA*	*NA*	*NA*	**4 676.50**	*4 596.13*	*0.70*	*0.21*
2001	1.26	*1.24*	*0.000274*	*0.000041*	NA	*NA*	*NA*	*NA*	**4 940.26**	*4 859.74*	*0.67*	*0.21*
2002	1.36	*1.34*	*0.000272*	*0.000045*	NA	*NA*	*NA*	*NA*	**5 148.17**	*5 068.00*	*0.64*	*0.21*
2003	1.47	*1.44*	*0.000317*	*0.000048*	NA	*NA*	*NA*	*NA*	**5 581.79**	*5 498.64*	*0.61*	*0.23*
2004	1.34	*1.32*	*0.000259*	*0.000044*	NA	*NA*	*NA*	*NA*	**6 477.99**	*6 387.53*	*0.58*	*0.25*
2005	1.42	*1.40*	*0.000256*	*0.000046*	NA	*NA*	*NA*	*NA*	**6 880.77**	*6 789.72*	*0.52*	*0.26*
2006	1.33	*1.32*	*0.000245*	*0.000044*	NA	*NA*	*NA*	*NA*	**6 585.12**	*6 501.36*	*0.44*	*0.24*
2007	1.36	*1.34*	*0.000240*	*0.000045*	NA	*NA*	*NA*	*NA*	**6 436.74**	*6 357.34*	*0.37*	*0.23*
2008	1.48	*1.46*	*0.000217*	*0.000050*	NA	*NA*	*NA*	*NA*	**6 596.74**	*6 515.18*	*0.33*	*0.24*
2009	1.27	*1.25*	*0.000206*	*0.000043*	NA	*NA*	*NA*	*NA*	**6 080.13**	*6 005.22*	*0.29*	*0.22*
Trend 1990-2009	*1.77%*	*1.95%*	*-34.41%*	*3.15%*	*NA*	*NA*	*NA*	*NA*	*129.95%*	*130.96%*	*-65.54%*	*160.97%*

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.

3.2.8.2 Civil Aviation (1A3a)

3.2.8.2.1 Source category description

In Luxembourg, civil aviation, excluding international flights, is a very small activity. There is only one airport for commercial aviation in Luxembourg operated by Lux-airport (Findel). Therefore, all commercial flights, either inbound or outbound, are international flights. For this 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 emergency (medical, police) flights made with small-sized propeller planes or helicopters using aviation gasoline.

In 2009, 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).

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

3.2.8.2.2 Methodological issues

3.2.8.2.2.1 Activity data

There is only one company selling aviation fuels in Luxembourg: Luxfuel S.A.. Activity data for aviation gasoline is obtained directly from this company.

For aviation gasoline, a country-specific NCV (botained directly from the sole vendor (Luxfuel S.A.)) of 43.5 GJ/t aviation gasoline has been applied for converting activity data.

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. Based on information obtained from the airport authorities, and from the aviation sport clubs registered in Luxembourg, it can be assumed that 90% of aviation gasoline sales are directed towards domestic flights.

Activity data of IPCC sub-category *1A3a – Civil Aviation* are listed in Table 3–47.

Table 3–47– Activity data and emission factors for IPCC Sub-category 1A3a – Civil Aviation: 1990-2009

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	11 078	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
1997	11 232	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
1998	9 667	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
1999	9 887	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
2000	9 418	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
2001	9 354	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
2002	8 670	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
2003	10 095	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
2004	8 850	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
2005	8 768	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
2006	7 466	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
2007	7 904	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
2008	7 576	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
2009	334 678	*69 300*	*D*	*0.50*	*D*	*2.00*	*D*	*2006 IPCC GL*
Trend 1990-2009	*10805.12%*	*0.00%*	*NA*	*0.00%*	*NA*	*0.00%*	*NA*	*NA*

Source: Environment Agency

3.2.8.2.2.2 Methodological choices

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.

3.2.8.2.2.3 Emission factors

Default CO_2, CH_4 and N_2O emission factors for aviation gasoline, from the 2006 IPCC Guidelines, have been used (Table 3–47).

3.2.8.3 Road Transportation (1A3b)

3.2.8.3.1 Source category description

In 2009, road transportation was responsible for 59.2% of GHG emissions from fuel combustion activities (this share was only 25.3% in 1990) and represented 49.5% of the total GHG emissions in CO_2e, excluding LULUCF (20.6% in 1990). Compared with 2009, GHG emissions decreased by about 7.7%. This decrease is mainly due to the repercussions of the economic crisis to heavy good transportation sector, i.e. less transit through Luxembourg, so less diesel was sold.

With 49.5% of the total GHG emissions from Luxembourg, road transportation is the largest key category in 2009. With regard to CO_2, it has been a key category for both diesel oil and gasoline without interruption since 1990. For N_2O, the picture is a bit different: diesel oil is a key category only in the trend assessment and gasoline has been identified as a key category between 1998 and 2000, only in the level assessment (excluding LULUCF).

Emission from road transportation, as reported in the CRF tables, are shown in Table 3–48.

Table 3–48 – Emission trends, activity data and implied emission factors of IPCC Sub-category 1A3b – Road Transportation: 1990-2009

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	36 194 821	17 742 786	18 277 695	174 340	NO	2 615.02	*2 574.09*	*0.83*	*0.08*	*71 118*	*23.06*	*2.09*
1991	43 024 469	20 798 622	22 043 319	182 528	NO	3 111.22	*3 063.29*	*0.98*	*0.09*	*71 199*	*22.73*	*2.05*
1992	46 985 140	22 498 982	24 335 922	150 236	NO	3 419.48	*3 361.70*	*0.97*	*0.12*	*71 548*	*20.56*	*2.57*
1993	47 587 400	22 614 604	24 812 441	160 356	NO	3 464.18	*3 400.62*	*0.87*	*0.15*	*71 461*	*18.38*	*3.06*
1994	48 423 793	23 455 249	24 809 200	159 344	NO	3 523.60	*3 455.50*	*0.86*	*0.16*	*71 360*	*17.71*	*3.34*
1995	45 987 840	22 084 354	23 749 937	153 548	NO	3 346.54	*3 280.25*	*0.76*	*0.16*	*71 329*	*16.55*	*3.53*
1996	47 299 174	22 349 322	24 834 623	115 230	NO	3 444.10	*3 375.38*	*0.79*	*0.17*	*71 362*	*16.61*	*3.56*
1997	50 072 656	23 247 340	26 772 048	53 268	NO	3 644.89	*3 572.72*	*0.72*	*0.18*	*71 351*	*14.39*	*3.67*
1998	52 306 032	23 284 040	28 893 100	128 892	NO	3 808.87	*3 737.09*	*0.69*	*0.18*	*71 447*	*13.27*	*3.53*
1999	56 341 727	24 125 370	32 097 033	119 324	NO	4 102.03	*4 028.58*	*0.69*	*0.19*	*71 503*	*12.33*	*3.37*
2000	63 869 486	24 915 240	38 847 756	106 490	NO	4 651.16	*4 573.38*	*0.70*	*0.20*	*71 605*	*10.90*	*3.19*
2001	67 381 971	24 533 324	42 711 705	136 942	NO	4 912.97	*4 835.24*	*0.67*	*0.21*	*71 759*	*9.93*	*3.05*
2002	70 228 123	23 957 037	46 135 064	136 022	NO	5 123.79	*5 046.08*	*0.64*	*0.21*	*71 853*	*9.15*	*2.95*
2003	76 115 115	24 382 857	51 623 422	108 836	NO	5 560.06	*5 479.06*	*0.61*	*0.22*	*71 984*	*7.97*	*2.89*
2004	88 226 466	23 641 012	64 492 396	93 058	24 435	6 460.48	*6 371.73*	*0.58*	*0.25*	*72 220*	*6.59*	*2.80*
2005	93 591 516	21 528 971	72 012 772	49 772	27 187	6 868.85	*6 778.91*	*0.51*	*0.26*	*72 431*	*5.50*	*2.73*
2006	89 547 808	19 344 448	70 129 438	73 922	24 407	6 575.89	*6 492.96*	*0.44*	*0.24*	*72 508*	*4.94*	*2.65*
2007	87 619 596	18 541 684	69 005 646	72 266	1 900 537	6 433.05	*6 353.87*	*0.37*	*0.23*	*72 517*	*4.21*	*2.58*
2008	89 489 653	17 681 767	71 673 106	134 780	1 881 026	6 574.77	*6 495.40*	*0.33*	*0.23*	*72 583*	*3.65*	*2.56*
2009	82 590 086	16 153 878	66 363 482	72 726	1 961 817	6 066.73	*5 993.10*	*0.29*	*0.22*	*72 564*	*3.46*	*2.58*
Trend 1990-2009	*128.18%*	*-8.96%*	*263.08%*	*-58.28%*	*NA*	*132.00%*	*132.82%*	*-65.57%*	*188.82%*	*2.03%*	*-85.00%*	*23.72%*

Source: Environment Agency

As already explained in previous sections of the NIR (please refer to chapter 2 on emission trends), Luxembourg's situation regarding emissions from *1A3b - Road Transportation* is quite unique, due to the high share of fuel export, also commonly called "tanktourism".

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 stabilize.

Figure 3-6 – Fuel sold trends - indexes - for 1A3b – Road Transportation by fuel type: 1990-2009

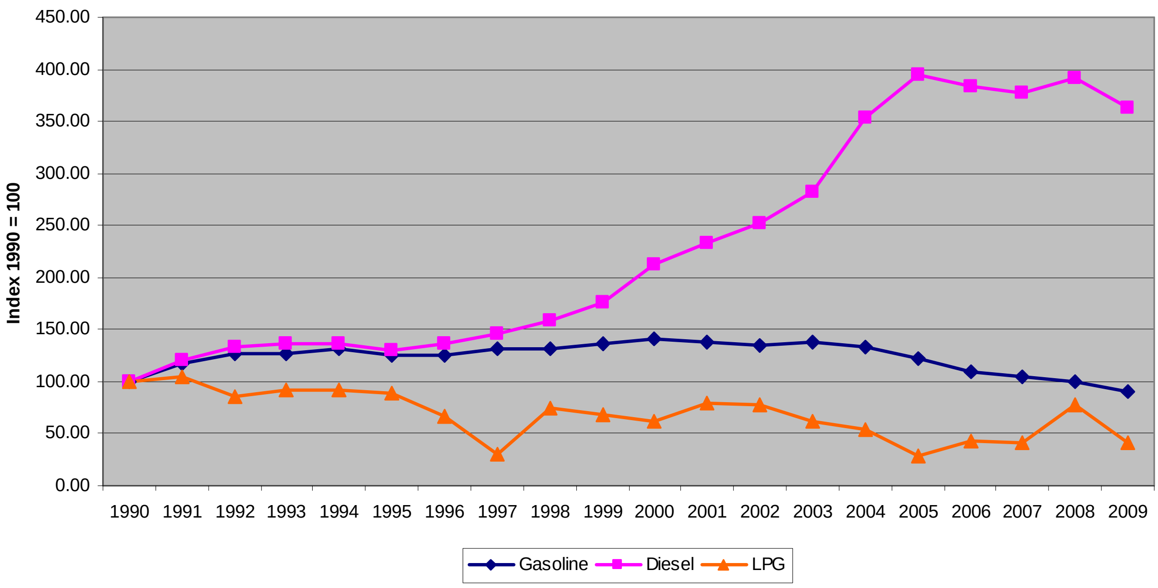


Table 3–49 and Figure 3-7 detail the quantities of blended fuel sold to the domestic fleet and the amount of fuel exported.

Table 3–49 – Total fuel sold for road transport – inland consumption and road fuel export: 1990-2009

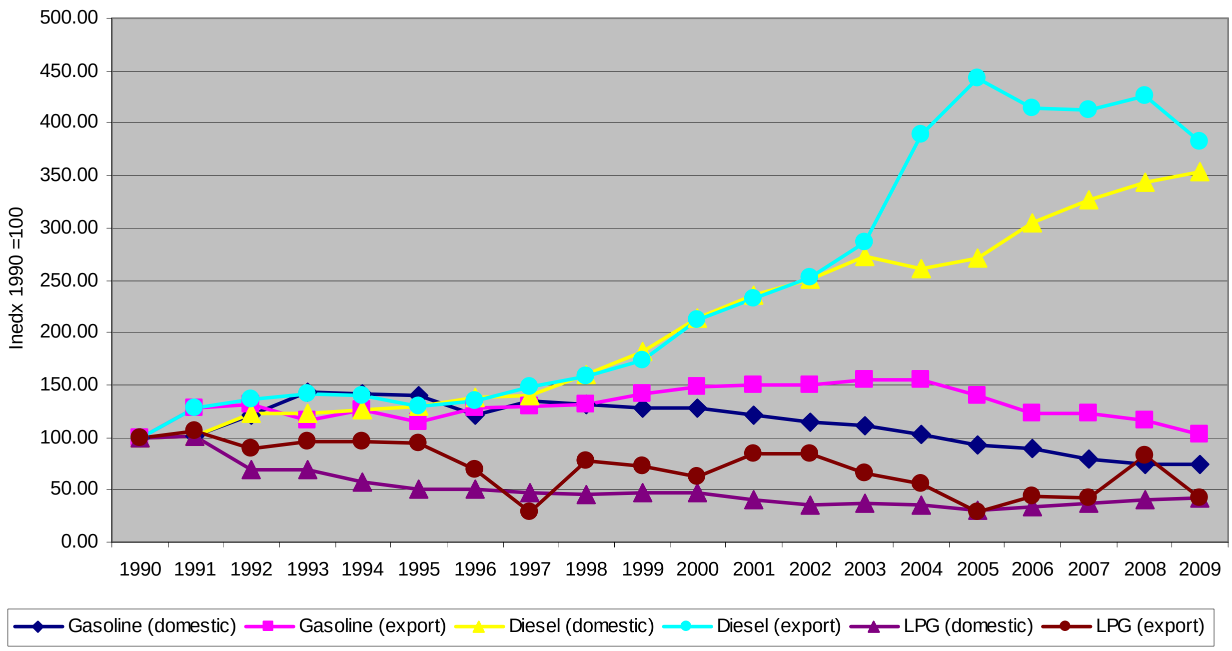
1A3b - Road Transportation

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**	**288 399.2**	34.08%	*165 877.1*	*122 036.8*	*485.3*	**557 788.1**	65.92%	*246 304.9*	*308 178.4*	*3 304.7*
1991	**1 005 989.4**	**290 852.6**	28.91%	*167 183.6*	*123 179.9*	*489.1*	**715 136.9**	71.09%	*315 988.4*	*395 669.6*	*3 478.9*
1992	**1 098 751.1**	**351 586.0**	32.00%	*200 832.1*	*150 417.5*	*336.4*	**747 165.1**	68.00%	*321 840.9*	*422 394.6*	*2 929.6*
1993	**1 112 873.3**	**388 873.8**	34.94%	*237 962.3*	*150 574.1*	*337.4*	**723 999.4**	65.06%	*287 396.7*	*433 454.1*	*3 148.6*
1994	**1 132 304.0**	**390 051.4**	34.45%	*235 811.1*	*153 959.1*	*281.3*	**742 252.6**	65.55%	*309 076.9*	*429 992.9*	*3 182.7*
1995	**1 075 398.2**	**391 369.1**	36.39%	*232 000.7*	*159 119.7*	*248.7*	**684 029.1**	63.61%	*281 040.1*	*399 899.7*	*3 089.3*
1996	**1 106 251.6**	**370 053.3**	33.45%	*202 081.1*	*167 729.5*	*242.6*	**736 198.3**	66.55%	*317 115.1*	*416 820.8*	*2 262.4*
1997	**1 171 369.0**	**394 076.6**	33.64%	*222 503.4*	*171 347.6*	*225.6*	**777 292.5**	66.36%	*317 554.7*	*458 805.4*	*932.4*
1998	**1 223 790.3**	**414 166.7**	33.84%	*219 121.3*	*194 821.4*	*224.0*	**809 623.6**	66.16%	*321 789.3*	*485 256.3*	*2 578.0*
1999	**1 318 540.5**	**434 441.3**	32.95%	*211 575.6*	*222 640.4*	*225.3*	**884 099.2**	67.05%	*348 880.0*	*532 850.6*	*2 368.7*
2000	**1 495 507.6**	**473 834.7**	31.68%	*212 536.0*	*261 067.5*	*231.2*	**1 021 672.9**	68.32%	*366 269.0*	*653 320.1*	*2 083.8*
2001	**1 578 245.8**	**490 024.8**	31.05%	*202 138.1*	*287 690.6*	*196.1*	**1 088 221.0**	68.95%	*367 794.6*	*717 645.5*	*2 780.9*
2002	**1 645 416.2**	**495 105.4**	30.09%	*189 331.5*	*305 603.8*	*170.1*	**1 150 310.8**	69.91%	*367 213.6*	*780 310.4*	*2 786.9*
2003	**1 783 900.8**	**517 861.3**	29.03%	*184 354.4*	*333 323.8*	*183.1*	**1 266 039.5**	70.97%	*382 082.8*	*881 773.8*	*2 182.9*
2004	**2 069 805.5**	**488 608.9**	23.61%	*169 537.0*	*318 902.5*	*169.5*	**1 581 196.6**	76.39%	*379 666.5*	*1 199 676.6*	*1 853.5*
2005	**2 196 877.1**	**484 471.2**	22.05%	*154 076.2*	*330 250.8*	*144.1*	**1 712 405.9**	77.95%	*346 062.5*	*1 365 405.5*	*937.9*
2006	**2 102 258.6**	**519 763.5**	24.72%	*147 153.4*	*372 443.7*	*166.4*	**1 582 495.2**	75.28%	*302 236.8*	*1 278 817.8*	*1 440.6*
2007	**2 101 265.2**	**529 142.0**	25.18%	*131 235.4*	*397 731.0*	*175.7*	**1 572 123.2**	74.82%	*300 776.6*	*1 269 951.2*	*1 395.3*
2008	**2 144 979.0**	**543 278.1**	25.33%	*124 045.3*	*419 039.0*	*193.8*	**1 601 700.9**	74.67%	*287 626.7*	*1 311 338.0*	*2 736.2*
2009	**1 985 060.8**	**552 696.9**	27.84%	*121 551.4*	*430 941.8*	*203.8*	**1 432 363.8**	72.16%	*254 632.6*	*1 176 354.0*	*1 377.2*
Trend 1990-2009	***134.59%***	***91.64%***	*NA*	*-26.72%*	*253.12%*	*-58.01%*	***156.79%***	*NA*	*3.38%*	*281.71%*	*-58.33%*
Share 1990	***NA***	***34.08%***	*NA*	*57.52%*	*42.32%*	*0.17%*	***65.92%***	*NA*	*44.16%*	*55.25%*	*0.59%*
Share 2009	***NA***	***27.84%***	*NA*	*21.99%*	*77.97%*	*0.04%*	***72.16%***	*NA*	*17.78%*	*82.13%*	*0.10%*

Source: Environment Agency

Figure 3-7 – Domestic and exported fuel sold trends - indexes - for 1A3b – Road Transportation by fuel type: 1990-2009



In 2009, as shown in Table 3–50, emissions from road fuel export were nearly three times higher than those from the domestic fleet.

Table 3–50 – Domestic and road fuel export emissions for 1A3b - Road Transportation: 1990-2009

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	**2615.02**	**889.11**	34.00%	*505.00*	*382.70*	*1.41*	**1725.91**	66.00%	*749.85*	*966.44*	*9.62*
1991	**3111.22**	**897.19**	28.84%	*509.37*	*386.39*	*1.43*	**2214.03**	71.16%	*962.75*	*1241.13*	*10.15*
1992	**3419.48**	**1092.47**	31.95%	*619.25*	*472.23*	*0.98*	**2327.02**	68.05%	*992.38*	*1326.10*	*8.54*
1993	**3464.18**	**1208.13**	34.88%	*734.96*	*472.19*	*0.98*	**2256.05**	65.12%	*887.65*	*1359.29*	*9.11*
1994	**3523.60**	**1211.88**	34.39%	*728.57*	*482.49*	*0.82*	**2311.72**	65.61%	*954.94*	*1347.55*	*9.23*
1995	**3346.54**	**1216.18**	36.34%	*716.93*	*498.53*	*0.72*	**2130.35**	63.66%	*868.48*	*1252.90*	*8.98*
1996	**3444.10**	**1151.04**	33.42%	*624.78*	*525.55*	*0.71*	**2293.07**	66.58%	*980.43*	*1306.04*	*6.60*
1997	**3644.89**	**1224.28**	33.59%	*686.58*	*537.04*	*0.66*	**2420.61**	66.41%	*979.88*	*1438.00*	*2.72*
1998	**3808.87**	**1287.38**	33.80%	*675.99*	*610.74*	*0.66*	**2521.49**	66.20%	*992.71*	*1521.21*	*7.56*
1999	**4102.03**	**1350.16**	32.91%	*651.47*	*698.02*	*0.67*	**2751.87**	67.09%	*1074.25*	*1670.59*	*7.03*
2000	**4651.16**	**1472.03**	31.65%	*653.29*	*818.06*	*0.68*	**3179.14**	68.35%	*1125.83*	*2047.18*	*6.12*
2001	**4912.97**	**1524.11**	31.02%	*621.91*	*901.62*	*0.58*	**3388.86**	68.98%	*1131.58*	*2249.10*	*8.18*
2002	**5123.79**	**1540.52**	30.07%	*581.87*	*958.15*	*0.50*	**3583.27**	69.93%	*1128.56*	*2446.48*	*8.23*
2003	**5560.06**	**1612.62**	29.00%	*564.89*	*1047.19*	*0.54*	**3947.44**	71.00%	*1170.76*	*2770.22*	*6.46*
2004	**6462.27**	**1521.92**	23.55%	*517.93*	*1003.49*	*0.50*	**4940.35**	76.45%	*1159.88*	*3775.01*	*5.47*
2005	**6870.85**	**1510.90**	21.99%	*470.12*	*1040.35*	*0.43*	**5359.96**	78.01%	*1055.91*	*4301.28*	*2.77*
2006	**6577.69**	**1622.69**	24.67%	*448.81*	*1173.39*	*0.49*	**4954.99**	75.33%	*921.81*	*4028.94*	*4.25*
2007	**6572.46**	**1652.42**	25.14%	*397.93*	*1253.98*	*0.52*	**4920.04**	74.86%	*912.01*	*4003.93*	*4.09*
2008	**6712.85**	**1697.80**	25.29%	*375.36*	*1321.88*	*0.57*	**5015.05**	74.71%	*870.35*	*4136.68*	*8.02*
2009	**6210.69**	**1726.99**	27.81%	*366.88*	*1359.51*	*0.60*	**4483.70**	72.19%	*768.57*	*3711.09*	*4.05*
Trend 1990-2009	***137.50%***	***94.24%***	*NA*	*-27.35%*	*255.24%*	*-57.63%*	***159.79%***	*NA*	*2.50%*	*284.00%*	*-57.95%*
Trend 2008-2009	***-7.48%***	***1.72%***	*NA*	*-2.26%*	*2.85%*	*5.39%*	***-10.60%***	*NA*	*-11.69%*	*-10.29%*	*-49.54%*
Share 1990	***NA***	***34.00%***	*NA*	*56.80%*	*43.04%*	*0.16%*	***66.00%***	*NA*	*43.45%*	*56.00%*	*0.56%*
Share 2009	***NA***	***27.81%***	*NA*	*21.24%*	*78.72%*	*0.03%*	***72.19%***	*NA*	*17.14%*	*82.77%*	*0.09%*

Source: Environment Agency

3.2.8.3.2 Methodological issues

3.2.8.3.2.1 Activity data

Parameters needed to feed the COPERT emission calculation model and the corresponding sources are listed in Table 3–51:

Table 3–51 – 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) (vehicle stock) AEV-expert judgement (annual mileage)

Table 3–52 gives an overview of the values of underlying parameters used in the COPERT model.[107] These parameters are identical over the entire time series.

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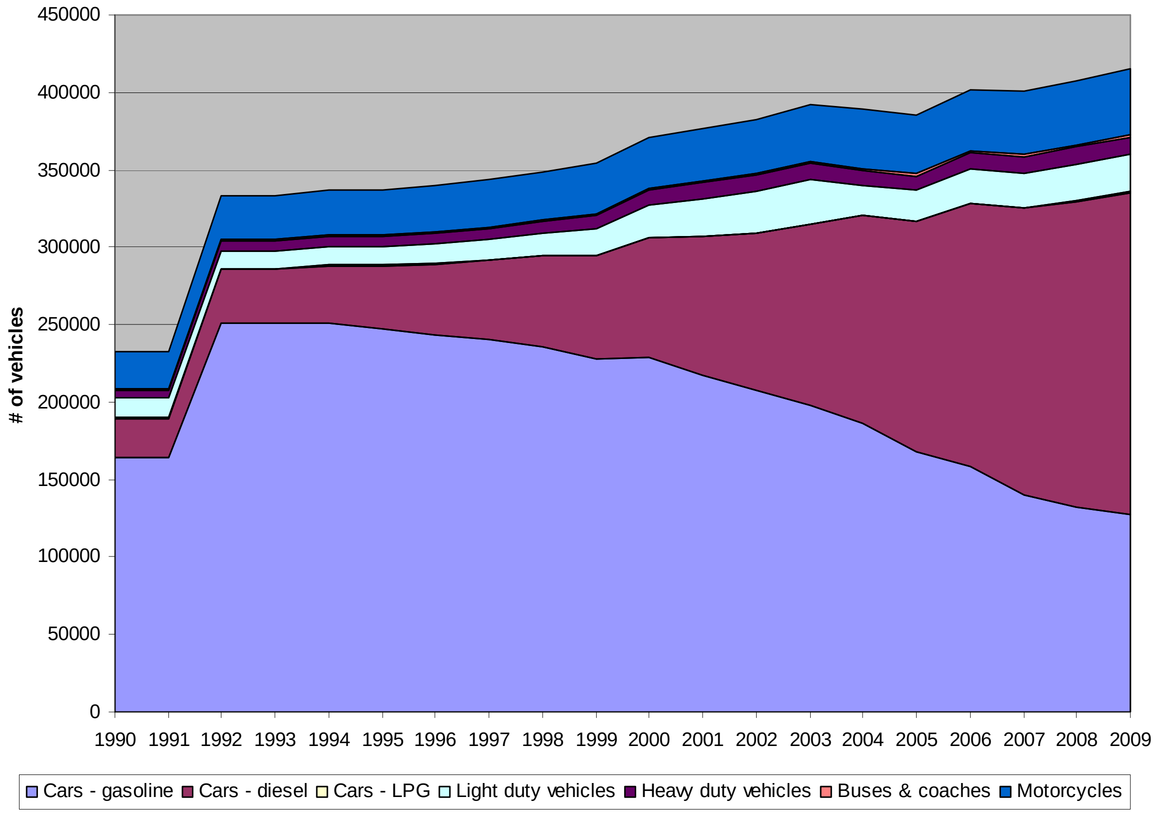
107 ARR 2009, § 63.

Table 3–52 – Driving Parameters of Luxembourg's fleet

Type	Mileage (km/year)	Speed (km/h)			Driving Share (%)		
		Urban	Rural	Highway	Urban	Rural	Highway
Passenger Cars	13 800	40	60	95	45	35	20
Light Duty Vehicles	40 000	40	60	95	15	45	40
Heavy Duty Trucks	40 000	19	50	80	35	35	30
Urban Buses	40 000	15	50	80	100	0	0
Coaches	40 000	19	50	80	20	40	40
Mopeds	1 500	25	40	0	80	20	0
Motorcycles	1 500 (2-stroke) 4 600 (4-stroke)	40	60	95	35	45	20

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

Figure 3-8 – National vehicle fleet: 1990-2009



Source: SNCT

3.2.8.3.2.2 Methodology

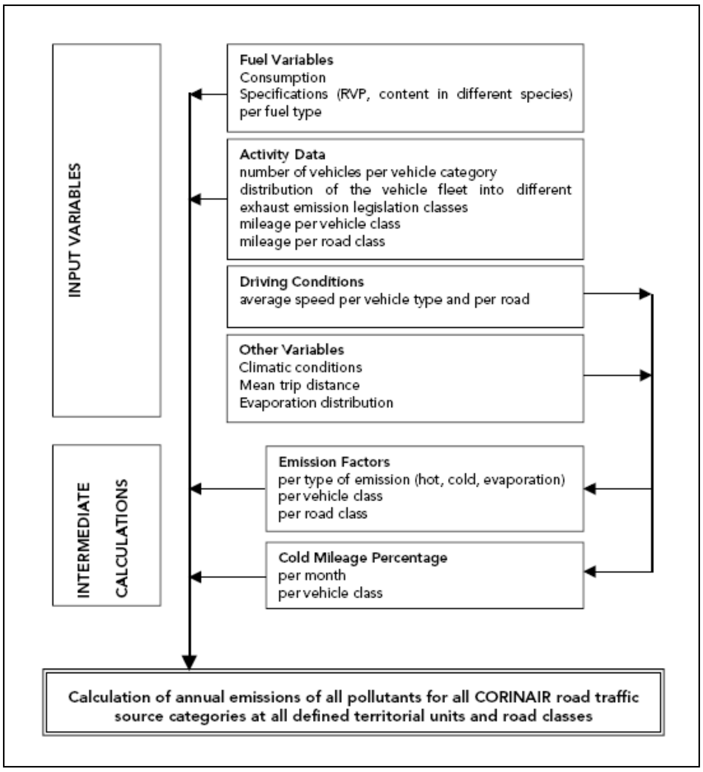
Road traffic emissions have been calculated using the COPERT model, which is referred to, in the 2006 IPCC Guidelines, as a Tier 3 method.

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 3–49). Lacking data on the vehicles commuting or transiting 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 IVv8.0. (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



3.2.8.3.2.3 Emission Factors

For gasoline, diesel oil and LPG, country specific CO_2 emission factors were used (see also section 3.2.5.3), whereas for CH_4 and N_2O, default emission factors from the COPERT IV model were used as these are technology dependant.

For biogasoline (ethanol, ETBE) and biodiesel (FAME, HVH, HVP), European CO_2 implied emission factors[108] for gasoline and diesel oil, respectively, were used as emission factors. For CH_4 and N_2O, national implied emission factors for gasoline and diesel were used.

For an overview of the implied emission factors, please refer to Table 3–53.

Table 3–53 – Implied emission factors per fuel type for IPCC Sub-category 1A3b – Road Transport: 1990-2009

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	68 793	42.47	3.35	73 452	4.27	0.88	62 918	18.59	NO	NO	NO	NO
1991	68 856	42.37	3.33	73 476	4.22	0.86	63 047	18.48	NO	NO	NO	NO
1992	69 460	38.29	4.41	73 532	4.18	0.89	62 892	18.59	0.26	NO	NO	NO
1993	69 340	33.98	5.47	73 451	4.16	0.89	62 436	18.56	0.26	NO	NO	NO
1994	69 258	32.00	5.95	73 404	4.20	0.88	62 436	18.74	0.60	NO	NO	NO
1995	69 170	29.85	6.43	73 394	4.16	0.85	62 436	18.81	1.14	NO	NO	NO
1996	69 133	30.49	6.61	73 410	4.11	0.82	62 436	18.91	1.82	NO	NO	NO
1997	69 002	26.62	6.85	73 408	3.76	0.92	62 436	18.80	2.05	NO	NO	NO
1998	69 042	25.31	6.75	73 424	3.55	0.93	62 612	18.49	2.32	NO	NO	NO
1999	68 992	24.41	6.54	73 421	3.22	0.99	63 249	18.13	2.79	NO	NO	NO
2000	68 893	23.28	6.53	73 369	2.95	1.05	62 530	17.74	3.13	NO	NO	NO
2001	69 005	22.38	6.45	73 370	2.75	1.09	62 521	17.41	3.35	NO	NO	NO
2002	68 976	21.53	6.35	73 374	2.70	1.18	62 653	17.55	3.80	NO	NO	NO
2003	68 953	20.31	5.82	73 435	2.11	1.51	62 820	16.81	3.61	NO	NO	NO
2004	68 848	19.62	5.52	73 470	1.80	1.80	62 577	16.75	3.92	73 450	1.80	1.80
2005	68 904	18.78	5.11	73 492	1.52	2.01	62 602	16.42	3.97	73 450	1.52	2.01
2006	69 011	18.24	4.71	73 483	1.26	2.08	62 637	15.82	3.58	73 450	1.26	2.08
2007	68 962	16.77	3.63	73 482	0.82	2.29	62 436	15.11	3.32	73 387	1.28	2.33
2008	68 938	15.69	3.32	73 501	0.65	2.38	62 436	14.90	3.15	73 405	0.96	2.39
2009	68 890	15.42	2.92	73 470	0.54	2.50	62 653	14.56	2.98	73 406	0.84	2.51
Trend 1990-2009	0.14%	-63.70%	-12.94%	0.02%	-87.40%	185.15%	-0.42%	-21.68%	NA	NA	NA	NA

Source: Environment Agency

3.2.8.4 Railways (1A3c)

3.2.8.4.1 Source category description

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.

In 2009, railways fuel consumption was responsible for 0.11% of GHG emissions from fuel combustion activities (0.27% in 1990) and represented 0.09% of the total GHG emissions in CO_2e, excluding LULUCF (0.22% in 1990).

However, the clear downwards trend of the GHG emissions in recent years, as shown in Table 3–54, was sharply interrupted in 2008 by a tenfold increase compared to 2007. The reason for this

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

increase is not very clear, and is currently being discussed with the company. The emissions for 2006 and 2007 should therefore be considered as provisional and might be revised in the next submission. The decrease in 2009 compared to 2008 could be due to the economic crisis, although this has also to be clarified with the operator.

GHG emissions from railways are not a key source.

Table 3–54 – Activity data, emissions and emission factors for IPCC Sub-category 1A3c – Railways: 1990-2009

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	334 678	27.58	24.58	0.0014	0.0096	73 452	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
1991	334 678	27.59	24.59	0.0014	0.0096	73 476	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
1992	334 678	27.61	24.61	0.0014	0.0096	73 532	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
1993	334 678	27.58	24.58	0.0014	0.0096	73 451	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
1994	324 884	26.76	23.85	0.0013	0.0093	73 404	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
1995	263 059	21.66	19.31	0.0011	0.0075	73 394	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
1996	293 972	24.21	21.58	0.0012	0.0084	73 410	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
1997	288 989	23.80	21.21	0.0012	0.0083	73 408	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
1998	288 989	23.81	21.22	0.0012	0.0083	73 424	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
1999	288 989	23.81	21.22	0.0012	0.0083	73 421	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
2000	285 971	23.54	20.98	0.0012	0.0082	73 369	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
2001	308 159	25.37	22.61	0.0013	0.0088	73 370	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
2002	272 319	22.42	19.98	0.0011	0.0078	73 374	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
2003	237 417	19.56	17.43	0.0010	0.0068	73 435	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
2004	188 736	15.56	13.87	0.0008	0.0054	73 470	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
2005	119 838	9.88	8.81	0.0005	0.0034	73 492	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
2006	89 359	7.37	6.57	0.0004	0.0026	73 483	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
2007	21 508	1.77	1.58	0.0001	0.0006	73 482	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
2008	242 055	19.96	17.79	0.0010	0.0069	73 501	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
2009	140 637	11.59	10.33	0.0006	0.0040	73 470	CS	4.00	D	28.60	D	AEV, 2006 IPCC G
Trend 1990-2009	-57.98%	-57.97%	-57.97%	-57.98%	-57.98%	0.02%	NA	0.00%	NA	0.00%	NA	NA

Source: Environment Agency

3.2.8.4.2 Methodological issues

3.2.8.4.2.1 Activity data

Diesel oil consumption is obtained directly from the sole railway company (CFL).

Activity data are listed in Table 3–54.

3.2.8.4.2.2 Methodology

The 2006 IPCC Guidelines Tier 1 approach has been applied.

3.2.8.4.2.3 Emission factors

The country specific CO_2 EF for diesel oil was used. 2006 IPCC default EFs have been applied for CH_4 and N_2O (Table 3–54).

3.2.8.5 Navigation (1A3d)

3.2.8.5.1 Source category description

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.

In 2009, fuel consumption in navigation was responsible for 0.012% of GHG emissions from fuel combustion activities (0.012% in 1990) and represented 0.01% of the total GHG emissions in CO_2e, excluding LULUCF (0.01% in 1990). From 1990 to 2009, the emissions have nearly doubled, due to the increase of tourism activities in the Moselle region: see Table 3–55.

Navigation related GHG emissions are not a key source.

Table 3–55 – Activity data and emissions for IPCC Sub-category 1A3d – Navigation: 1990-2009

1A3d - Navigation *Gas Oil, Diesel Oil, Motor Gasoline*					
Year	Activity (GJ)	Emissions (Gg)			
		Total $CO_{2\,eq}$	CO_2	CH_4	N_2O
1990	16 952	1.25	*1.23*	*0.000314*	*0.000042*
1991	19 476	1.43	*1.40*	*0.000432*	*0.000047*
1992	17 802	1.31	*1.29*	*0.000394*	*0.000043*
1993	18 692	1.37	*1.35*	*0.000394*	*0.000044*
1994	17 492	1.28	*1.26*	*0.000361*	*0.000041*
1995	15 422	1.13	*1.11*	*0.000322*	*0.000036*
1996	15 221	1.12	*1.10*	*0.000304*	*0.000036*
1997	15 796	1.16	*1.14*	*0.000302*	*0.000037*
1998	15 630	1.15	*1.13*	*0.000284*	*0.000037*
1999	17 836	1.31	*1.29*	*0.000333*	*0.000042*
2000	15 405	1.13	*1.12*	*0.000253*	*0.000036*
2001	17 150	1.26	*1.24*	*0.000274*	*0.000041*
2002	18 430	1.36	*1.34*	*0.000272*	*0.000045*
2003	19 915	1.47	*1.44*	*0.000317*	*0.000048*
2004	18 105	1.34	*1.32*	*0.000259*	*0.000044*
2005	19 218	1.42	*1.40*	*0.000256*	*0.000046*
2006	18 069	1.33	*1.32*	*0.000245*	*0.000044*
2007	18 449	1.36	*1.34*	*0.000240*	*0.000045*
2008	20 055	1.48	*1.46*	*0.000217*	*0.000050*
2009	17 147	1.27	*1.25*	*0.000206*	*0.000043*
Trend 1990-2009	*1.15%*	*1.77%*	*1.95%*	*-34.41%*	*3.15%*

Source: Environment Agency

3.2.8.5.2 Methodological issues

3.2.8.5.2.1 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. The activity data are listed in Table 3–55.

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 and diesel oil filling station. The amount of fuel sold at this station was obtained from the operator for the entire time-series.[109] It is assumed that the quantities sold at this station are being combusted entirely on Luxembourg's side of the river.

3.2.8.5.2.2 Methodology

The 2006 IPCC Guidelines Tier 1 approach has been applied.

109 ARR 2009, §55

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 from gasoil, 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.

3.2.8.5.2.3 Emission factors

The country specific CO_2 EFs for gas oil, diesel oil and gasoline were used. 2006 IPCC default EFs for gas oil have been applied for CH_4 and N_2O, whereas, for diesel oil and gasoline combusted in the small boats, default EFs from the EMEP/EEA Guidebook 2009 were used. ().

Table 3–56 – Emission factors for IPCC Sub-category 1A3d – Navigation: 2009

1A3d - Navigation *Emission Factors for 2009 (kg/TJ)*								
Fuel	Fuel Type	CO_2 EF	CO_2 type	CH_4 EF	CH_4 type	N_2O EF	N_2O type	Source
Gas Oil	liquid	73 470	CS	7.00	D	2.00	D	AEV 2006 IPCC GL
Diesel Oil	liquid	73 470	CS	2.75	D	2.99	D	AEV EMEP/EEA 2009
Motor Gasoline	liquid	68 890	CS	63.00	D	1.63	D	AEV EMEP/EEA 2009

Source: Environment Agency

3.2.8.6 Other Transportation (1A3e)

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

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.

3.2.8.7 Uncertainties and time-series consistency

For uncertainties on activity data and emission factors, please refer to section 1.7.

The time series reported under 1A3 - Transportation, are considered as being consistent.

3.2.8.8 Source-specific QA/QC and verification

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.

3.2.8.9 Source-specific recalculations

Table 3–57 presents the main revisions and recalculations done since submission 2010v2.1 relevant to IPCC sub-category *1A3 - Transport*.

Table 3–57 – Recalculations done since submission 2010v2.1

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
1A3b	Emission calculations based on COPERT IV v8.0 model.[110]	updated model version
1A3d	Emissions from diesel oil and motor gasoline combusted by small leisure boats are now estimated, due to the availability of the needed AD.[111]	updated EF

3.2.8.10 Source-specific 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 3–58 will be explored.

Table 3–58 – Planned improvements for IPCC Sub-category 1A3 – Transport

GHG source & sink category	Planned improvement
1A3b – Road Transportation	A detailed study has been commissioned to better estimate emissions from both the domestic fleet, and the emissions due to fuel export.[112] A preliminary report is currently being prepared, but further work will be needed to refine the data before incorporation into the GHG inventory.
1A3b – Road Transportation	lubricants: 50% of carbon that is not stored will be allocated in this sub-category[113]

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110 Compared to submission 2010v2.1, where COPERT IV v7.0 was used, a newer version has been used for this submission (COPERT IV v8.0). For details on the changes, please refer to the documentation on the COPERT website: http://lat.eng.auth.gr/copert/

111 ARR 2009, § 55

112 ARR 2009, § 64

113 ARR 2009, § 58

3.2.9 Other Sectors (1A4)

3.2.9.1 Source category description

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*

In 2009, IPCC Sub-category 1A4 was responsible for 18.0% of GHG emissions from fuel combustion activities (this share was 12.8% in 1990) and represented around 15.1% of the total GHG emissions in CO_2e, excluding LULUCF (10.3% was recorded for the year 1990).

Table 3–59 summarizes GHG emissions for IPCC Sub-category 1A4.

3.2.9.2 Commercial/Institutional (1A4a)

3.2.9.2.1 Source category description

In 2009, fuel combustion from the commercial and institutional sectors was responsible for 4.8% of GHG emissions from fuel combustion activities (this share was 6.2% in 1990). With regard to total GHG emissions in CO_2e, excluding LULUCF and excluding CO_2 emissions from biomass, percentages were 4.0% in 2008 and 5.0% in 1990. Compared to 2008, GHG emissions have increased by 2.8%.

Commercial and institutional fuel combustion is a key category with regard to CO_2 emissions. It has been a key category for gaseous fuels without interruption since 1990 and for liquid fuels from 1990-2007.

Table 3–59 – GHG emission trends in CO_2e for IPCC Sub-category 1A4 – Other Sectors: 1990-2009

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	636.78	*633.93*	*0.08*	*0.00*	668.01	*660.12*	*0.27*	*0.01*	16.75	*15.65*	*0.001*	*0.003*	**1 321.54**	*1 309.70*	*0.35*	*0.01*
1991	766.23	*762.75*	*0.09*	*0.00*	801.88	*793.32*	*0.29*	*0.01*	20.08	*18.76*	*0.002*	*0.004*	**1 588.19**	*1 574.84*	*0.39*	*0.02*
1992	707.23	*704.08*	*0.09*	*0.00*	736.96	*728.77*	*0.28*	*0.01*	20.05	*18.74*	*0.002*	*0.004*	**1 464.24**	*1 451.59*	*0.37*	*0.02*
1993	698.89	*695.81*	*0.08*	*0.00*	730.67	*722.54*	*0.28*	*0.01*	16.70	*15.61*	*0.001*	*0.003*	**1 446.26**	*1 433.96*	*0.37*	*0.01*
1994	673.30	*670.35*	*0.08*	*0.00*	695.76	*687.82*	*0.28*	*0.01*	20.03	*18.71*	*0.002*	*0.004*	**1 389.09**	*1 376.88*	*0.36*	*0.02*
1995	678.85	*675.91*	*0.08*	*0.00*	705.55	*697.61*	*0.28*	*0.01*	16.69	*15.59*	*0.001*	*0.003*	**1 401.09**	*1 389.12*	*0.36*	*0.01*
1996	757.82	*754.57*	*0.09*	*0.00*	775.78	*767.58*	*0.28*	*0.01*	19.98	*18.67*	*0.002*	*0.004*	**1 553.57**	*1 540.82*	*0.38*	*0.02*
1997	734.79	*731.59*	*0.09*	*0.00*	751.77	*743.62*	*0.28*	*0.01*	23.37	*21.84*	*0.002*	*0.005*	**1 509.94**	*1 497.06*	*0.37*	*0.02*
1998	768.78	*765.45*	*0.09*	*0.00*	788.72	*780.13*	*0.30*	*0.01*	23.37	*21.84*	*0.002*	*0.005*	**1 580.87**	*1 567.42*	*0.39*	*0.02*
1999	736.16	*732.98*	*0.09*	*0.00*	752.36	*744.09*	*0.29*	*0.01*	28.61	*28.09*	*0.004*	*0.001*	**1 517.13**	*1 505.17*	*0.38*	*0.01*
2000	538.79	*536.92*	*0.06*	*0.00*	1 069.64	*1 060.12*	*0.32*	*0.01*	49.89	*44.47*	*0.003*	*0.017*	**1 658.32**	*1 641.51*	*0.38*	*0.03*
2001	616.24	*614.05*	*0.07*	*0.00*	1 159.51	*1 149.39*	*0.34*	*0.01*	56.32	*50.20*	*0.003*	*0.020*	**1 832.06**	*1 813.63*	*0.41*	*0.03*
2002	626.05	*623.89*	*0.07*	*0.00*	1 103.63	*1 094.20*	*0.32*	*0.01*	55.75	*49.69*	*0.003*	*0.019*	**1 785.43**	*1 767.79*	*0.39*	*0.03*
2003	528.04	*526.18*	*0.06*	*0.00*	1 147.47	*1 137.81*	*0.33*	*0.01*	59.33	*52.89*	*0.003*	*0.021*	**1 734.84**	*1 716.88*	*0.39*	*0.03*
2004	457.89	*456.21*	*0.05*	*0.00*	1 227.61	*1 217.36*	*0.35*	*0.01*	57.42	*51.19*	*0.003*	*0.020*	**1 742.92**	*1 724.76*	*0.40*	*0.03*
2005	476.79	*475.12*	*0.05*	*0.00*	1 202.20	*1 192.32*	*0.33*	*0.01*	58.26	*51.94*	*0.003*	*0.020*	**1 737.25**	*1 719.38*	*0.39*	*0.03*
2006	503.47	*501.95*	*0.05*	*0.00*	1 189.88	*1 179.96*	*0.33*	*0.01*	59.80	*53.32*	*0.003*	*0.021*	**1 753.15**	*1 735.23*	*0.39*	*0.03*
2007	514.51	*512.93*	*0.05*	*0.00*	1 072.78	*1 063.80*	*0.30*	*0.01*	63.78	*56.87*	*0.003*	*0.022*	**1 651.07**	*1 633.60*	*0.36*	*0.03*
2008	479.72	*478.45*	*0.04*	*0.00*	1 163.62	*1 153.69*	*0.33*	*0.01*	59.58	*53.12*	*0.003*	*0.021*	**1 702.92**	*1 685.26*	*0.38*	*0.03*
2009	493.08	*491.88*	*0.04*	*0.00*	1 262.62	*1 252.46*	*0.34*	*0.01*	91.26	*81.35*	*0.005*	*0.032*	**1 846.96**	*1 825.69*	*0.39*	*0.04*
Trend 1990-2009	*-22.57%*	*-22.41%*	*-43.39%*	*-76.72%*	*89.01%*	*89.73%*	*24.69%*	*39.44%*	*444.91%*	*419.85%*	*219.76%*	*818.91%*	*39.76%*	*39.40%*	*10.58%*	*193.92%*

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.

3.2.9.2.2 Methodological issues

3.2.9.2.2.1 Activity data

Under *1A4a – Commercial/Institutional*, emissions from non-industrial commercial and institutional combustion plants (<50 MW) are accounted (**Error! Not a valid bookmark self-reference.**). This source category covers numerous small combustion units, mainly for the heating of buildings. No specific bottom-up data could be obtained, so that emission estimates solely rely on top-down data from national statistics.

However, for the period 1990-1999, the consumptions are only reported under the so-called "*domestic sector*" by national statistics, covering 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*. From 2000-2009, the consumptions reported by national statistics are properly split between the two sub-categories 1A4a and 1A4b.

Fuel consumption data was converted into energy units using national NCV values.

Table 3–60 – Activity data for IPCC Sub-category 1A4a – Commercial/Institutional

1A4a - Commercial/Institutional *Activity Data by fuel type (GJ)*						
Year	Activity Total (excl. biomass)	Solid	Liquid *Gas Oil, Diesel Oil, LPG*	Gaseous *Natural Gas*	Biomass	Other
1990	9 296 234	*NO*	*6 359 553*	*2 936 681*	*NO*	*NO*
1991	11 122 561	*NO*	*7 822 330*	*3 300 231*	*NO*	*NO*
1992	10 323 786	*NO*	*6 985 232*	*3 338 553*	*NO*	*NO*
1993	10 259 446	*NO*	*6 708 868*	*3 550 579*	*NO*	*NO*
1994	9 898 224	*NO*	*6 406 937*	*3 491 287*	*NO*	*NO*
1995	10 042 374	*NO*	*6 223 973*	*3 818 401*	*NO*	*NO*
1996	11 278 089	*NO*	*6 794 806*	*4 483 283*	*NO*	*NO*
1997	10 906 999	*NO*	*6 718 170*	*4 188 829*	*NO*	*NO*
1998	11 461 249	*NO*	*6 954 434*	*4 506 815*	*NO*	*NO*
1999	11 022 087	*NO*	*6 580 448*	*4 441 640*	*NO*	*NO*
2000	8 743 749	*NO*	*2 716 447*	*6 027 301*	*NO*	*NO*
2001	9 917 716	*NO*	*3 350 416*	*6 567 300*	*NO*	*NO*
2002	10 156 080	*NO*	*3 043 380*	*7 112 700*	*NO*	*NO*
2003	8 496 853	*NO*	*2 726 053*	*5 770 800*	*NO*	*NO*
2004	7 253 995	*NO*	*2 717 995*	*4 536 000*	*NO*	*NO*
2005	7 630 544	*NO*	*2 514 027*	*5 116 517*	*NO*	*NO*
2006	8 378 842	*NO*	*1 516 313*	*6 862 529*	*NO*	*NO*
2007	8 565 417	*NO*	*1 603 000*	*6 962 418*	*NO*	*NO*
2008	8 277 713	*NO*	*571 959*	*7 705 755*	*NO*	*NO*
2009	8 575 022	*NO*	*204 162*	*8 370 860*	*NO*	*NO*
Trend 1990-2009	*-7.76%*	*NA*	*-96.79%*	*185.04%*	*NA*	*NA*

Source: Environment Agency

As can be seen from Table 3–60, during the last years, a remarkable shift from liquid fuels towards gaseous fuels has occurred, although the total activity rate of sub-category 1A4a has been relatively constant.

3.2.9.2.2.2 Methodology

The 2006 IPCC Guidelines Tier 2 approach has been applied for CO_2, while the Tier 1 approach was used for CH_4 and N_2O.

3.2.9.2.2.3 Emission factors

Default CH_4 and N_2O emission factors have been applied. For gas oil, diesel oil, LPG and natural gas, country specific CO_2 emission factors were used: see Table 3–61.

Table 3–61 – Emission factors for IPCC Sub-category 1A4a – Commercial/Institutional

1A4a - Commercial/Institutional *Emission Factors for 2009 (kg/TJ)*								
Fuel	Fuel Type	CO_2		CH_4		N_2O		Source
		EF	type	EF	type	EF	type	
LPG	liquid	62 653	CS	5.00	D	0.10	D	AEV 2006 IPCC GL
Gas Oil	liquid	73 470	CS	10.00	D	0.60	D	AEV 2006 IPCC GL
Diesel Oil	liquid	73 470	CS	4.15	D	28.60	D	AEV 2006 IPCC GL
Natural Gas	gaseous	57 056	CS	5.00	D	0.10	D	AEV 2006 IPCC GL

Source: Environment Agency

Table 3–62 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3–62 – 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	NO	NO	NO	73 011	9.79	0.58	57 755	5.00	0.10
1991	NO	NO	NO	73 148	9.84	0.58	57 743	5.00	0.10
1992	NO	NO	NO	73 147	9.82	0.58	57 848	5.00	0.10
1993	NO	NO	NO	73 076	9.83	0.58	57 894	5.00	0.10
1994	NO	NO	NO	73 055	9.84	0.58	57 940	5.00	0.10
1995	NO	NO	NO	73 059	9.85	0.58	57 929	5.00	0.10
1996	NO	NO	NO	73 081	9.85	0.59	57 546	5.00	0.10
1997	NO	NO	NO	73 230	9.92	0.59	57 205	5.00	0.10
1998	NO	NO	NO	73 216	9.90	0.59	56 863	5.00	0.10
1999	NO	NO	NO	73 237	9.91	0.59	56 522	5.00	0.10
2000	NO	NO	NO	72 913	9.79	0.58	56 221	5.00	0.10
2001	NO	NO	NO	73 001	9.83	0.58	56 258	5.00	0.10
2002	NO	NO	NO	73 197	9.92	0.59	56 396	5.00	0.10
2003	NO	NO	NO	73 343	9.96	0.60	56 533	5.00	0.10
2004	NO	NO	NO	73 269	9.91	0.59	56 671	5.00	0.10
2005	NO	NO	NO	73 164	9.85	0.58	56 910	5.00	0.10
2006	NO	NO	NO	73 026	9.79	0.58	57 008	5.00	0.10
2007	NO	NO	NO	73 309	9.92	0.59	56 793	5.00	0.10
2008	NO	NO	NO	73 083	9.81	0.58	56 665	5.00	0.10
2009	NO	NO	NO	69 887	8.34	0.43	57 056	5.00	0.10

Source: Environment Agency

3.2.9.3 Residential (1A4b)

3.2.9.3.1 Source category description

In 2009, fuel combustion from the residential sector was responsible for 12.3% of GHG emissions from fuel combustion activities (this share was 6.2% in 1990). With regard to total GHG emissions in CO_2e, excluding LULUCF and excluding CO_2 emissions from biomass, percentages were 10.3% in 2009 and 5.2% in 1990. Compared to 2008, GHG emissions increased by 8.5%.

Residential fuel combustion is a key category with regard to CO_2 emissions. It has been a key category for both liquid and gaseous fuels without interruption since 1990.

3.2.9.3.2 Methodological issues

3.2.9.3.2.1 Activity data

Under *1A4b – Residential*, the following activities have been classified:

Non-industrial residential combustion plants < *50 MW*

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 national statistics.

However, for 1990-1999, the consumptions of gasoil and natural gas are reported under the so-called "*domestic sector*" by national statistics, covering 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*. From 2000-2009, the consumptions reported by national statistics are properly split between the two sub-categories 1A4a and 1A4b.

Fuel consumption data was converted into energy units using national NCV values.

Household and gardening

Gasoline consumption was obtained from national statistics and is only reported for the years 1998-2000.

Activity data from both stationary and mobile sources, as described above, are listed in Table 3–63.

Table 3–63 – 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	9 564 974	*268 741*	*6 359 553*	*2 936 681*	*645 000*	*NO*
1991	11 435 805	*313 244*	*7 822 330*	*3 300 231*	*645 000*	*NO*
1992	10 576 977	*253 192*	*6 985 232*	*3 338 553*	*645 000*	*NO*
1993	10 530 946	*271 499*	*6 708 868*	*3 550 579*	*645 000*	*NO*
1994	10 077 365	*179 141*	*6 406 937*	*3 491 287*	*645 000*	*NO*
1995	10 256 600	*214 226*	*6 223 973*	*3 818 401*	*645 000*	*NO*
1996	11 411 736	*133 647*	*6 794 806*	*4 483 283*	*645 000*	*NO*
1997	11 030 576	*123 577*	*6 718 170*	*4 188 829*	*645 000*	*NO*
1998	11 637 080	*89 753*	*7 040 511*	*4 506 815*	*645 000*	*NO*
1999	11 148 810	*83 642*	*6 623 529*	*4 441 640*	*645 000*	*NO*
2000	15 980 538	*63 640*	*9 358 596*	*6 558 301*	*632 000*	*NO*
2001	17 358 262	*51 332*	*10 049 330*	*7 257 600*	*683 000*	*NO*
2002	16 603 189	*40 632*	*9 231 158*	*7 331 400*	*631 000*	*NO*
2003	17 299 267	*29 511*	*9 399 256*	*7 870 500*	*644 000*	*NO*
2004	18 517 167	*27 390*	*9 964 977*	*8 524 800*	*681 000*	*NO*
2005	18 151 468	*30 074*	*9 583 966*	*8 537 429*	*653 000*	*NO*
2006	17 829 586	*25 786*	*9 904 467*	*7 899 333*	*653 000*	*NO*
2007	16 023 114	*21 523*	*9 179 574*	*6 822 017*	*585 000*	*NO*
2008	17 339 541	*19 861*	*10 131 422*	*7 188 258*	*655 000*	*NO*
2009	18 939 763	*21 702*	*10 459 902*	*8 458 159*	*646 000*	*NO*
Trend 1990-2009	*98.01%*	*-91.92%*	*64.48%*	*188.02%*	*0.16%*	*NA*

Source: Environment Agency

3.2.9.3.2.2 Methodology

The 2006 IPCC Guidelines Tier 2 approach has been applied for CO_2, while the Tier 1 approach was used for CH_4 and N_2O.

3.2.9.3.2.3 Emission factors

Default CH_4 and N_2O emission factors have been applied, while country specific CO_2 emission factor was used for the main fuels: see Table 3–64.

Table 3–64 – Emission factors for IPCC Sub-category 1A4b – Residential

1A4b - Residential *Emission Factors for 2009 (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*	*2006 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	*62 653*	*CS*	*5.00*	*D*	*0.10*	*D*	*AEV 2006 IPCC GL*
Gas Oil	liquid	*73 470*	*CS*	*10.00*	*D*	*0.60*	*D*	*AEV 2006 IPCC GL*
Gasoline	liquid	*68 890*	*CS*	*180.00*	*D*	*0.40*	*D*	*AEV 2006 IPCC GL*
Natural Gas	gaseous	*57 056*	*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 3–65 gives an overview of the evolution of the implied emission factors per fuel type.

Table 3–65 – 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	97 464	10.00	1.50	73 011	9.79	0.58	57 755	5.00	0.10
1991	97 593	10.00	1.50	73 148	9.84	0.58	57 743	5.00	0.10
1992	97 515	10.00	1.50	73 147	9.82	0.58	57 848	5.00	0.10
1993	98 441	10.00	1.50	73 076	9.83	0.58	57 894	5.00	0.10
1994	97 530	10.00	1.50	73 055	9.84	0.58	57 940	5.00	0.10
1995	101 287	10.00	1.50	73 059	9.85	0.58	57 929	5.00	0.10
1996	97 350	10.00	1.50	73 081	9.85	0.59	57 546	5.00	0.10
1997	97 367	10.00	1.50	73 230	9.92	0.59	57 205	5.00	0.10
1998	97 365	10.00	1.50	73 165	11.98	0.59	56 863	5.00	0.10
1999	97 303	10.00	1.50	73 210	11.02	0.59	56 522	5.00	0.10
2000	97 500	10.00	1.50	73 216	10.72	0.59	56 221	5.00	0.10
2001	97 500	10.00	1.50	73 247	9.94	0.59	56 258	5.00	0.10
2002	97 500	10.00	1.50	73 315	9.97	0.60	56 396	5.00	0.10
2003	97 500	10.00	1.50	73 408	9.99	0.60	56 533	5.00	0.10
2004	97 500	10.00	1.50	73 415	9.97	0.60	56 671	5.00	0.10
2005	97 500	10.00	1.50	73 406	9.96	0.60	56 910	5.00	0.10
2006	97 500	10.00	1.50	73 413	9.97	0.60	57 008	5.00	0.10
2007	97 500	10.00	1.50	73 452	9.99	0.60	56 793	5.00	0.10
2008	97 500	10.00	1.50	73 477	9.99	0.60	56 665	5.00	0.10
2009	97 500	10.00	1.50	73 400	9.97	0.60	57 056	5.00	0.10

Source: Environment Agency

3.2.9.4 Agriculture/Forestry/Fisheries (1A4c)

3.2.9.4.1 Source category description

In 2009, fuel combustion in agriculture, as well as in forestry and fishery activities, was responsible for 0.89% 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 0.74% in 2009 and 0.13% in 1990. Compared to 2008, GHG emissions increased by 53%.

Emissions of 1A4c are shown in Table 3–59 at the beginning of this section.

Fuel combustion CO_2 emissions related to agriculture/forestry/fisheries are a key category for liquid fuels from 2001 to 2003 and in 2007 and 2009.

3.2.9.4.2 Methodological issues

3.2.9.4.2.1 Activity data

Under *1A4c – Agriculture/Forestry/Fisheries*, the following activities have been classified:

Non-industrial combustion plants in agriculture, forestry and aquaculture

The consumption data of this activity group is derived from national statistics. However, only the consumption of gas oil is reported for the entire time series. Natural gas is only reported from 2000 onwards, but its consumption is very small (900 to 1800 GJ per year). Other fuels might be included elsewhere by national statistics.

Tractors and harvesters used in agriculture

Diesel oil consumption, as reported by national statistics, 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 3–66.

Table 3–66 – 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**			**Gaseous**		
		CO_2	*CH_4*	*N_2O*	*CO_2*	*CH_4*	*N_2O*
1990	213 058	*73 452*	*6.75*	*16.16*	*NO*	*NO*	*NO*
1991	255 366	*73 476*	*6.75*	*16.16*	*NO*	*NO*	*NO*
1992	254 864	*73 532*	*6.75*	*16.16*	*NO*	*NO*	*NO*
1993	212 467	*73 451*	*6.75*	*16.16*	*NO*	*NO*	*NO*
1994	254 927	*73 404*	*6.75*	*16.16*	*NO*	*NO*	*NO*
1995	212 464	*73 394*	*6.75*	*16.16*	*NO*	*NO*	*NO*
1996	254 317	*73 410*	*6.75*	*16.16*	*NO*	*NO*	*NO*
1997	297 511	*73 408*	*6.75*	*16.16*	*NO*	*NO*	*NO*
1998	297 473	*73 424*	*6.75*	*16.16*	*NO*	*NO*	*NO*
1999	382 614	*73 421*	*9.35*	*3.71*	*NO*	*NO*	*NO*
2000	605 421	*73 369*	*4.15*	*28.60*	*56 221*	*5.00*	*0.10*
2001	683 480	*73 370*	*4.15*	*28.60*	*56 258*	*5.00*	*0.10*
2002	676 567	*73 374*	*4.15*	*28.60*	*56 396*	*5.00*	*0.10*
2003	719 517	*73 435*	*4.15*	*28.60*	*56 533*	*5.00*	*0.10*
2004	696 073	*73 470*	*4.15*	*28.60*	*56 671*	*5.00*	*0.10*
2005	706 080	*73 492*	*4.15*	*28.60*	*56 910*	*5.00*	*0.10*
2006	724 150	*73 483*	*4.15*	*28.60*	*57 008*	*5.00*	*0.10*
2007	772 512	*73 482*	*4.15*	*28.60*	*56 793*	*5.00*	*0.10*
2008	721 376	*73 501*	*4.15*	*28.60*	*56 665*	*5.00*	*0.10*
2009	1 105 920	*73 470*	*4.15*	*28.60*	*57 056*	*5.00*	*0.10*

Source: Environment Agency

3.2.9.4.2.2 Methodological issues

The 2006 IPCC Guidelines Tier 2 approach has been applied.

3.2.9.4.2.3 Emission factors

Country specific CO_2 emission factors for have been applied for natural gas, gas oil and diesel oil, whereas for CH_4 and N_2O, default 2006 IPCC EFs were used (Table 3–67).

Table 3–67 – Emission factors for IPCC Sub-category 1A4c – Agriculture/Forestry/Fisheries

1A4c - Agriculture/Forestry/Fisheries *Emission Factors for 2009 (kg/TJ)*								
Fuel	**Fuel Type**	*CO_2*		*CH_4*		*N_2O*		***Source***
		EF	***type***	***EF***	***type***	***EF***	***type***	
Gas Oil	liquid	*73 503*	*CS*	*10.00*	*D*	*0.60*	*D*	*AEV* *2006 IPCC GL*
Diesel Oil	liquid	*73 503*	*CS*	*4.15*	*D*	*28.60*	*D*	*AEV* *2006 IPCC GL*
Natural Gas	gaseous	*57 056*	*CS*	*5.00*	*D*	*0.10*	*D*	*AEV* *2006 IPCC GL*

Source: Environment Agency

An overview of the evolution of the implied emission factors per fuel type is given in Table 3–66.

3.2.9.5 Uncertainties and time-series consistency

For uncertainties on activity data and emission factors, please refer to section 1.7.

The time series reported under *1A4 - Other Sectors*, are considered to be consistent, to the best of data availability. Further investigations will be needed, in collaboration with STATEC, to see whether, for the years 1990-1999, the arbitrary 50/50 split between 1A4a and 1A4b could be replaced by a more accurate split.

3.2.9.6 Source-specific QA/QC and verification

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.

3.2.9.7 Source-specific recalculations

Table 3–68 presents the main revisions and recalculations done since submission 2010v2.1 relevant to IPCC sub-category *1A4 – Other Sectors*.

Table 3–68 – Recalculations done since submission 2010v2.1

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v2.1	Type of revision
1A4	AD was revised due to revised energy balance from national statistics.	updated AD
1A4a / 1A4b	2000-2009: split of fuel consumption between 1A4a and 1A4b has been revised, based on the revised energy balance.[114]	revised AD
1A4a / 1A4b	Solid fuels and biomass from 1A4a were reallocated to 1A4b, as the revised energy balance from national statistics allocated these fuel types to 1A4b only.	reallocated AD

3.2.9.8 Source-specific 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 3–69 will be explored.

Table 3–69 – 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 and the residential sector for the years 1990-1999.

114 ARR 2009, § 50

3.2.10 Other (1A5)

3.2.10.1 Source category description

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 2009, no GHG emissions occurred in IPCC Sub-category 1A5, hence, notation key *NO* is used. In 1990, 1A5 was responsible for 0.16% of GHG emissions from fuel combustion activities and represented around 0.23% of the total GHG emissions in CO_2e, excluding LULUCF..

Table 3–70 summarizes GHG emissions for IPCC sub-category 1A5.

3.2.10.2 Stationary (1A5a)

3.2.10.2.1 Source category description

In 2009, no emissions from fuel combustion activities from *1A5a - Stationary* were reported (notation key NO). In 1990 this category was responsible for 0.03% of GHG emissions from fuel combustion activities. With regard to total GHG emissions in CO_2e, excluding LULUCF and excluding CO_2 emissions from biomass, the share was 0.02% in 1990.

1A5a - Stationary related GHG emissions are not a key category.

3.2.10.2.2 Methodological issues:

3.2.10.2.2.1 Activity data

Fuel consumption data (gas oil, LPG) is obtained from national statistics (STATEC, IEA Joint Questionnaires) and was attributed to this sub-category based on expert judgement. Activity data is listed in Table 3–71.

3.2.10.2.2.2 Methodology

The 2006 IPCC Guidelines Tier 2 approach has been applied for CO_2.

Table 3–70 – GHG emission trends in CO_2e for IPCC Sub-category 1A4 – Other Sectors: 1990-2009

Year	1A5 - Other *GHG emissions by source & sink category (Gg)* 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	2.88	*2.88*	*0.000229*	*0.000005*	26.25	*23.40*	*0.0013*	*0.0091*	**29.14**	*26.28*	*0.0016*	*0.0091*
1991	2.89	*2.88*	*0.000229*	*0.000005*	26.26	*23.41*	*0.0013*	*0.0091*	**29.15**	*26.29*	*0.0016*	*0.0091*
1992	2.88	*2.88*	*0.000229*	*0.000005*	26.28	*23.43*	*0.0013*	*0.0091*	**29.16**	*26.30*	*0.0016*	*0.0091*
1993	2.86	*2.86*	*0.000229*	*0.000005*	22.76	*20.29*	*0.0011*	*0.0079*	**25.62**	*23.14*	*0.0014*	*0.0079*
1994	2.86	*2.86*	*0.000229*	*0.000005*	21.00	*18.71*	*0.0011*	*0.0073*	**23.86**	*21.57*	*0.0013*	*0.0073*
1995	2.64	*2.64*	*0.000211*	*0.000004*	8.75	*7.80*	*0.0004*	*0.0030*	**11.39**	*10.43*	*0.0007*	*0.0030*
1996	2.55	*2.54*	*0.000204*	*0.000004*	17.46	*15.56*	*0.0009*	*0.0061*	**20.01**	*18.10*	*0.0011*	*0.0061*
1997	6.83	*6.82*	*0.000546*	*0.000011*	17.50	*15.60*	*0.0009*	*0.0061*	**24.33**	*22.42*	*0.0014*	*0.0061*
1998	8.40	*8.38*	*0.000669*	*0.000013*	28.01	*24.96*	*0.0014*	*0.0097*	**36.40**	*33.34*	*0.0021*	*0.0097*
1999	12.02	*11.99*	*0.000948*	*0.000019*	35.02	*31.21*	*0.0018*	*0.0122*	**47.04**	*43.21*	*0.0027*	*0.0122*
2000	11.46	*11.43*	*0.000914*	*0.000018*	NO	*NO*	*NO*	*NO*	**11.46**	*11.43*	*0.0009*	*0.0000*
2001	22.82	*22.77*	*0.001821*	*0.000036*	NO	*NO*	*NO*	*NO*	**22.82**	*22.77*	*0.0018*	*0.0000*
2002	12.61	*12.58*	*0.001004*	*0.000020*	NO	*NO*	*NO*	*NO*	**12.61**	*12.58*	*0.0010*	*0.0000*
2003	2.96	*2.95*	*0.000235*	*0.000005*	NO	*NO*	*NO*	*NO*	**2.96**	*2.95*	*0.0002*	*0.0000*
2004	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*	**NO**	*NO*	*NO*	*NO*
2005	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*	**NO**	*NO*	*NO*	*NO*
2006	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*	**NO**	*NO*	*NO*	*NO*
2007	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*	**NO**	*NO*	*NO*	*NO*
2008	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*	**NO**	*NO*	*NO*	*NO*
2009	NO	*NO*	*NO*	*NO*	NO	*NO*	*NO*	*NO*	**NO**	*NO*	*NO*	*NO*
Trend 1990-2009	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

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 3–71 – 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	45 728	62 918	5.00	0.10	318 580	73 452	4.15	28.60
1991	45 728	63 047	5.00	0.10	318 580	73 476	4.15	28.60
1992	45 728	62 892	5.00	0.10	318 580	73 532	4.15	28.60
1993	45 728	62 436	5.00	0.10	276 206	73 451	4.15	28.60
1994	45 728	62 436	5.00	0.10	254 927	73 404	4.15	28.60
1995	42 224	62 436	5.00	0.10	106 232	73 394	4.15	28.60
1996	40 752	62 436	5.00	0.10	211 931	73 410	4.15	28.60
1997	109 177	62 436	5.00	0.10	212 508	73 408	4.15	28.60
1998	133 810	62 612	5.00	0.10	339 969	73 424	4.15	28.60
1999	189 645	63 249	5.00	0.10	425 126	73 421	4.15	28.60
2000	182 846	62 530	5.00	0.10	NO	NO	NO	NO
2001	364 232	62 521	5.00	0.10	NO	NO	NO	NO
2002	200 842	62 653	5.00	0.10	NO	NO	NO	NO
2003	47 005	62 820	5.00	0.10	NO	NO	NO	NO
2004	NO	NO	NO	NO	NO	NO	NO	NO
2005	NO	NO	NO	NO	NO	NO	NO	NO
2006	NO	NO	NO	NO	NO	NO	NO	NO
2007	NO	NO	NO	NO	NO	NO	NO	NO
2008	NO	NO	NO	NO	NO	NO	NO	NO
2009	NO	NO	NO	NO	NO	NO	NO	NO

Source: Environment Agency

3.2.10.2.2.3 Emission factors

Country specific CO_2 emission factors for have been applied for gas oil and LPG, whereas for CH_4 and N_2O, default 2006 IPCC EFs were used Table 3–72.

Table 3–72 – Emission factors for IPCC Sub-category 1A5 – Other

1A5 - Other *Emission Factors for 2009 (kg/TJ)*								
Fuel	Fuel Type	CO_2		CH_4		N_2O		Source
		EF	type	EF	type	EF	type	
LPG	liquid	62 653	CS	5.00	D	0.10	D	AEV 2006 IPCC GL
Gas Oil	liquid	73 470	CS	10.00	D	0.60	D	AEV 2006 IPCC GL
Diesel Oil	liquid	73 470	CS	4.15	D	28.60	D	AEV 2006 IPCC GL

Source: Environment Agency

An overview of the evolution of the implied emission factors per fuel type is given in Table 3–71.

3.2.10.3 Mobile (1A5b)

3.2.10.3.1 Source category decription

In 2009, no emissions from fuel combustion activities from *1A5b - Mobile* were reported (notation key NO). In 1990 this category was responsible for 0.25% of GHG emissions from fuel combustion activities. With regard to total GHG emissions in CO_2e, excluding LULUCF and excluding CO_2 emissions from biomass, the share was 0.20% in 1990.

1A5b - Mobile related GHG emissions are not a key category.

3.2.10.3.2 Methodological issues

3.2.10.3.2.1 Activity data

Fuel consumption data (diesel oil) is obtained from national statistics (STATEC, IEA Joint Questionnaires) and was attributed to this sub-category based on expert judgement. Activity data is listed in Table 3–71.

3.2.10.3.2.2 Methodology

The 2006 IPCC Guidelines Tier 2 approach has been applied for CO_2.

3.2.10.3.2.3 Emission factors

Country specific CO_2 emission factors for have been applied for diesel oil, whereas for CH_4 and N_2O, default 2006 IPCC EFs were used Table 3–72.

3.2.10.4 Uncertainties and time-series consistency

For uncertainties on activity data and emission factors, please refer to section 1.7.

The time series reported under *1A5 - Other* are considered to be consistent.

3.2.10.5 Source-specific QA/QC and verification

Standard QA/QC procedures were followed.

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

3.2.10.6 Source-specific recalculations

Table 3–73 presents the main revisions and recalculations done since submission 2010v2.1 relevant to IPCC sub-category *1A5 – Other*.

Table 3–73 – Recalculations done since submission 2010v2.1

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
1A5	AD was revised according to the revised energy balance from national statistics.	updated AD

3.2.10.7 Source-specific 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 3–74 will be explored.

Table 3–74 – Planned improvements for IPCC Sub-category 1A5 – Other

GHG source & sink category	Planned improvement
1A5 – Other	further investigate whether the consumption data for the remaining years, reported by the national statistics, has been correctly understood, and correctly allocated.

3.3 Fugitive Emissions from Fuels (1B)

3.3.1 Solid Fuels (1B1)

This source category does not exist in Luxembourg.

3.3.2 Oil and Natural Gas (1B2)

3.3.2.1 Source category description

In Luxembourg, fugitive emissions only occur from natural gas transmission, distribution and leakages (IPCC Sub-categories 1B2b3, 1B2b4 and 1B2b5). 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 from oil distribution (IPCC Sub-category 1B2a5) are reported with notation key NA in the CRF tables, as only NMVOC emissions occur.

With regards to natural gas, methane emissions from leaks or accidental events are included in IPCC sub-categories *1B2b3 – Transmission* and *1B2b4 – Distribution*, hence notation key IE used in IPCC sub-category *1B2b5 – Other Leakage*.

In 2009, fugitive emissions from IPCC category *1B2 – Oil and Natural Gas* were responsible for 0.41% of GHG emissions from the energy sector (0.16% in 1990) and represented 0.34% of the total GHG emissions in CO_2e, excluding LULUCF (0.13% in 1990). Compared to 2008, fugitive GHG emissions increased by 1.1%. Table 3–75 summarizes GHG emissions for IPCC category 1B2.

Fugitive emissions from *1B2 – Oil and Natural Gas* are not a key category.

Table 3–75 – GHG emission trends in CO_2e for IPCC Sub-category 1B2 – Oil and Natural Gas: 1990-2009

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	NA	*NA*	*NA*	*NO*	16.29	*0.03*	*16.26*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**16.29**	*0.03*	*16.26*	*NA,NO*
1991	NA	*NA*	*NA*	*NO*	16.90	*0.03*	*16.87*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**16.90**	*0.03*	*16.87*	*NA,NO*
1992	NA	*NA*	*NA*	*NO*	17.63	*0.03*	*17.61*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**17.63**	*0.03*	*17.61*	*NA,NO*
1993	NA	*NA*	*NA*	*NO*	18.30	*0.03*	*18.28*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**18.30**	*0.03*	*18.28*	*NA,NO*
1994	NA	*NA*	*NA*	*NO*	18.43	*0.03*	*18.40*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**18.43**	*0.03*	*18.40*	*NA,NO*
1995	NA	*NA*	*NA*	*NO*	21.02	*0.03*	*20.98*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**21.02**	*0.03*	*20.98*	*NA,NO*
1996	NA	*NA*	*NA*	*NO*	22.99	*0.04*	*22.95*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**22.99**	*0.04*	*22.95*	*NA,NO*
1997	NA	*NA*	*NA*	*NO*	23.51	*0.04*	*23.48*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**23.51**	*0.04*	*23.48*	*NA,NO*
1998	NA	*NA*	*NA*	*NO*	23.70	*0.04*	*23.66*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**23.70**	*0.04*	*23.66*	*NA,NO*
1999	NA	*NA*	*NA*	*NO*	24.53	*0.04*	*24.49*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**24.53**	*0.04*	*24.49*	*NA,NO*
2000	NA	*NA*	*NA*	*NO*	25.18	*0.04*	*25.14*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**25.18**	*0.04*	*25.14*	*NA,NO*
2001	NA	*NA*	*NA*	*NO*	28.06	*0.04*	*28.01*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**28.06**	*0.04*	*28.01*	*NA,NO*
2002	NA	*NA*	*NA*	*NO*	40.16	*0.06*	*40.10*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**40.16**	*0.06*	*40.10*	*NA,NO*
2003	NA	*NA*	*NA*	*NO*	40.71	*0.06*	*40.65*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**40.71**	*0.06*	*40.65*	*NA,NO*
2004	NA	*NA*	*NA*	*NO*	45.14	*0.07*	*45.07*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**45.14**	*0.07*	*45.07*	*NA,NO*
2005	NA	*NA*	*NA*	*NO*	44.42	*0.07*	*44.35*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**44.42**	*0.07*	*44.35*	*NA,NO*
2006	NA	*NA*	*NA*	*NO*	46.62	*0.07*	*46.54*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**46.62**	*0.07*	*46.54*	*NA,NO*
2007	NA	*NA*	*NA*	*NO*	43.61	*0.07*	*43.54*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**43.61**	*0.07*	*43.54*	*NA,NO*
2008	NA	*NA*	*NA*	*NO*	41.70	*0.07*	*41.64*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**41.70**	*0.07*	*41.64*	*NA,NO*
2009	NA	*NA*	*NA*	*NO*	42.15	*0.07*	*42.08*	*NA*	NO	*NO*	*NO*	*NO*	NA	*NA*	*NA*	*NA*	**42.15**	*0.07*	*42.08*	*NA,NO*
Trend 1990-2009	*NA*	*NA*	*NA*	*NA*	*158.73%*	*158.73%*	*158.73%*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*158.73%*	*158.73%*	*158.73%*	*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.

3.3.2.2 Methodological issues

3.3.2.2.1 Activity data

Activity data on national natural gas consumption are obtained from national statistics and are listed in Table 3–76.

Table 3–76 – Activity data for IPCC Sub-category 1B2 – Oil and Natural Gas: 1990-2009

Natural Gas Consumption (GJ)									
1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
17'933'317	18'646'148	19'434'013	20'184'361	20'334'431	23'237'685	25'491'948	26'121'115	26'375'107	27'358'063
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
28'107'906	31'246'200	44'666'100	45'214'200	50'068'800	49'248'165	51'513'517	48'083'522	45'771'030	46'576'577

Source: STATEC: Statistical Yearbook, table A4200 (natural gas) and converted to the NCV basis.

3.3.2.2.2 Methodology

The 2006 IPCC Guidelines Tier 1 approach has been applied.

3.3.2.2.3 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: $1.1*10^{-3}$ $Gg/10^6 m^3$

3.3.2.3 Uncertainties and time-series consistency

For uncertainties on activity data and emission factors, please refer to section 1.7.

The time series reported under *1B2 - Oil and Natural Gas* are considered to be consistent.

3.3.2.4 Source-specific QA/QC and verification

Standard QA/QC procedures were followed.

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

3.3.2.5 Source-specific recalculations

Table 3–77 presents the main revisions and recalculations done since submission 2010v2.1 relevant to IPCC category *1B2 – Oil and Natural Gas*.

Table 3–77 – Recalculations done since submission 2010v2.1

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
1B2b3 1B2b4	Natural Gas: national consumption is now calculated on the NCV basis. National statistics express the consumption on the GCV basis.	updated AD

3.3.2.6 Source-specific 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 3–78 will be explored.

Table 3–78 – Planned improvements for IPCC Sub-category 1A5 – Other

GHG source & sink category	Planned improvement
1B2a5 - Distribution of refined oil products	Assess whether these emissions occur and, if appropriate, estimate and report fugitive emissions from the infrastructure supporting the transport, distribution, storage and sale of refined fuel oils. Investigate the German EFs in detail, since it is the only country reporting emissions from the distribution of oil products.[115]

115 ARR 2010, §44

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 2009.

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).

4.1.1 Emission Trends

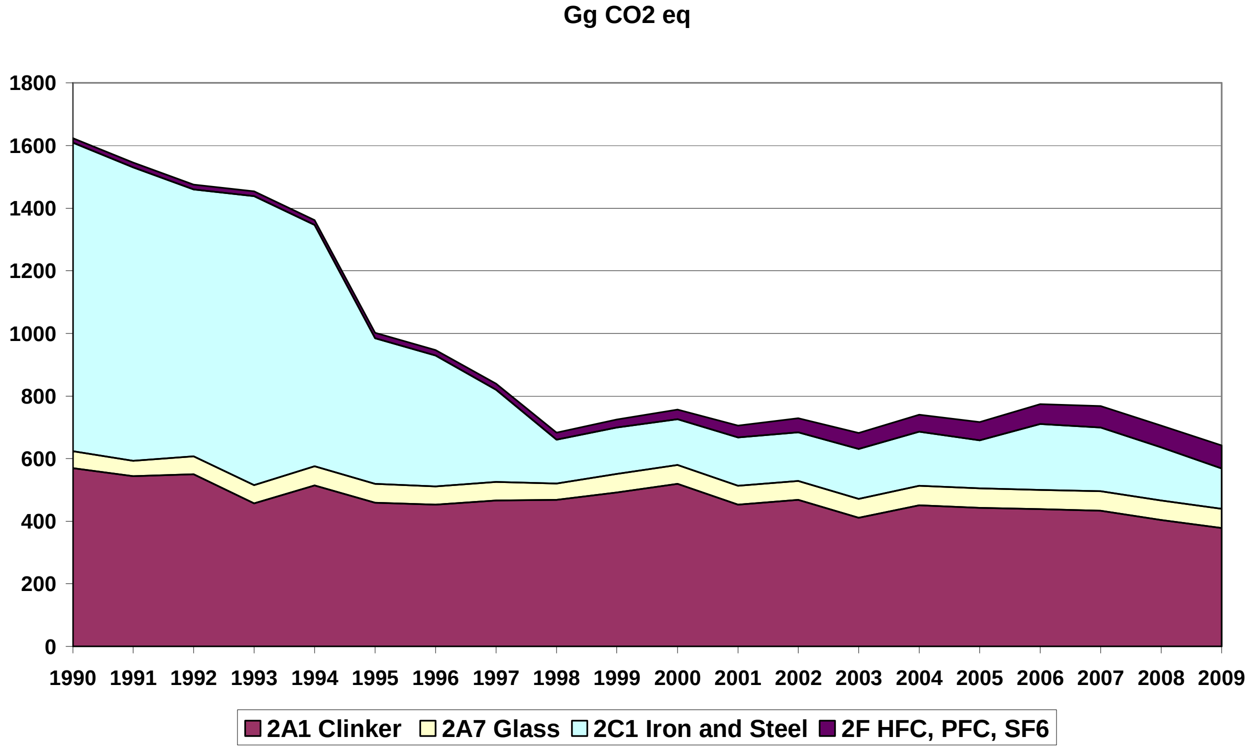
This section briefly describes the emission trends from 1990 to 2009 for each of the IPCC categories under CRF Sector 2 for which GHG emissions are reported – i.e. categories *2A – Mineral Products*, *2C – Metal Production* and *2F - Consumption of Halocarbons and* SF_6.

Industrial process emissions include emissions from industrial installations and from consumption of halocarbons and SF_6 (the fluorinated gases (HFCs, PFCs, SF_6) or F-gases). 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 60.3% between 1990 and 2009 (-64.6% for carbon dioxide but +400% for F-gases). It is for IPCC Category *2C – Metal Production* that CO_2 emissions have decreased the most over the period: -86.9%. For IPCC Category 2A – Mineral Products the decline is limited to -29.4% 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 clinker works unit and one flat glass manufacturing company;
- IPCC sub-category 2C: the iron and steel manufacturing company ArcelorMittal, as already mentioned in previous chapters.

Figure 4-1 – GHG emission trends for CRF Sector 2 – Industrial Processes: 1990-2009



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., Chapter 2) 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 2009. 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: 1990-2009

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	623.45	623.45	NO	NO	984.91	984.91	NO	NO	14.67	13.54	NO	1.13	1 623.03	1 608.36	NO	NO	14.67
1991	592.76	592.76	NO	NO	937.74	937.74	NO	NO	14.75	13.54	NO	1.21	1 545.26	1 530.51	NO	NO	14.75
1992	607.15	607.15	NO	NO	853.29	853.29	NO	NO	14.83	13.54	NO	1.29	1 475.28	1 460.44	NO	NO	14.83
1993	515.03	515.03	NO	NO	923.19	923.19	NO	NO	15.20	13.83	NO	1.37	1 453.43	1 438.23	NO	NO	15.20
1994	575.35	575.35	NO	NO	770.83	770.83	NO	NO	15.78	14.32	NO	1.46	1 361.97	1 346.19	NO	NO	15.78
1995	519.11	519.11	NO	NO	465.38	465.38	NO	NO	17.18	15.62	NO	1.55	1 001.67	984.50	NO	NO	17.18
1996	512.12	512.12	NO	NO	416.60	416.60	NO	NO	17.73	16.02	NO	1.71	946.46	928.72	NO	NO	17.73
1997	525.97	525.97	NO	NO	294.10	294.10	NO	NO	19.20	17.32	NO	1.87	839.27	820.07	NO	NO	19.20
1998	520.30	520.30	NO	NO	140.69	140.69	NO	NO	22.11	20.14	NO	1.97	683.09	660.99	NO	NO	22.11
1999	551.34	551.34	NO	NO	147.70	147.70	NO	NO	26.16	24.12	NO	2.05	725.20	699.04	NO	NO	26.16
2000	579.74	579.74	NO	NO	146.05	146.05	NO	NO	30.95	28.79	0.01	2.15	756.73	725.78	NO	NO	30.95
2001	513.12	513.12	NO	NO	154.76	154.76	NO	NO	37.20	34.38	0.01	2.82	705.08	667.88	NO	NO	37.20
2002	528.32	528.32	NO	NO	155.40	155.40	NO	NO	45.47	42.09	0.01	3.37	729.20	683.72	NO	NO	45.47
2003	471.66	471.66	NO	NO	158.94	158.94	NO	NO	51.11	47.00	0.02	4.09	681.71	630.60	NO	NO	51.11
2004	513.37	513.37	NO	NO	172.45	172.45	NO	NO	54.11	49.40	0.11	4.60	739.92	685.82	NO	NO	54.11
2005	504.99	504.99	NO	NO	152.92	152.92	NO	NO	58.43	53.23	0.15	5.04	716.34	657.91	NO	NO	58.43
2006	500.63	500.63	NO	NO	209.79	209.79	NO	NO	63.02	57.15	0.17	5.71	773.44	710.42	NO	NO	63.02
2007	496.26	496.26	NO	NO	203.49	203.49	NO	NO	67.69	61.33	0.21	6.15	767.44	699.74	NO	NO	67.69
2008	466.41	466.41	NO	NO	169.30	169.30	NO	NO	70.50	63.68	0.24	6.57	706.21	635.71	NO	NO	70.50
2009	440.16	440.16	NO	NO	128.66	128.66	NO	NO	73.40	65.78	0.22	7.40	642.21	568.81	NO	NO	73.40
Trend 2008-2009	-5.63%	-5.63%	NA	NA	-24.01%	-24.01%	NA	NA	4.11%	3.29%	16.62%	12.65%	-9.06%	-10.52%	NA	NA	4.11%
Trend 1990-2009	-29.40%	-29.40%	NA	NA	-86.94%	-86.94%	NA	NA	400.26%	385.64%	NA	556.54%	-60.43%	-64.63%	NA	NA	400.26%

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 (*GW*P) 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: 1990-2009

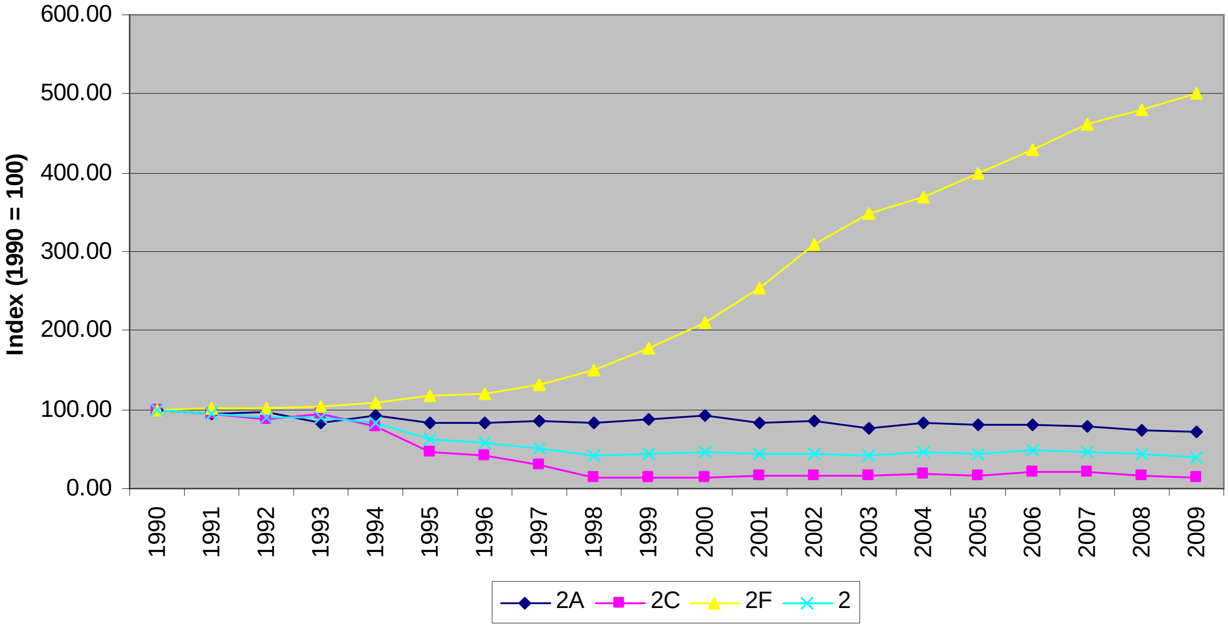
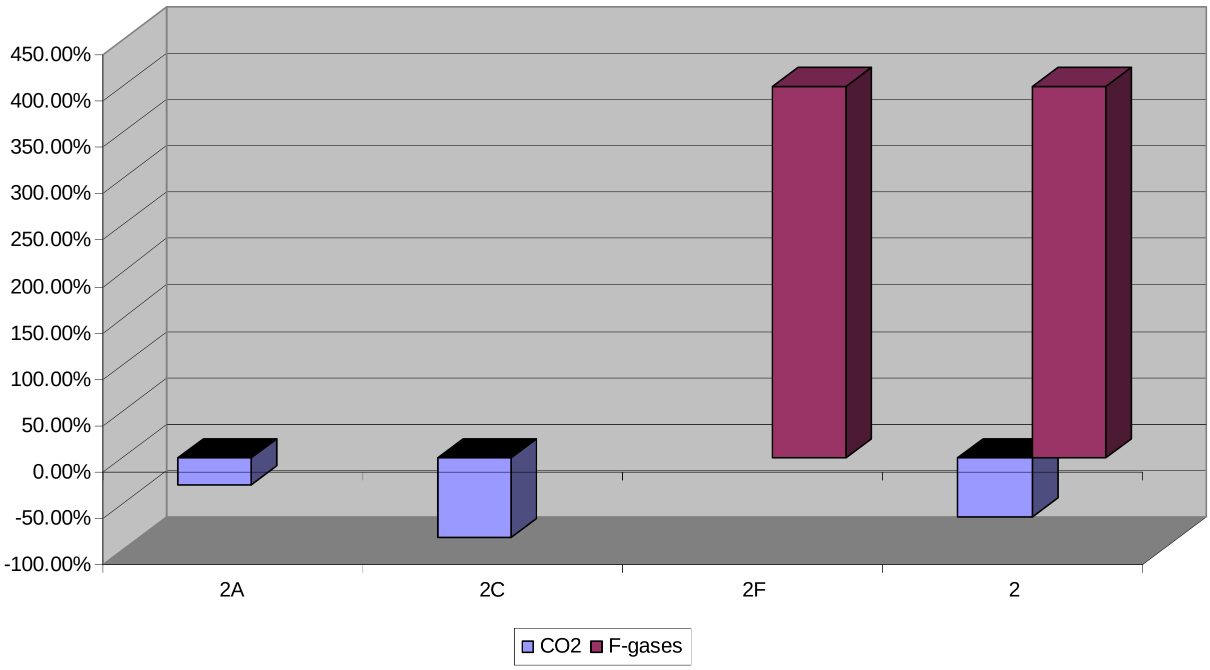


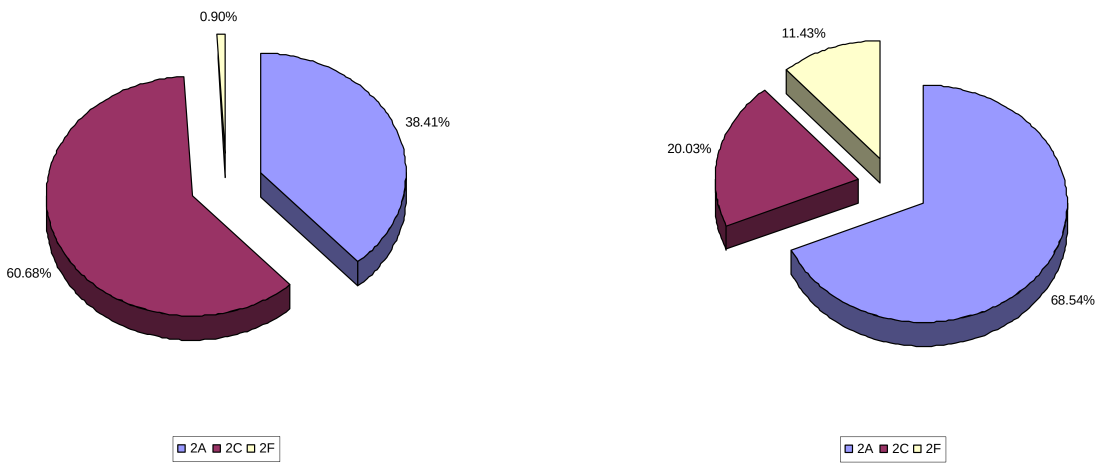
Figure 4-3 – GHG emission trends in % for CRF Sector 2 – Industrial Processes: 1990-2009



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 2009

1990 *2009*



4.1.2 Key Categories

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	CO_2	90-09	90-09	X	X
2A7	Other - Glass Production	CO_2	95-09			
2C1	Iron & Steel Production	CO_2	90-09	90-00, 06-08	X	X
2F	Consumption of Halocarbons & SF6	F-gases	04-09		X	X

Source: Environment Agency

Notes: LA = Level Assessement including respectively exluding LULUCF

TA = Trend Assessement 2008 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**	**X**	NO
2F2	consumption of halocarbons and SF_6 - foam blowing	**X**	NO	NO
2F3	consumption of halocarbons and SF_6 - fire extinguishers	NO	NO	NO
2F4	consumption of halocarbons and SF_6 - aerosols/metered dose inhalers	**X**	NO	NO
2F5	consumption of halocarbons and SF_6 - solvents	NO	NO	NO
2F6	consumption of halocarbons and SF_6 - other applications using ODS substitutes	NO	NO	NO
2F7	consumption of halocarbons and SF_6 - semiconductor manufacture	NO	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**
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.

4.2 Mineral Products (2A)

This section describes the estimation of carbon dioxide emissions resulting from industrial processes used in clinker works and flat glass production installations. In 2009, this source category was responsible for 77.4% of CO_2 emissions from industrial processes – but only 38.6% in 1990 – and for 4.1% of the total CO_2 emissions estimated for Luxembourg. It represented 3.8% of the total GHG emissions in CO_2e (excluding LULUCF) in 2009 and 4.9% in 1990.

4.2.1 Cement Production (2A1)

4.2.1.1 Source category description

In 2009, clinker production was responsible for 66.5% of CO_2 emissions from industrial processes – but only 35.4% in 1990 – and for 3.3% of the total CO_2 emissions estimated for Luxembourg. It represented 3.1% of the total GHG emissions in CO_2e (excluding LULUCF).

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 Methodological issues

4.2.1.2.1 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).

4.2.1.2.2 Methodology

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: 1990-2009

2A1 - Clinker Production *Activity data, emissions and implied emission factors*			
Year	AD t	CO_2 *Gg*	IEF *kg CO_2 / t clinker*
1990	1048 000	*569.88*	*543.78*
1991	1001 637	*544.10*	*543.21*
1992	1013 452	*549.88*	*542.58*
1993	842 855	*456.79*	*541.95*
1994	950 854	*514.72*	*541.33*
1995	848 455	*458.76*	*540.70*
1996	837 518	*452.38*	*540.14*
1997	865 659	*467.09*	*539.58*
1998	870 053	*468.98*	*539.02*
1999	913 265	*491.76*	*538.47*
2000	965 369	*519.28*	*537.91*
2001	843 608	*452.71*	*536.64*
2002	874 577	*468.22*	*535.37*
2003	769 754	*411.12*	*534.10*
2004	847 389	*451.51*	*532.83*
2005	833 798	*443.21*	*531.56*
2006	826 131	*438.74*	*531.08*
2007	816 688	*433.34*	*530.60*
2008	761 816	*403.86*	*530.13*
2009	708 048	*378.06*	*533.94*
Trend 2008-2009	*-7.06%*	*-6.39%*	*0.72%*
Trend 1990-2009	*-32.44%*	*-33.66%*	*-1.81%*

Sources: AD: plant operator ; CO2 and IEF: Environment Agency

4.2.1.2.3 Emission factors

According to 2007 ETS Tier 3 method, the emission factor is based on the CaO and MgO content of the clinker:

$$EF_{clinker} = 0.785 \bullet CaO\ Content + 1.092 \bullet MgO\ Content\ (Weight\ Fraction\ in\ Clinker)$$

It is assumed that all the CaO and MgO are from carbonate source (e.g. $CaCO_3$ and $MgCO_3$ in lime-stone). Plant-specific CaO and MgO contents are available (chemical analysis done by the plant operator). These contents are provided in Table 4-6.

Table 4-6 – CaO and MgO contents in %

Year	CaO Content weight %	MgO Content weight %
1990	67.72%	1.12%
1995	67.46%	1.02%
2000	67.16%	0.98%
2005	66.49%	0.88%
2008	66.28%	0.90%
2009	66.78%	0.89%

Source: plant operator

The CaO and MgO contents for the years for which no CaO and no MgO contents are available, are estimated by a linear interpolation (Table 4-7).

Table 4-7 – Effective and interpolated CaO content in % and EFs: 1990-2009

Year	CaO (%) operator	CaO (%) *interpolation*	MgO (%) *operator*	MgO (%) *interpolation*	EF *kg CO_2 / t clinker*
	2A1 - Cement Production *CaO content & emission factors*				
1990	67.72	*67.72*	*1.12*	*1.12*	*543.78*
1991		*67.67*		*1.10*	*543.21*
1992		*67.62*		*1.08*	*542.58*
1993		*67.56*		*1.06*	*541.95*
1994		*67.51*		*1.04*	*541.33*
1995	67.46	*67.46*	*1.02*	*1.02*	*540.70*
1996		*67.40*		*1.01*	*540.14*
1997		*67.34*		*1.00*	*539.58*
1998		*67.28*		*1.00*	*539.02*
1999		*67.22*		*0.99*	*538.47*
2000	67.16	*67.16*	*0.98*	*0.98*	*537.91*
2001		*67.03*		*0.96*	*536.64*
2002		*66.89*		*0.94*	*535.37*
2003		*66.76*		*0.92*	*534.10*
2004		*66.62*		*0.90*	*532.83*
2005	66.49	*66.49*	*0.88*	*0.88*	*531.56*
2006		*66.42*		*0.89*	*531.08*
2007		*66.35*		*0.89*	*530.60*
2008	66.28	*66.28*	*0.90*	*0.90*	*530.13*
2009	66.78	*66.78*	*0.89*	*0.89*	*533.94*

Sources: plant operator and Environment Agency

The calculated plant-specific EFs are consistent with the 2007 ETS Tier 1 Guidelines default EF of 525 kg CO_2/t clinker.

4.2.1.3 Uncertainties and time-series consistency

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 %

4.2.1.4 Source-specific QA/QC and verification

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.

4.2.1.5 Source-specific recalculations

No recalculations were done since the last submission.

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

4.2.7.1 Source category description

In 2009, glass production was responsible for 10.9% of CO_2 emissions from industrial processes – but only 3.3% in 1990 – and for 0.55% of the total CO_2 emissions estimated for Luxembourg. It represented 0.51% of the total GHG emissions in CO_2e (excluding LULUCF).

2A7 - Glass Production is a key source with regard to CO_2 emissions. It has been a key source since 1995: see Table 4-2 in Section 4.1.2.

4.2.7.2 Methodological issues

4.2.7.2.1 <u>Activity data</u>

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).

4.2.7.2.2 Methodology

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: 1990-2009

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*
2008	440 538	*62.56*	*142.00*
2009	437 319	*62.10*	*142.00*
Trend 2008-2009	*-0.73%*	*-0.73%*	*0.00%*
Trend 1990-2009	*15.93%*	*15.93%*	*0.00%*

Sources: AD: plant operator ; CO2 and IEF: Environment Agency

4.2.7.2.3 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 specific EF is consistent with the calculated value for 2009 according to the 2007 ETS Guidelines carbonates method. For 2009, plant-specific EF's of 142.2 and 140.0 kg CO_2/t glass were determined based on the carbonates contents in the raw materials and the activity data for plant 1 and plant 2.

4.2.7.3 Uncertainties and time-series consistency

Estimation of uncertainties based on expert judgement:

- Activity data uncertainty .... 2.0 %
- Emission factor uncertainty .... 5.0 %
- Cumulative emission uncertainty .. 5.4 %

4.2.7.4 Source-specific QA/QC and verification

The calculated CO_2 emission is consistent with the calculated value according to the 2007 ETS Guidelines' carbonates method.

4.2.7.5 Source-specific recalculations

No revisions and recalculations have been done since the submission 2010v2.1 to IPCC sub-category 2A7.

4.2.8 Source-specific 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
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[116] (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)

4.4.1.1 Source category description

In 2009, iron and steel production was responsible for 22.6% of CO_2 emissions from industrial processes – but 61.2% in 1990 – and for 1.14%of the total CO_2 emissions estimated for Luxembourg. It represented 1.05% 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: 1990-2009

2C1 - Iron & Steel Production *Emissions, AD, IEFs*					
Year	CO_2 (Gg)	BOF (t)	EAF (t)	Total (t)	IEF kg CO_2/t steel
1990	984.91	*3506 230*	*NO*	3506 230	280.90
1991	937.74	*3379 440*	*NO*	3379 440	277.48
1992	853.29	*3068 463*	*NO*	3068 463	278.08
1993	923.19	*3288 847*	*4 095*	3292 942	280.36
1994	770.83	*2627 278*	*445 990*	3073 268	250.82
1995	465.38	*1410 469*	*1202 668*	2613 137	178.09
1996	416.60	*1168 070*	*1333 758*	2501 828	166.52
1997	294.10	*597 814*	*1982 405*	2580 219	113.98
1998	140.69	*NO*	*2476 909*	2476 909	56.80
1999	147.70	*NO*	*2600 324*	2600 324	56.80
2000	146.05	*NO*	*2571 243*	2571 243	56.80
2001	154.76	*NO*	*2724 679*	2724 679	56.80
2002	155.40	*NO*	*2736 000*	2736 000	56.80
2003	151.94	*NO*	*2675 000*	2675 000	56.80
2004	152.45	*NO*	*2684 000*	2684 000	56.80
2005	119.13	*NO*	*2194 485*	2194 485	54.29
2006	170.49	*NO*	*2802 049*	2802 049	60.85
2007	162.22	*NO*	*2845 872*	2845 872	57.00
2008	134.69	*NO*	*2584 341*	2584 341	52.12
2009	112.66	*NO*	*2103 281*	2103 281	53.56

Sources: AD: plant operator ; Statec
Note: STATEC's 1990 value for BOF replaced by TÜV Rheinland 1992-1993 study reported value.

116 Accounted for under IPCC Category 1A – Fuel Combustion Activities. See also Section 4.4.1.3 below.

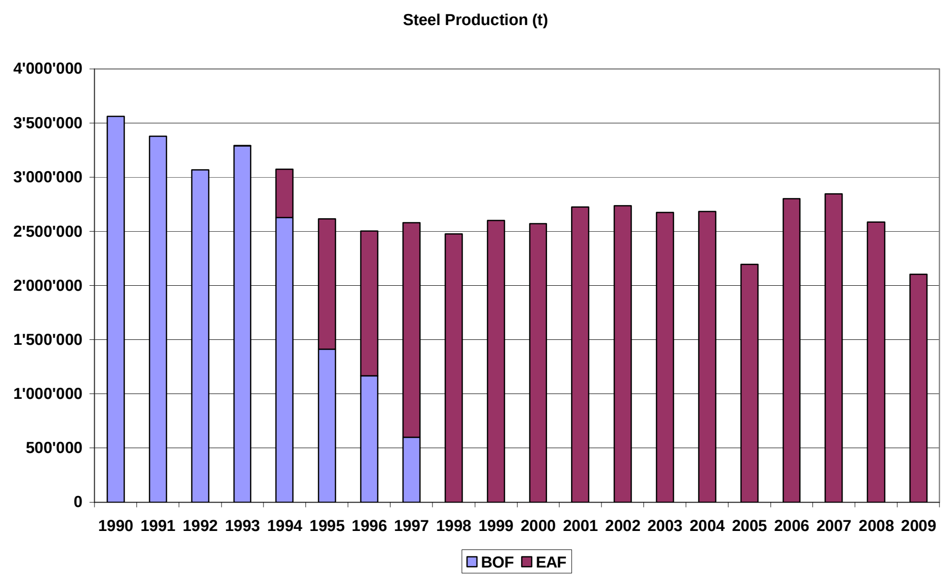
2C1 – Iron and Steel Production is a key source with regard to CO_2 emissions. It has been a key source since 1990: see Table 4-2 in Section 4.1.2.

4.4.1.2 Methodological issues

4.4.1.2.1 Activity data

One sinter plant, two blast furnaces and three basic oxygen furnace steel plants (*BOF*) were operated in Luxembourg in 1990. In 2009, 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: 1990-2009



Several plants are considered:

Sinter Plant (SP)

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.

Blast furnace (BF)

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: 1990-2009

2C1 - Iron & Steel Production					
	Steel Production (t)				*Filter Dust (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*
2008	NO	*NO*	*NO*	*2 584 341*	*35 717*
2009	NO	*NO*	*NO*	*2 103 281*	*16 514*

Sources: AD: plant operator ; Statec

Note: STATEC's 1990 value for BOF replaced by TÜV Rheinland 1992-1993 study reported value.

4.4.1.2.2 Methodology

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.

$$Emissions_{BF} = E_{Iron} = (C_{Reducing\ Agent} + C_{Ore} - C_{Iron}) \bullet 44/12$$

$$Emissions_{BOF} = E_{Steel} = (C_{Iron} + C_{Scrap} + C_{AddBOF} - C_{Steel}) \bullet 44/12$$

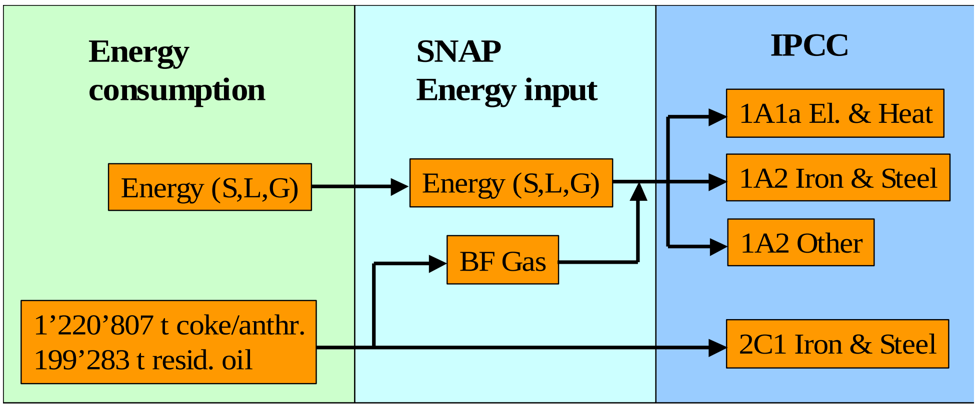
With:

$C_{Reducing\ Agent}$	= 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 2009.

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 are:

$$2009 - CO_2\ Emissions_{EAF} = 112.66\ Gg\ CO_2$$

$$2008 - CO_2\ Emissions_{EAF} = 134.69\ Gg\ CO_2$$

$$2007 - CO_2\ Emissions_{EAF} = 162.22\ Gg\ CO_2$$

$$2006 - CO_2\ Emissions_{EAF} = 170.49\ Gg\ CO_2$$

$$2005 - CO_2\ Emissions_{EAF} = 119.13\ Gg\ CO_2$$

$$2004 - CO_2\ Emissions_{EAF} = 152.45\ Gg\ CO_2$$

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 2009.

$$E_{Primus} = (C_{Raw\ materials} + C_{Electrodes} + C_{Carbon} + C_{Anthracite} - C_{Products})\ x\ 44/12$$

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 2009 are:

$$Emissions_{PRIMUS} = 16.00\ Gg\ CO_2$$

The same methodology is applied for the years 2005 to 2009.

The emissions for the years 2003 and 2004 are estimated based on the relative carbon consumption (Table 4-15) and the average ratio of the CO_2 emissions per carbon consumption for the years 2005-2008.

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
2008	10'683

Source: plant operator

4.4.1.2.3 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 CO2	EF_{EAF} = 56.80 kg CO2 / t
Production	**Emissions**	**EF_{EAF} *(kg CO_2 / t steel)***
2005 – 2 194 485 t steel	2005 – 119.13 Gg CO2	57.86
2006 – 2 802 049 t steel	2006 – 170.49 Gg CO2	60.85
2007 – 2 845 872 t steel	2007 – 162.22 Gg CO2	57.00
2008 – 2 584 341 t steel	2008 – 134.69 Gg CO2	52.12
2009 – 2 103 281 t steel	2009 – 112.66 Gg CO2	53.56

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 2005-2009, 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 CO2)	EF PRIMUS (Mg CO2 / t dust)
2005	29'263	33.79	1.15
2006	38'942	39.30	1.01
2007	46'446	41.27	0.89
2008	35'717	34.61	0.97
2009	16'514	16.00	0.97

4.4.1.3 Uncertainties and time-series consitency

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 Chap. 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 %

4.4.1.4 Source-specific QA/QC and verification

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).

4.4.1.5 Source-specific recalculations

No revisions and recalculations have been done since the submission 2010v2.1 to IPCC sub-category 2C1.

4.4.1.6 Source-specific planned improvements

There are no planned improvements to IPCC sub-category 2C1.

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*.

4.5 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)

4.7.1 Source category description

This section describes the estimation of F-gas emissions resulting from industrial processes (production, consumption). In 2009, F-gases represented 0.61% of the total GHG emissions in CO_2e (excluding LULUCF). This percentage was only 0.11% in 1990. As shown in Figure 4-2 in Section 4.1.1, F-gases related emissions experienced a major increase between 1990 and 2009.

F-gas emission estimates are presented in Table 4-20.

Table 4-20 – Estimated emissions of HFCs, PFCs and SF_6: 1990-2009

Year	2F - Consumption of halocarbons & SF6	2F1 - Refrigeration and Air Conditioning Equipment (HFC)	2F1 - Refrigeration and Air Conditioning Equipment (PFC)	2F2 - Foam Blowing (HFC)	2 F4 - Aerosols/ Metered Dose Inhalers (HFC)	2F8 - Electrical Equipment (SF6)	2F9 - Other (noise reduction windows) (SF6)
	Gg CO_2 e						
1990	14.67	0.00	NO	12.01	1.54	0.55	0.58
1991	14.75	0.00	NO	12.01	1.54	0.55	0.66
1992	14.83	0.00	NO	12.01	1.54	0.55	0.74
1993	15.20	0.29	NO	12.01	1.54	0.55	0.82
1994	15.78	0.78	NO	12.01	1.54	0.55	0.91
1995	17.18	2.08	NO	12.01	1.54	0.55	1.00
1996	17.73	4.08	NO	10.25	1.69	0.62	1.09
1997	19.20	6.99	NO	8.55	1.79	0.70	1.18
1998	22.11	11.38	NO	6.93	1.83	0.71	1.26
1999	26.16	16.85	NO	5.41	1.86	0.72	1.33
2000	30.95	22.88	0.01	3.99	1.92	0.74	1.41
2001	37.20	28.62	0.01	3.34	2.42	0.82	1.99
2002	45.47	35.09	0.01	4.59	2.42	0.81	2.56
2003	51.11	41.49	0.02	3.00	2.50	0.98	3.11
2004	54.11	45.51	0.11	1.44	2.45	0.96	3.63
2005	58.43	49.19	0.15	1.62	2.43	0.93	4.12
2006	63.02	52.85	0.17	1.72	2.59	1.13	4.57
2007	67.69	57.02	0.21	1.81	2.50	1.15	5.01
2008	70.50	59.43	0.24	1.71	2.54	1.15	5.42
2009	73.40	61.34	0.22	1.73	2.71	1.59	5.81
Trend 1990-2009	*400%*	*2359039%*	*NA*	*-86%*	*76%*	*188%*	*909%*
Trend 2008-2009	*4.11%*	*3.20%*	*-9.99%*	*1.30%*	*6.57%*	*38.27%*	*7.22%*

Source: Environment Agency and ECONOTEC.

2F – Consumption of Halocarbons & SF_6 is a key source with regard to F-gas emissions since 2004: see Table 4-2 in Section 4.1.2.

Finally, although Luxembourg now reports emissions from 1990 onwards, it is worth to know that 1995 was chosen as the base year for HFCs, PFCs and SF_6.

4.7.2 Methodological issues

4.7.2.1 Activity data

Compared to last years submission, emissions from the consumption of fluorinated gases (HFCs, PFCs and SF_6) have been completely reassessed.

The following sources have been identified:

2(I) F Consumption of Halocarbons and SF_6;

2(I) F1	Refrigeration and Air Conditioning Equipment (HFC & PFC);
2(I) F 2	Foam Blowing;
2(I) F 4	Aerosols/Metered Dose Inhalers;
2(I) F 8	Electrical Equipment;
2(I) F 9	Other (windows containing SF_6).

4.7.2.2 Methodology

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
Emissions from the manufacturing of refrigerators are based on figures provided by the only manufacturer and are very small (below 0,2 kt CO2-eq).

Emissions from "installations" (all on-site assembled systems for industrial & commercial refrigeration as well as stationary air-conditioning applications) have been estimated by modelling, on the basis of an inquiry among the refrigerant distributors on their national supply by refrigerant mixture carried out in 2007 on the year 2006. The evolution in time of the total supply by refrigerant has been assumed to be the same as in Belgium. No distinction has been made between industrial refrigeration, commercial refrigeration and air conditioning installations, for it is not possible to disaggregate the consumption data between these sub-sectors, because of the presence of intermediary wholesalers. The emissions are modelled on the basis of assumptions on the percentage assembly losses, percentages of annual losses and an average equipment lifetime.

The refrigerant consumption and emissions of the transportation sector are estimated by modelling the evolution of the vehicle stock, on the basis of the number of new vehicle registrations and of the percentage of new vehicles equipped with air conditioning., by category of vehicles (cars, buses and coaches).

Emissions from refrigerated transport are calculated using reported emissions by Germany (Schwarz, 2009) expressed per capita with the relative population in Luxembourg (population ratio calculated based on data from 2005).

F2 – Foam Blowing
The PU spray emissions (HFC 134a, HFC 152a) are estimated using the reported quantities of PU spray containers used per habitant and year in Belgium, and their average HFC content, expressed per capita with the relative population in Luxembourg.

F4 – Aerosols / Metered Dose Inhalers (MDI)

The MDI emissions (HFC 134a, HFC 227a) ,for 2001-2005, were estimated based on the number of units and doses sold in pharmacies in Luxembourg (data from IMS Health). From 2005-2009, MDI emissions were extrapolated based on the evolution of sold units in Belgium and by taking into account the poulation growth in Luxembourg (which is higher than in Belgium). Other aerosols (HFC 134a, HFC 152) were estimated from the reported other aerosol emissions by Germany per capita with the relative population in Luxembourg.

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 (CREOS) 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:

$$Emissions = EF \bullet AR$$

The activity rate (*AR*) is the calculated SF_6 stock on the basis of the estimated installed noise reduction windows, and the SF_6 liberated when the windows are dismantled (assumed lifespan = 25 years).

The yearly emissions are assumed to be 1% of the activity rate, i.e. EF=0.01.

4.7.3 Source-specific QA/QC and verification

Compared with the old study (*Centre de Ressources des Technologies pour l'Environnement* (*CRTE*), 1999) results from the new study confirm that the levels of emissions reported for 1995 are reasonable.

4.7.4 Source specific recalculations

Table 4-21 presents the main revisions and recalculations done since submission 2010v1.2 relevant to IPCC sub-category *2F – Consumption of Halocarbons and SF_6*.

Table 4-21 – Recalculations done since submission 2010v1.2

GHG source & sink category	Revisions 2010v1.2 ➔ 2011v1.3	Type of revision
2F	Complete re-evaluation of the consumption of halocarbons and SF_6 in Luxembourg based on a new study	updated AD and emissions
2F3	There are no fire extinguishers using halocarbons or SF_6 in Luxembourg, hence notation key was changed from NE to NO in CRF tables	updated notation key
2F5	There is no solvent applications using halocarbons or SF_6 in Luxembourg, hence notation key was changed from NE to NO in CRF tables	updated notation key

4.7.5 Source-specific 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 4-22 will be explored.

Table 4-22 – Planned improvements for IPCC Category 2F – Consumption of Halocarbons and SF_6

GHG source & sink category	Planned improvement
2F – Consumption of Halocarbons & SF_6	increase transparency of category 2F description, especially the methodologies and assumptions made.

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 2009.

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.

5.1.1 Emission Trends

In 2009, 0.14% of total GHG emissions (excluding LULUCF) in Luxembourg originated from *Solvent and Other Product Use*, compared to 0.19% in 1990. 71% of these emissions were indirect CO_2 emissions, 29% were accounted for by N_2O emissions. Compared to 2008, GHG emissions from *Solvent and Other Product Use* decreased by 5.2%.

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 – 2009 by Sub-Categories of 3 - Solvent and Other Product Use.

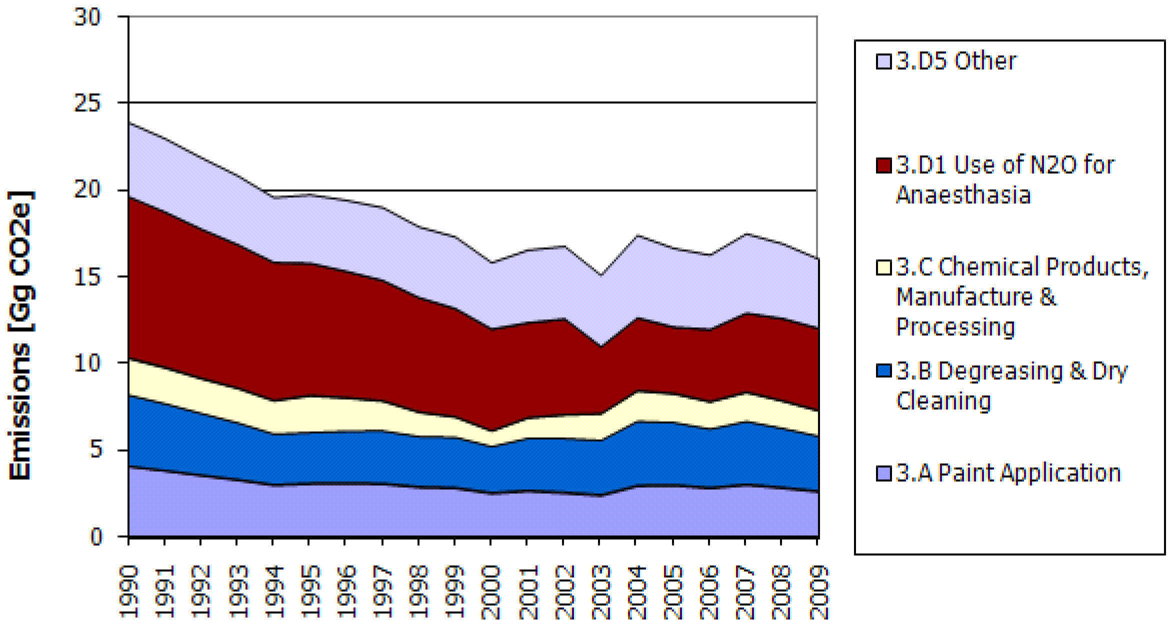


Table 5-1 - Emissions and trend from 1990 – 2009 by Sub-Categories of 3 - Solvent and Other Product Use.

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 Extin-guishers[117]	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	NO	NO	4.27
1991	22.98	3.84	3.91	2.07	13.16	8.92	NA	NO	NO	4.24
1992	21.88	3.58	3.62	2.00	12.68	8.56	NA	NO	NO	4.12
1993	20.85	3.32	3.33	1.99	12.21	8.23	NA	NO	NO	3.98
1994	19.57	3.02	2.98	1.92	11.66	7.91	NA	NO	NO	3.75
1995	19.74	3.10	2.98	2.12	11.53	7.58	NA	NO	NO	3.95
1996	19.42	3.12	3.05	1.92	11.34	7.23	NA	NO	NO	4.10
1997	19.00	3.10	3.08	1.72	11.10	6.89	NA	NO	NO	4.21
1998	17.88	2.90	2.95	1.40	10.62	6.55	NA	NO	NO	4.08
1999	17.30	2.85	2.96	1.17	10.32	6.19	NA	NO	NO	4.13
2000	15.81	2.56	2.72	0.90	9.64	5.82	NA	NO	NO	3.82
2001	16.54	2.69	3.07	1.17	9.61	5.43	NA	NO	NO	4.19

117 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[117]	N_2O from Aerosol Cans	Other Use of N_2O	Other
					[Gg CO_2 equivalent]					
2002	16.76	2.58	3.16	1.36	9.66	5.47	NA	NO	NO	4.18
2003	15.09	2.43	3.20	1.53	7.92	3.80	NA	NO	NO	4.12
2004	17.39	2.98	3.76	1.75	8.90	4.15	NA	NO	NO	4.75
2005	16.65	3.02	3.65	1.66	8.32	3.79	NA	NO	NO	4.54
2006	16.25	2.85	3.44	1.57	8.40	4.11	NA	NO	NO	4.28
2007	17.48	3.04	3.68	1.68	9.08	4.50	NA	NO	NO	4.58
2008	16.90	2.86	3.46	1.58	9.00	4.69	NA	NO	NO	4.31
2009	16.02	2.66	3.21	1.46	8.69	4.69	NA	NO	NO	4.00
Trend 2008–2009	-5%	-7%	-7%	-7%	-3%	0%				-7%
Trend 1990–2009	-33%	-35%	-23%	-31%	-36%	-49%				-6%
Share in CRF 3 in 1990		17%	17%	9%	57%	39%				18%
Share in CRF 3 in 2009		17%	20%	9%	54%	29%				25%
Share in National Total 1990	0.19%	0.03%	0.03%	0.02%	0.11%	0.07%				0.03%
Share in National Total 2009	0.14%	0.02%	0.03%	0.01%	0.07%	0.04%				0.03%

Greenhouse gas emissions in this sector decreased by 33% between 1990 and 2009, due to decreasing solvent and N_2O use (partially due to the onset of the economic crisis in late 2009) 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[118];
- 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[119]

118 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 European Council Directive 2004/42/CE).

119 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)[120], extended by eight protocols from which the following have relevance:
    - The 1988 Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes;[121]
    - The 1991 Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes;[122]
    - The 1998 Protocol on Persistent Organic Pollutants (POPs);[123]
    - The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone; 21 Parties.[124]
- Ordinance for volatile organic compounds (VOC) due to the use of organic solvents in certain activities and installations;[125]
- European 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;
- European 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;
- Regulation on the limitation of emission during the use of solvents containing lightly volatile halogenated hydrocarbons in industrial facilities and installations.[126]

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120 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)

121 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)

122 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)

123 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)

124 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 entered into force on 17 May 2005; ratified by Luxembourg 07.08.2001)

125 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'utilisation 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.

126 Règlement grand-ducal du 12 juillet 1995, relatif aux générateurs d'aérosols.

But also the N_2O use has significantly decreased due to shorter duration of anaesthesia during operations and due to a more frequent use of local anaesthetics than general anaesthesia.

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: correlation 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)

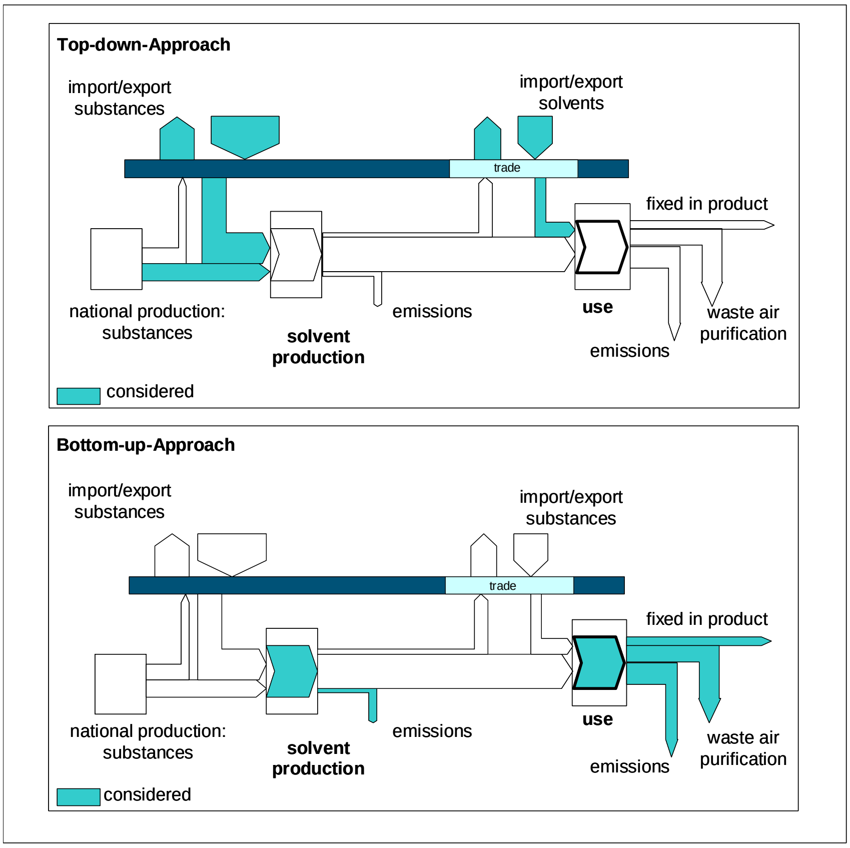
5.2.1 Methodology Overview

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[127] (WINDSPERGER et al. 2002a, 2004) and was in the meantime applied for different European countries within the network "non-energy use of fossils and CO_2 emissions" (WINDSPERGER & STEINLECHNER, 2006). The application for Luxembourg is 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.



127

Figure 5-3 - Overview of the methodology for solvent emissions.

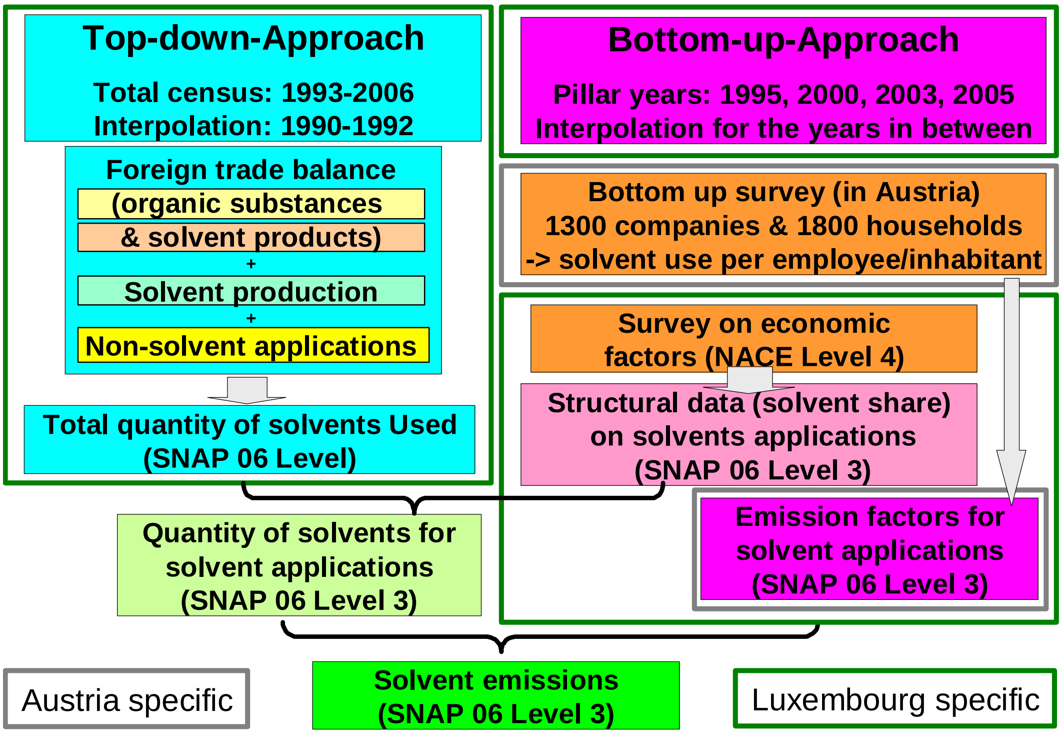


Figure 5-4 - Data of Top-down-Approach and Bottom-up-Approach for 2005.

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, de-icing 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 2008 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 [128].

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.

128 http://epp.eurostat.ec.europa.eu

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 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%

SNAP category	description	year	Distribution of used paints		Part of waste gas treatment	
			Solvent based paints	Water based paints	application	Purification
		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 adhesives	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%
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 (preservation 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%

SNAP	Description	Changes in the number of employees compared to the year 2000				
		1990	1995	2000	2003	2005
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)					
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] 1990-2009.

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
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
2008	**1'930**	23	77	493	96	178	174	889
2009	**1'791**	22	72	457	89	165	162	825

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
2008	**2'285**	1'013	25	2	1'245
2009	**2'120**	940	23	2	1'155

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**	0	30	73	57	0	201	1	6	63
1991	**1'008**	0	30	73	57	0	201	1	6	63
1992	**1'008**	0	30	73	57	0	201	1	6	63
1993	**1'008**	0	30	73	57	0	201	1	6	63
1994	**997**	0	30	72	57	0	198	1	6	62
1995	**1'065**	0	32	77	61	0	212	1	6	67
1996	**1'018**	0	36	74	63	0	191	2	6	75
1997	**887**	0	37	65	61	0	153	2	5	77
1998	**734**	0	37	54	57	0	113	2	4	77
1999	**625**	0	39	46	56	0	81	2	4	80
2000	**468**	0	37	35	50	0	44	2	3	75
2001	**587**	0	52	37	52	0	48	2	2	80
2002	**662**	0	63	37	50	0	47	2	1	78
2003	**726**	0	73	36	47	0	46	1	0	75
2004	**818**	0	71	42	54	0	53	2	0	79
2005	**761**	0	56	40	51	0	51	1	0	68
2006	**719**	0	52	38	48	0	48	1	0	64
2007	**768**	0	56	40	52	0	52	1	0	68
2008	**722**	0	53	38	49	0	49	1	0	64
2009	**670**	0	49	35	45	0	45	1	0	60

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
2008	**2'527**	723	20	0	10	22	1,292	302	157
2009	**2'344**	671	19	0	10	21	1,199	280	145

Table 5-9 - Implied NMVOC emission factors for Solvent Use 1990–2009

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
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
2008	643.39	859.61	886.58	887.69	519.02	900.16	502.99
2009	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
2008	292.87	844.04	821.68	675.86
2009	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
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
2008	930.02	258.96	1'000.00	1'000.00	1'000.00	10.03	942.81	901.43	1'000.00
2009	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
2008	651.09	200.89	628.51	991.79	850.00	843.39	940.86	775.11
2009	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 1990–2009 (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
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
2008	33.02	50.10	NO	49.53
2009	33.02	50.10	NO	49.53

Figure 5-5 - NMVOC emissions and trend from 1990–2009 by subcategories of Category 3 - Solvent and Other Product Use

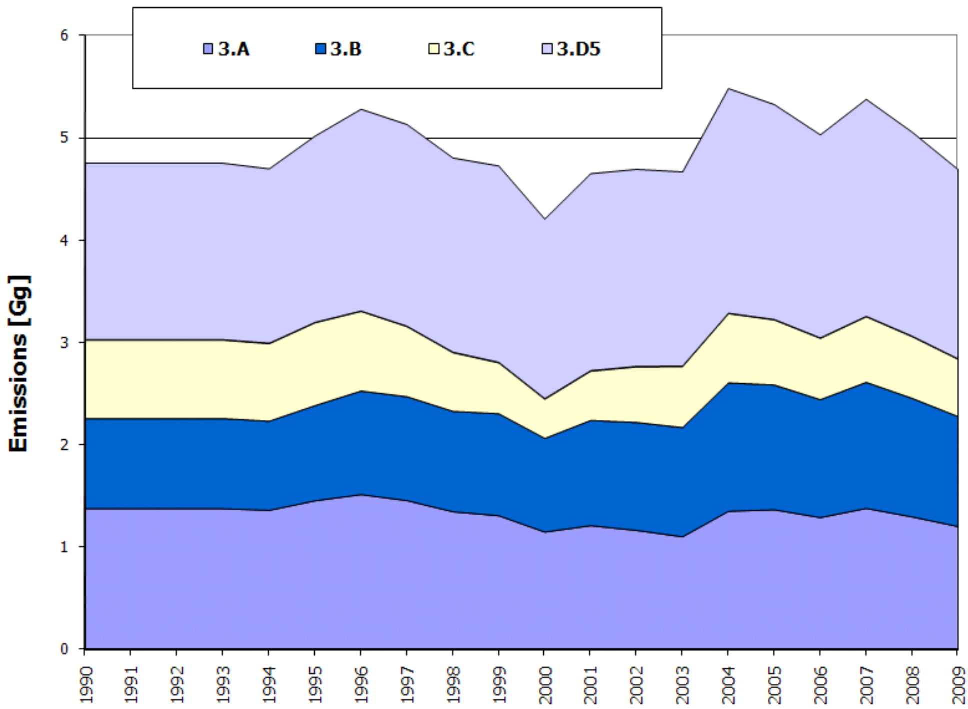


Table 5-11 - NMVOC emissions of Category 3 - Solvent and Other Product Use:[Mg] 1990–2009

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
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
2008	**1’299**	15	66	437	85	92	157	447
2009	**1’206**	14	62	405	79	86	146	415

IPCC	3.B	3.B	3.B	3.B	3.B
SNAP	0602	060201	060202	060203	060204
Unit	Mg				
1990	**883**	459	19	0	405
1991	**883**	459	19	0	405
1992	**883**	459	19	0	405
1993	**883**	459	19	0	405
1994	**873**	454	18	0	401
1995	**933**	485	20	0	428
1996	**1’014**	493	21	0	500
1997	**1’018**	462	21	1	534
1998	**984**	417	20	1	546
1999	**999**	394	20	1	583
2000	**917**	338	19	1	560
2001	**1’031**	346	20	1	663
2002	**1’058**	324	20	1	713
2003	**1’069**	297	19	1	752
2004	**1’257**	335	23	1	898
2005	**1’223**	313	22	2	887
2006	**1’154**	295	21	1	837
2007	**1’235**	316	22	2	895
2008	**1’161**	297	21	1	842
2009	**1’077**	275	19	1	781

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
2006	**599**	434	14	38	48	0	0	1	0	64
2007	**641**	464	15	40	52	0	1	1	0	68
2008	**602**	436	14	38	49	0	0	1	0	64
2009	**559**	404	13	35	45	0	0	1	0	60

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
2008	**2’000**	471	4	0	10	19	1’090	284	121
2009	**1’855**	437	4	0	9	18	1’011	264	113

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 2009 are shown.

Table 5-13 - CO_2 emission of Category 3 Solvent and Other Product Use 1990–2009.

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

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							
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
2008	**2.86**	0.04	0.18	1.21	0.23	0.26	0.31	0.65
2009	**2.66**	0.03	0.17	1.12	0.21	0.24	0.28	0.60

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	0.0002	1.14
1991	**3.91**	2.74	0.03	0.0001	1.15
1992	**3.62**	2.46	0.03	0.0001	1.13
1993	**3.33**	2.19	0.03	0.0001	1.11
1994	**2.98**	1.90	0.03	0.0001	1.05
1995	**2.98**	1.84	0.03	0.0001	1.12
1996	**3.05**	1.76	0.03	0.0004	1.26
1997	**3.08**	1.66	0.03	0.0007	1.38
1998	**2.95**	1.49	0.03	0.0010	1.43
1999	**2.96**	1.40	0.03	0.0012	1.53
2000	**2.72**	1.20	0.03	0.0013	1.49
2001	**3.07**	1.27	0.03	0.0014	1.76
2002	**3.16**	1.23	0.03	0.0014	1.90
2003	**3.20**	1.16	0.03	0.0013	2.00
2004	**3.76**	1.32	0.04	0.0017	2.39
2005	**3.65**	1.24	0.04	0.0018	2.36
2006	**3.44**	1.17	0.04	0.0017	2.23
2007	**3.68**	1.25	0.04	0.0018	2.39
2008	**3.46**	1.18	0.04	0.0017	2.24
2009	**3.21**	1.09	0.03	0.0016	2.08

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	NO	0.0067	0.0027	0.0120	0.09
1991	2.07	1.66	0.03	0.18	0.09	NO	0.0068	0.0028	0.0119	0.08
1992	2.00	1.65	0.02	0.15	0.08	NO	0.0067	0.0028	0.0118	0.08
1993	1.99	1.62	0.02	0.16	0.09	NO	0.0067	0.0028	0.0118	0.07
1994	1.92	1.57	0.02	0.16	0.08	NO	0.0064	0.0027	0.0115	0.07
1995	2.12	1.70	0.02	0.21	0.11	NO	0.0070	0.0028	0.0128	0.07
1996	1.92	1.52	0.02	0.18	0.10	NO	0.0060	0.0033	0.0117	0.07
1997	1.72	1.32	0.02	0.18	0.11	NO	0.0050	0.0036	0.0105	0.07
1998	1.40	1.06	0.02	0.14	0.09	NO	0.0037	0.0038	0.0089	0.07
1999	1.17	0.87	0.02	0.11	0.09	NO	0.0026	0.0041	0.0077	0.07
2000	0.90	0.62	0.02	0.09	0.09	NO	0.0015	0.0041	0.0060	0.07
2001	1.17	0.87	0.03	0.10	0.09	NO	0.0016	0.0040	0.0045	0.07
2002	1.36	1.06	0.03	0.10	0.09	NO	0.0016	0.0034	0.0025	0.07
2003	1.53	1.24	0.04	0.10	0.08	NO	0.0015	0.0029	0.0004	0.07
2004	1.75	1.43	0.04	0.11	0.10	NO	0.0018	0.0033	0.0005	0.07

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									
2005	1.66	1.37	0.03	0.11	0.09	NO	0.0017	0.0032	0.0005	0.06
2006	1.57	1.29	0.03	0.10	0.09	NO	0.0016	0.0030	0.0005	0.06
2007	1.68	1.38	0.03	0.11	0.09	NO	0.0017	0.0032	0.0005	0.06
2008	1.58	1.30	0.03	0.10	0.09	NO	0.0016	0.0030	0.0005	0.06
2009	1.46	1.20	0.03	0.09	0.08	NO	0.0015	0.0028	0.0004	0.05

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
2008	4.31	1.01	0.01	0.00	0.03	0.05	2.35	0.65	0.21
2009	4.00	0.94	0.01	0.00	0.03	0.04	2.18	0.60	0.20

Table 5-14 - Implied CO_2 Emission factors for Category 3 Solvent and Other Product Use 1990–2009.

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

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	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
2008	1.53	2.34	2.45	2.39	1.47	1.75	0.73
2009	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
2008	1.16	1.47	0.94	1.80
2009	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								
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

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								
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
2008	2.77	0.55	2.69	1.78	2.68	0.03	2.18	2.19	0.89
2009	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
2008	1.40	0.66	1.84	2.65	2.03	1.82	2.15	1.35
2009	1.40	0.66	1.84	2.65	2.03	1.82	2.15	1.35

5.3 N_2O emissions from Anaesthesia (3D1)

For the period 1990-2002, no data from the hospitals on the consumption of N_2O could be obtained. Hence, N_2O emissions from anaesthesia usage were estimated by combining reported emissions in Germany with the relative population in Luxembourg.

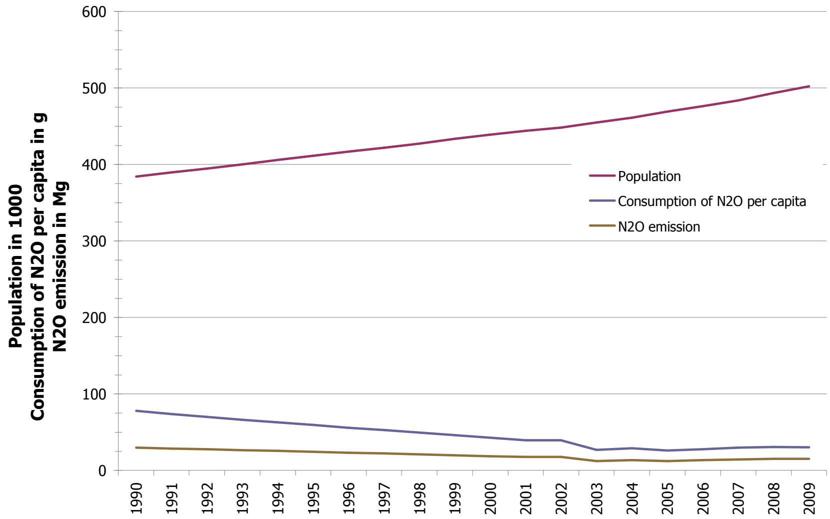
From 2003 to 2009, the use of N_2O in hospitals for anaesthesia was directly obtained from the "Entente des hôpitaux luxembourgeois". Thus, country-specific data was used.

It was assumed that all the N_2O used for anaesthesia is completely released to the atmosphere. Emissions are shown in Table 5-15 and Figure 5-6 as well as in Table 5-1 of section 5.1.1.

Table 5-15 - 3D1 - Use of N_2O for Anaesthesia: 1990–2009.

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N2O [Mg]																			
29.88	28.79	27.62	26.54	25.51	24.44	23.34	22.24	21.13	19.98	18.77	17.50	17.65	12.26	13.38	12.21	13.26	14.51	15.14	15.14

Figure 5-6 – N_2O emissions and N_2O consumption for anaesthesia per capita and trend:1990–2009



5.4 Uncertainties and time-series consistency

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 5-16 and Table 5-17 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 5-16 - 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 5-17 - 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

Direct use of N_2O has been specifically collected from the hospitals in Luxembourg. According to WINIWARTER (2008) pursuant to RAMIREZ ET AL. 2006, an uncertainty of 20% for the amount of N_2O is used. In contrast to Ramirez, it is assumed that virtually all of the N_2O actually used is also fully released, thus no additional uncertainty is applied.

Table 5-18 - Uncertainties for Sector 3D - Solvent and other product use.

IPCC Source category	Gas	AD	EF	Combined
			Uncertainty [%]	
3 - Solvent and other product use	N_2O	20.0	0	20.0

5.5 Source specific QA/QC and verification

The calculations of the data for category 3 are embedded in the overall QA/QC-system of the GHG inventory (see Chapter 1.6) of which important elements include:

- ✓ Are the correct values used (check for transcription errors, …)?
- ✓ Check of plausibility of input data (time-series, order of magnitude, …)
- ✓ Is the data set complete for the whole time series?
- ✓ Check of calculations, units ...
- ✓ Check of plausibility of results (time-series, order of magnitude, …)
- ✓ Correct transformation/transcription into CRF
- ✓ Where possible, data is checked with data from other sources, order of magnitude checks, …
- ✓ Are all references clearly made?
- ✓ Are all assumptions documented?

Source-specific elements of QA/QC for Solvent and Other Product Use include:

a) Bottom-up checks on:

Input data and emission factors:

- check for the plausibility of the activity data and their trend and check for plausibility of the emission factors as well as the related input data and their trends
- check documentation of the most important reasons for changes and non-changes of activity data
- check if these changes or non-changes of activity data fit to trends of underlying conditions
- if checks do not allow any explanation, further check of the used statistics and their estimates and/or communication with the data providers
- check of input data for completeness

Emissions:

- check the correctness of all equations in the calculation files
- check the correctness of all intermediate results
- check the plausibility of the results and their trends related to activity data and emission factors
- check the correctness of the transfer of all data and results

b) Top-down checks include:

- Comparison of the used activity data with those from other statistics: STATEC publication and EUROSTAT database.
- Comparison of the used activity data with those from relevant plant operators.
- Comparison of the used emission factors and underlying input data with those of other data sources (e.g. from literature, results in NIRs of other comparable regions, IPCC default values).

5.6 Source-specific recalculations

Table 5-19 presents the main revisions and recalculations done since submission 2010v2.1 relevant to IPCC category 3 – *Solvents and Other Product Use*.

Table 5-19 – Recalculations done since submission 2010v2.1

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
3A, 3B, 3C, 3D5	AD was revised for the period 2008-2009 due to revised Intrastat data from Statec.	updated AD

5.7 Source-specific 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 5-20 will be explored.

Table 5-20 – Planned improvements for Sector 3 – Solvent and Other Product Use

GHG source & sink category	Planned improvement
3A, 3B, 3C, 3D5	Investigate the possibility of acquiring more country-specific data in order to establish the emission levels from solvent and other product use.[129] Nevertheless the IEF for CO_2 emission from Austria seemed to be more accurate and applicable than the *default fossil carbon content fraction* provided by the 2006 IPCC GL[130] because the IEF_{CO2} is based on substance specific carbon dioxide factors for 15 substances. The amount of these substance used in Luxemburg (production/import/export) are taken into account in emission estimation.

129 ARR 2010, § 52 Solvent and other product use - CO_2: Luxembourg bases its CO_2 emission estimates for this category on AD from Luxembourg using an implied CO_2 EF from Austria. The ERT reiterates the recommendation from the previous review that Luxembourg enhance the accuracy of these estimates by using country-specific data.

130 "*The default fossil carbon content fraction of NMVOC is 60 percent by mass, based on limited published national analyses of the speciation profile (U.S. EPA, 2002; Austria, 2004; Hungary, 2004; Klein Goldewijk et al., 2005). It may vary between 50 and 70 percent carbon by mass, so having an uncertainty of about ±10 percent. Country-specific fractions should have a lower uncertainty, e.g., ±5 percent.*" 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, Chapter 5: Industrial Processes and Product Use, page 5.17, and 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 1, Chapter 7: Precursors and Indirect Emissions, page 7.6.

6 Agriculture (CRF Sector 4)

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 2009.

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 2009 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 9.6% (-0.1% for methane and -17.6% for nitrous oxide). IPCC Category 4A – Enteric Fermentation saw its emissions falling by 5.8%, whereas for IPCC category 4D – Agricultural Soils, the decrease reaches 15.2%. For manure management (IPCC Category 4B), emissions remained quite stable between 1990 and 2008 (-1%), though opposite variations are observed for the two GHG emitted by this activity: methane increased by 18.6% and nitrous oxide declined by 38.9%.

Figure 6-1 and Figure 6-2 provide a quick overview on agriculture related emission trends between 1990 and 2009. More details and explanations are presented in the subsequent sections detailing each of the sector source categories.

Table 6-1 – GHG emission trends in CO_2e for CRF Sector 4 – Agriculture: 1990-2009

Year	4A - Enteric Fermentation				4B - Manure Management				4D - Agricultural Soils				4 - Agriculture			
CO_2e emissions (Gg) – GHG source & sink category	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	261.38	*NA*	*261.38*	*NA*	120.95	*NA*	*79.67*	*41.28*	363.55	*NA*	*NA*	*363.55*	**745.87**	*NA*	*341.05*	*404.82*
1991	260.67	*NA*	*260.67*	*NA*	121.48	*NA*	*85.94*	*35.54*	372.01	*NA*	*NA*	*372.01*	**754.16**	*NA*	*346.61*	*407.55*
1992	250.09	*NA*	*250.09*	*NA*	118.98	*NA*	*86.58*	*32.40*	379.63	*NA*	*NA*	*379.63*	**748.70**	*NA*	*336.67*	*412.03*
1993	252.03	*NA*	*252.03*	*NA*	121.43	*NA*	*89.48*	*31.95*	362.18	*NA*	*NA*	*362.18*	**735.64**	*NA*	*341.51*	*394.13*
1994	249.84	*NA*	*249.84*	*NA*	120.01	*NA*	*89.38*	*30.63*	348.75	*NA*	*NA*	*348.75*	**718.60**	*NA*	*339.22*	*379.38*
1995	256.91	*NA*	*256.91*	*NA*	125.33	*NA*	*93.73*	*31.60*	354.91	*NA*	*NA*	*354.91*	**737.15**	*NA*	*350.64*	*386.51*
1996	260.11	*NA*	*260.11*	*NA*	126.36	*NA*	*94.34*	*32.02*	360.44	*NA*	*NA*	*360.44*	**746.91**	*NA*	*354.45*	*392.46*
1997	254.86	*NA*	*254.86*	*NA*	127.08	*NA*	*96.87*	*30.21*	352.54	*NA*	*NA*	*352.54*	**734.48**	*NA*	*351.74*	*382.74*
1998	252.19	*NA*	*252.19*	*NA*	128.79	*NA*	*100.16*	*28.62*	347.84	*NA*	*NA*	*347.84*	**728.82**	*NA*	*352.36*	*376.47*
1999	251.92	*NA*	*251.92*	*NA*	133.64	*NA*	*109.49*	*24.15*	352.89	*NA*	*NA*	*352.89*	**738.46**	*NA*	*361.42*	*377.04*
2000	248.73	*NA*	*248.73*	*NA*	128.47	*NA*	*104.88*	*23.59*	346.91	*NA*	*NA*	*346.91*	**724.11**	*NA*	*353.61*	*370.49*
2001	249.97	*NA*	*249.97*	*NA*	126.55	*NA*	*102.99*	*23.57*	320.70	*NA*	*NA*	*320.70*	**697.23**	*NA*	*352.96*	*344.27*
2002	242.85	*NA*	*242.85*	*NA*	122.83	*NA*	*100.40*	*22.43*	324.73	*NA*	*NA*	*324.73*	**690.41**	*NA*	*343.25*	*347.16*
2003	235.61	*NA*	*235.61*	*NA*	120.56	*NA*	*97.75*	*22.81*	294.32	*NA*	*NA*	*294.32*	**650.49**	*NA*	*333.36*	*317.13*
2004	233.20	*NA*	*233.20*	*NA*	118.07	*NA*	*95.37*	*22.70*	329.51	*NA*	*NA*	*329.51*	**680.78**	*NA*	*328.57*	*352.21*
2005	232.82	*NA*	*232.82*	*NA*	121.09	*NA*	*99.03*	*22.06*	306.72	*NA*	*NA*	*306.72*	**660.63**	*NA*	*331.85*	*328.78*
2006	230.63	*NA*	*230.63*	*NA*	118.40	*NA*	*97.36*	*21.04*	303.35	*NA*	*NA*	*303.35*	**652.39**	*NA*	*327.99*	*324.39*
2007	239.01	*NA*	*239.01*	*NA*	117.22	*NA*	*91.43*	*25.79*	300.19	*NA*	*NA*	*300.19*	**656.42**	*NA*	*330.44*	*325.98*
2008	244.19	*NA*	*244.19*	*NA*	118.62	*NA*	*93.06*	*25.56*	306.82	*NA*	*NA*	*306.82*	**669.63**	*NA*	*337.25*	*332.38*
2009	246.24	*NA*	*246.24*	*NA*	119.69	*NA*	*94.48*	*25.22*	308.16	*NA*	*NA*	*308.16*	**674.09**	*NA*	*340.72*	*333.38*
Trend 1990-2009	*-5.79%*	*NA*	*-5.79%*	*NA*	*-1.04%*	*NA*	*18.58%*	*-38.91%*	*-15.23%*	*NA*	*NA*	*-15.23%*	*-9.62%*	*NA*	*-0.10%*	*-17.65%*

Source: MDDI-DEV.

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 6-1 – GHG emission trends in % for CRF Sector 4 – Agriculture: 1990-2009

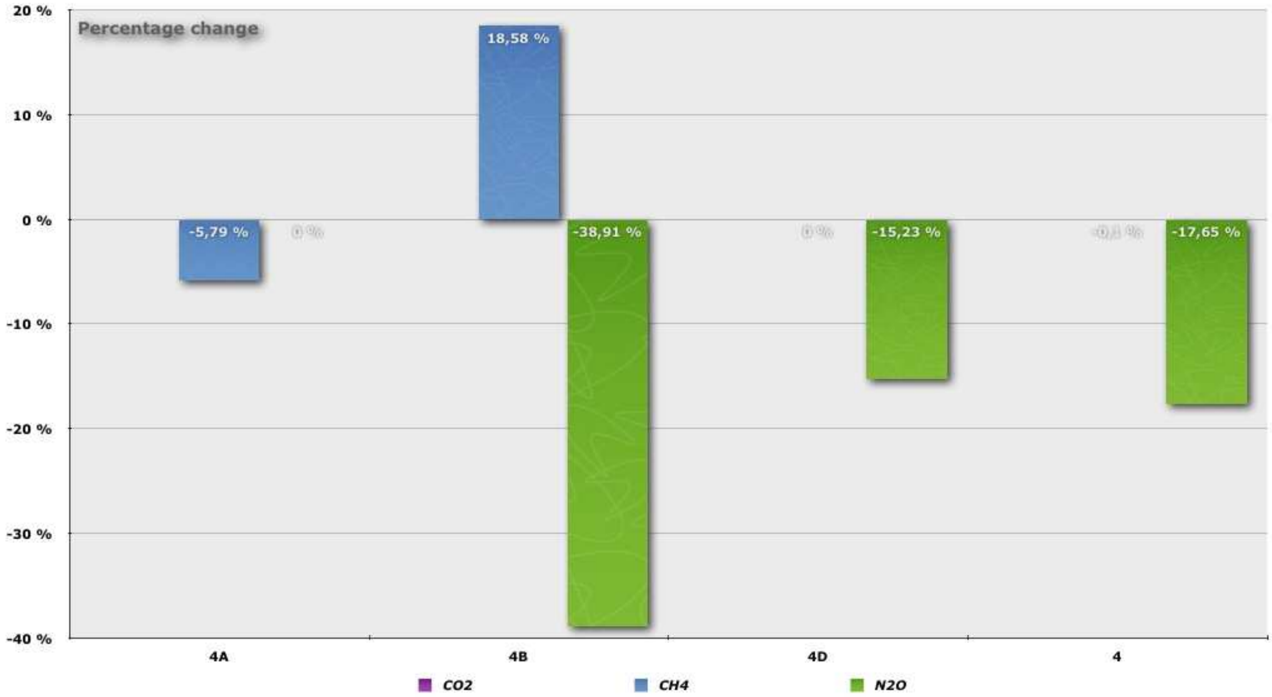
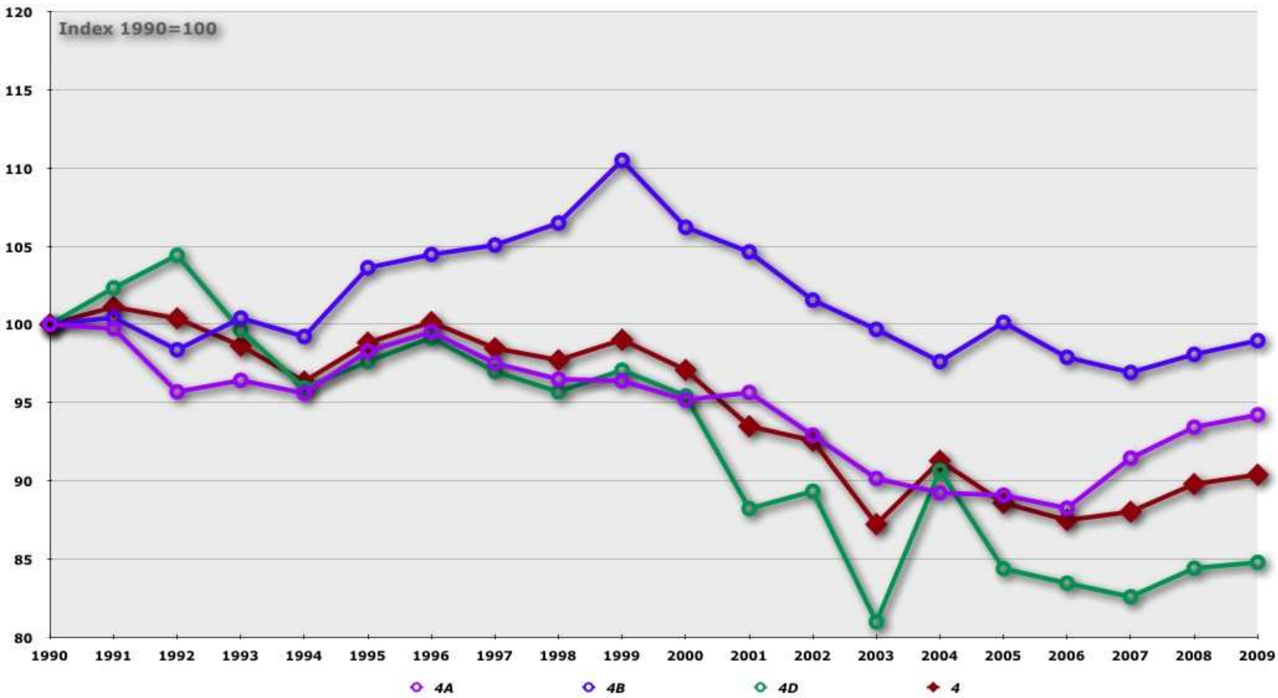


Figure 6-2 – GHG emission trends – indexes – for CRF Sector 4 – Agriculture: 1990-2009

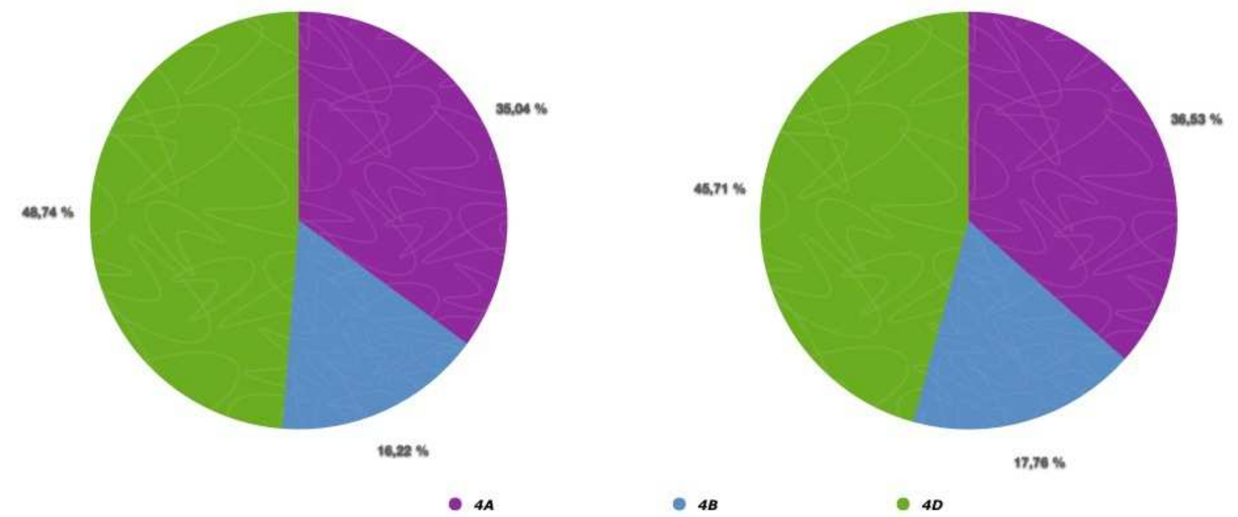


As shown in Figure 6-2, IPCC Category *4D – Agricultural Soils* presents an erratic evolution towards the end of the period. This is explained mainly by important changes in crops, as well as in N-fertilizer use, which showed a slack in 2003 and a peak in 2004. The lower N-fertilizer use in 2003 was 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 2009, 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 not changed much over the period.

Figure 6-3 – IPCC Categories weights in GHG emissions for CRF Sector 4 – Agriculture: 1990 and 2009

1990 *2009*



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_LU_GHG_Estimates_1990-2009.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/envtawb5a

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 Sector 4 - Agriculture.

Table 6-2 – Key sources of IPCC Sector 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	CH_4	90-09	90-09		
4B1	Manure Management - Cattle	CH_4	95-06, 08			
4D1	Agricultural Soils - direct soil emissions	N_2O	90-09	90-95, 98-00, 09		
4D2	Agricultural Soils - pasture, range & paddock manure	N_2O	96-04, 08			
4D3	Agricultural Soils - indirect emissions	N_2O	90-09	90-92, 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 6-1 – 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		X	
4A5	enteric fermentation – camels & llamas		NO	
4A6	enteric fermentation – horses		X	
4A7	enteric fermentation – mules & asses		IE (1990-2004) (1) X (2005-2009)	
4A8	enteric fermentation – swine		X	
4A9	enteric fermentation – poultry		X	
4A10	enteric fermentation – other livestock		X (2)	
4B1 – option B	manure management – cattle		X	
4B2	manure management – buffalo		NO	
4B3	manure management – sheep		X	
4B4	manure management – goats		X	
4B5	manure management – camels & llamas		NO	
4B6	manure management – horses		X	
4B7	manure management – mules & asses		IE (1990-2004) (1) X (2005-2009)	
4B8	manure management – swine		X	
4B9	manure management – poultry		X	
4B10	manure management – other livestock		X	
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

GHG source & sink category	Description	Status		
		CO_2	CH_4	N_2O
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 (3)	X
4D2	agricultural soils – pasture, range & paddock manure			X
4D3	agricultural soils – indirect emissions		NE (3)	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.

(1) the number of mules & asses where recorded together with horses (category 4A6) up to 2004 included.

(2) the sub-category other livestock – other poultry could not be estimated due to lack of information both at national level and in the literature (see section 6.2.3.2)

(3) NE but not indicated in the sectoral background data for agriculture table 4D.

6.2 Enteric Fermentation (IPCC Source Category 4A)

This section describes the estimation of methane emissions resulting from enteric fermentation. In 2009, this source category was responsible for 72.3% of agricultural methane emissions and for 54.9% of the total methane emissions estimated for Luxembourg. It represented 36.5% of the total GHG emissions from the agriculture sector and 2.9% of the total GHG emissions in CO_2e (excluding LULUCF).

6.2.1 Key source

With 2.05% of the total GHG emissions in CO_2e, excluding LULUCF in 2009 (2.11% 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: 1990-2009

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	506	NO	1 722	IE	75 463	69 021	2 261	6 679	283
1991	55 604	163 940	*25 319*	*5 624*	*59 254*	*73 743*	NO	7 726	482	NO	1 829	IE	66 592	63 559	2 169	6 679	283
1992	51 110	158 225	*25 713*	*4 728*	*56 214*	*71 570*	NO	6 924	458	NO	1 835	IE	67 837	60 281	2 077	6 679	283
1993	50 182	158 696	*27 314*	*4 714*	*55 747*	*70 921*	NO	6 775	434	NO	1 925	IE	71 800	63 444	1 985	6 679	283
1994	48 978	159 766	*28 884*	*4 247*	*58 026*	*68 609*	NO	7 744	410	NO	2 123	IE	68 854	60 451	1 893	6 679	283
1995	48 599	165 288	*30 732*	*4 936*	*57 582*	*72 038*	NO	7 552	387	NO	2 164	IE	72 640	55 618	1 800	6 679	283
1996	47 953	169 974	*31 989*	*5 064*	*59 094*	*73 827*	NO	7 152	374	NO	2 198	IE	72 494	61 855	1 869	6 679	283
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	145 895	*31 593*	*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	38 983	152 945	*33 877*	*2 803*	*52 699*	*63 566*	NO	9 339	2 814	NO	4 182	152	83 255	81 908	814	4 792	175
2008	39 968	155 693	*36 196*	*3 187*	*52 055*	*64 255*	NO	8 477	2 912	NO	4 310	226	81 374	81 375	632	4 112	323
2009	40 633	155 837	*36 460*	*3 817*	*52 410*	*63 150*	NO	8 824	3 130	NO	4 365	197	80 217	97 418	833	4 144	334
Trend 1990-2009	*-30.94%*	*-1.75%*	*65.37%*	*-29.86%*	*-11.99%*	*-11.76%*	*NA*	*21.19%*	*518.58%*	*NA*	*153.48%*	*62.81%*	*6.30%*	*41.14%*	*-63.16%*	*-37.95%*	*18.02%*

Sources: SER: http://www.ser.public.lu/statistik/agrarstrukturen/statec_15_mai_pluriannuel.pdf

STATEC, *Statistical Yearbook*, Table D.2107: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=702&IF_Language=fra&MainTheme=4&FldrName=2&RFPath=11

STATEC, *Bulletin du STATEC 03_2009*, *Les recencements agricoles en 2008*: http://www.statistiques.public.lu/fr/publications/series/bulletin-statec/2009/03-09-recensement-agricole/index.html

data updated on 22 April 2010 (subject to changes since that date)

Notes:

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.

Mules & Asses population was reported together with horses population up to the 2004 census included.

Data in blue have been estimated by the MDDI-DEV for those livestock categories for which there are no reported values in the yearly agricultural censuses:
- for 4A4 – goats and 4A10 – other – other poultry, census data are reported for 1990, 1995 and from 1997 onwards: 1991-1994 and 1996 have therefore been interpolated;
- for 4A10 – other – rabbits & cervidae species, there are no data reported in the censuses before 1997. For backcasting the serie back to 1990, a rounded 10-year averaged population (1997-2006) has been calculated.

The livestock description is provided on the next page.

Table 6-5 – CH_4 emission trends for IPCC Category 4A – Enteric Fermentation: 1990-2009

Year	*CH_4 emissions (Mg)* Livestock category																	
	4A1	**4A1**	***4A1***	***4A1***	***4A1***	***4A1***	**4A2**	**4A3**	**4A4**	**4A5**	**4A6**	**4A7**	**4A8**	**4A9**	**4A10**	**4A10**	**4A10**	**4A**
	Cattle - Mature Dairy Cattle	**Non-Dairy Cattle**	***Cattle - Mature Non-Dairy Cattle - Females***	***Cattle - Mature Non-Dairy Cattle - Males***	***Cattle - Young Cattle - Calves***	***Cattle - Young Cattle - Growing Heifers***	**Buffalo**	**Sheep**	**Goats**	**Camels & Llamas**	**Horses**	**Mules & Asses**	**Swine**	**Poultry - Chickens**	**Other - Other Poultry**	**Other - Rabbits**	**Other - Cervidae Species**	**Total**
1990	5 725.12	6 508.82	*1 217.01*	*289.65*	*1 864.07*	*3 138.09*	NO	58.25	2.53	NO	31.00	IE	113.19	1.33	NE	0.54	5.66	**12 446.45**
1991	5 421.81	6 786.75	*1 397.56*	*299.33*	*1 855.97*	*3 233.89*	NO	61.81	2.41	NO	32.92	IE	99.89	1.22	NE	0.54	5.66	**12 413.01**
1992	5 136.51	6 572.60	*1 419.31*	*251.64*	*1 762.50*	*3 139.15*	NO	55.39	2.29	NO	33.03	IE	101.76	1.16	NE	0.54	5.66	**11 908.95**
1993	5 176.41	6 618.88	*1 507.68*	*250.90*	*1 748.80*	*3 111.50*	NO	54.20	2.17	NO	34.65	IE	107.70	1.22	NE	0.54	5.66	**12 001.43**
1994	5 032.14	6 651.96	*1 594.34*	*226.04*	*1 821.09*	*3 010.49*	NO	61.95	2.05	NO	38.21	IE	103.28	1.16	NE	0.54	5.66	**11 896.97**
1995	5 088.16	6 928.35	*1 696.35*	*262.71*	*1 807.98*	*3 161.31*	NO	60.42	1.94	NO	38.95	IE	108.96	1.07	NE	0.54	5.66	**12 234.05**
1996	5 039.93	7 131.67	*1 765.73*	*269.53*	*1 856.20*	*3 240.21*	NO	57.22	1.87	NO	39.56	IE	108.74	1.19	NE	0.54	5.66	**12 386.38**
1997	4 930.64	6 977.46	*1 702.70*	*296.78*	*1 790.99*	*3 187.00*	NO	64.07	1.80	NO	41.31	IE	115.72	1.28	NE	0.59	3.48	**12 136.35**
1998	4 918.23	6 851.81	*1 694.36*	*280.49*	*1 738.15*	*3 138.80*	NO	65.90	1.47	NO	42.16	IE	122.09	1.32	NE	0.55	5.68	**12 009.19**
1999	4 879.98	6 861.35	*1 771.69*	*256.11*	*1 740.22*	*3 093.32*	NO	65.76	1.32	NO	50.72	IE	128.75	1.20	NE	0.50	6.66	**11 996.23**
2000	4 763.99	6 828.58	*1 814.42*	*233.28*	*1 722.71*	*3 058.17*	NO	63.77	1.49	NO	56.77	IE	120.21	1.38	NE	0.54	7.66	**11 844.39**
2001	4 778.19	6 872.84	*1 845.11*	*257.23*	*1 708.43*	*3 062.07*	NO	67.81	1.56	NO	56.27	IE	117.81	1.62	NE	0.53	6.78	**11 903.40**
2002	4 748.39	6 553.43	*1 809.50*	*222.90*	*1 689.60*	*2 831.43*	NO	72.83	5.52	NO	56.11	IE	119.50	1.50	NE	0.57	6.36	**11 564.20**
2003	4 642.12	6 297.41	*1 738.68*	*203.32*	*1 614.17*	*2 741.24*	NO	75.57	9.39	NO	62.08	IE	126.21	1.53	NE	0.53	4.76	**11 219.60**
2004	4 616.46	6 199.34	*1 718.48*	*190.06*	*1 598.21*	*2 692.58*	NO	77.94	10.05	NO	66.35	IE	126.92	1.41	NE	0.54	5.70	**11 104.71**
2005	4 594.93	6 181.76	*1 743.87*	*182.66*	*1 547.20*	*2 708.02*	NO	82.22	11.02	NO	73.30	1.21	135.22	1.61	NE	0.53	4.68	**11 086.46**
2006	4 547.13	6 138.36	*1 745.14*	*168.67*	*1 555.58*	*2 668.97*	NO	77.15	9.75	NO	74.90	1.75	126.23	1.56	NE	0.56	4.88	**10 982.26**
2007	4 617.12	6 468.21	*1 869.95*	*149.19*	*1 657.88*	*2 791.20*	NO	74.71	14.07	NO	75.28	1.52	124.88	1.58	NE	0.39	3.50	**11 381.26**
2008	4 708.04	6 627.33	*1 997.95*	*169.63*	*1 638.21*	*2 821.54*	NO	67.82	14.56	NO	77.58	2.26	122.06	1.57	NE	0.33	6.46	**11 628.01**
2009	4 791.01	6 638.76	*2 012.52*	*203.16*	*1 649.80*	*2 773.29*	NO	70.59	15.65	NO	78.57	1.97	120.33	1.88	NE	0.34	6.68	**11 725.77**
Trend 1990-2009	*-16.32%*	*2.00%*	*65.37%*	*-29.86%*	*-11.50%*	*-11.63%*	*NA*	*21.19%*	*518.58%*	*NA*	*153.48%*	*62.81%*	*6.30%*	*41.14%*	*NA*	*-37.95%*	*18.02%*	*-5.79%*

Source: MDDI-DEV.

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 2009, there were 227 ostriches and only 10 "productive animals" reported.

Looking at animal species for which data are available for the whole period 1990-2009, goats 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, goats related methane emissions are really 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 5.8% over the period 1990-2009. This was mainly the result from declining emissions generated by cattle – -16.3% for dairy cattle but +2% for non-dairy cattle – whilst increasing emissions were recorded for the other livestock categories – with +6.3% for swine, +21.2% for sheep and +153.5% 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.[131]

With regard to cattle, its total population size declined throughout the period 1990-2009. However, a shift did occur within the cattle population with a reduction for dairy cattle (-30.9%) and an increase for female mature non-dairy cattle (+65.4%). 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

131 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 almost 31% between 1990 and 2009, related methane emissions only declined by 16.3%. This is explained by increasing milk yield over the period that, in turn, led to an augmentation of the gross energy intake for dairy cattle.[132]

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;
- the milk yield and the fat content of milk for dairy cattle: see Table 6-6.

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).

Over the period 1990-2009, the milk yield has increased by almost 46%. At the same time – see Table 6-4 above – the dairy cattle population declined by 31%. 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 21.2% increase since 1990 for the IEF expressed in CH_4/head/year – see Table 6-12 in Section 6.2.3.2.

132 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).

Table 6-6 – Milk yield and fat content of milk for dairy cattle: 1990-2009

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	7035	4.19%
2008	6947	4.21%
2009	6986	4.18%
Trend 1990-2009	*45.94%*	*NA*

Sources: SER: http://www.ser.public.lu/statistik/tier_produktion/milchliefermenge_erzeugerpreis_jahr.pdf
STATEC, *Statistical Yearbook*, Table D.2111:
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=706&IF_Language=fra&MainTheme=4&FldrName=2&RFPath=11
data updated on 20 September 2010 (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	
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	

Livestock category	Live-weight in kg used for estimating enteric fermentation emissions	Comments
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 and default coefficients/parameters from the IPCC Guidelines; Ym are extracted from table 4.8 – 2000 IPCC-GPG: see Table 6-9 for details*
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	
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 derived from the GHG inventory of Austria*
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*

Livestock category	Estimation method	IEF	Comments
			the 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: MDDI-DEV.

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 100422)	AD (see Table 6-4)
Live Weight	kg	SER, not published (provided 070601)	AD (see Table 6-7), 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 100719)	AD (see Table 6-6)
Daily Milk Production	kg/cow/day	-	calculated using 365.25 days/year
Fat Content of Milk	%	SER (updated 100719)	AD (see Table 6-6)
Digestible Energy	%	based on table 10.2 - 2006 IPCC Guidelines	expert judgment, invariable; the judgment is based on the fact that 2006 IPCC Guidelines in table 10.2 suggests that cattle and other ruminants have a digestible energy (*DE*) of 75-85% for feedlot animals with over 90% concentrate diet and a DE of 55-75% for pasture fed animals - with, in Luxembourg, cattle spending around 50% of the time grazing and 50% in stalls, the average is 70%; note that the 2000 IPCC-GPG suggests a range of 60 to 75% for animals grazing in good pastures
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
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 100422)	AD (see Table 6-4)
Live Weight	kg	SER, not published (provided 070601)	AD (see Table 6-7), 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: based on table 10.2 - 2006 IPCC Guidelines - young cattle: table A-2 – Revised 1996 IPCC Guidelines	- expert judgment, invariable: see explanations in Table 6-9 - 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 not corrected by a factor as for dairy cattle (expert judgment); valid 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 6-4 and 6-5 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[133]

AD, parameter, coefficient	Unit	Source(s)	Type of value
Livestock (# of heads)	#	SER & STATEC (updated 100422)	AD (see Table 6-4)
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 6-7), invariable
Gross Energy Intake (average)	MJ/day	- 4A3 to 4A8: table A-4 – Revised 1996 IPCC Guidelines - 4A9: derived from the GHG inventory of Austria - 4A10 – rabbits: obtained from the GHG inventory of Italy	- default for developed countries - invariable - invariable
CH_4 Conversion Rate (average)	%	- 4A3 to 4A8: table A-4 – Revised 1996 IPCC Guidelines - 4A9: derived from the GHG inventory of Austria - 4A10 – rabbits: obtained from the GHG inventory of Italy	- 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.

For sub-category 4A9, both GE and Ym are derived from the Austrian GHG inventory. Indeed, the IPCC Guidelines (revised 1996 or 2006) do not provide specific methodologies for the estimation of emissions of poultry (note that both Switzerland and Liechtenstein use the same value as Austria for Ym. For GE, these 2 countries reports variable values through years, hence the choice of the constant value reported by Austria).

For sub-category 4A10 – rabbits, there are not so many Annex I countries reporting data. Since the 2006 IPCC Guidelines suggests Italian values for the weight (table 10A.9), it makes sense, so to be consistent, to use both FE and Ym reported in the Italian GHG inventory.

For sub-category 4A10 – other poultry no estimates of methane emissions are presented due to lack of information in both Guidelines and other countries. Moreover, in the EMEP/CORINAIR Emission Inventory Guidebook — 2007 (http://www.eea.europa.eu/publications/EMEPCORINAIR5), table 2 on page B1040-5 suggests that calculating enteric fermentation for poultry is "not relevant".

6.2.3.2.3 Methane IEFs for 4A – Enteric Fermentation

Table 6-12 presents the IEFs obtained for each farm animal category using the Tier 1 or Tier 2 methods described above.

133 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: 1990-2009

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	97.30	41.04	*55.20*	*53.22*	*31.30*	*43.85*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
1991	97.51	41.40	*55.20*	*53.22*	*31.32*	*43.85*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
1992	100.50	41.54	*55.20*	*53.22*	*31.35*	*43.86*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
1993	103.15	41.71	*55.20*	*53.22*	*31.37*	*43.87*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
1994	102.74	41.64	*55.20*	*53.22*	*31.38*	*43.88*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
1995	104.70	41.92	*55.20*	*53.22*	*31.40*	*43.88*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
1996	105.10	41.96	*55.20*	*53.22*	*31.41*	*43.89*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
1997	106.48	42.03	*55.20*	*53.22*	*31.42*	*43.89*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
1998	107.03	42.09	*55.20*	*53.22*	*31.42*	*43.90*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
1999	108.20	42.16	*55.20*	*53.22*	*31.42*	*43.90*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
2000	109.91	42.22	*55.20*	*53.22*	*31.43*	*43.90*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
2001	111.50	42.34	*55.20*	*53.22*	*31.44*	*43.90*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
2002	112.85	42.23	*55.20*	*53.22*	*31.45*	*43.91*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
2003	114.34	42.24	*55.20*	*53.22*	*31.45*	*43.91*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
2004	115.76	42.22	*55.20*	*53.22*	*31.45*	*43.91*	NO	8.00	5.00	NO	18.00	IE	1.50	0.02	NE	0.08	20.00
2005	116.80	42.37	*55.20*	*53.22*	*31.45*	*43.91*	NO	8.00	5.00	NO	18.00	10.00	1.50	0.02	NE	0.08	20.00
2006	117.75	42.33	*55.20*	*53.22*	*31.46*	*43.91*	NO	8.00	5.00	NO	18.00	10.00	1.50	0.02	NE	0.08	20.00
2007	118.44	42.29	*55.20*	*53.22*	*31.46*	*43.91*	NO	8.00	5.00	NO	18.00	10.00	1.50	0.02	NE	0.08	20.00
2008	117.80	42.57	*55.20*	*53.22*	*31.47*	*43.91*	NO	8.00	5.00	NO	18.00	10.00	1.50	0.02	NE	0.08	20.00
2009	117.91	42.60	*55.20*	*53.22*	*31.48*	*43.92*	NO	8.00	5.00	NO	18.00	10.00	1.50	0.02	NE	0.08	20.00
Trend 1990-2009	*21.18%*	*3.81%*	*NA*	*NA*	*0.57%*	*0.16%*	*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: MDDI-DEV.

Notes:

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 2010v2.1 and 2011v1.3 (see also CRF tables 8).

Table 6-13 – Changes in GHG inventories: submissions 2010v2.1 and 2011v1.3

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
4A9 - Poultry	1990 to 2008 – revised estimates for the parameters "average gross energy intake" & "average CH_4 conversion rate", (and, consequently, for IEFs and CH_4 emissions). Use of AT values instead of the Swiss ones used previously (see also comments for Table 6-11).	revised parameters

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 MDDI-DEV 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 MDDI-DEV and the sector experts, SER and ASTA.

Category-specific checklists have also been filled in.

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; - implementing ERT's recommendations on including in the NIR additional information on the parameters, coefficients and activity data used.
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.
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	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 (IPCC Source Category 4B)

This section describes the estimation of methane and nitrous oxide emissions resulting from manure management. In 2009, this source category was responsible for 17.8% of the total GHG emissions from the agriculture sector and it represented 0.81% of the total GHG emissions in CO_2e (excluding LULUCF). For each of the two gases reported, excluding LULUCF, in 2009:

- CH_4 represented 27.7% of agricultural methane emissions and 21.1% of the total methane emissions estimated for Luxembourg;
- N_2O represented 7.6% of agricultural nitrous oxide emissions and 5.6% of the total nitrous oxide emissions estimated for Luxembourg.

6.3.1 Key source

With 0.51% of the total GHG emissions in CO_2e, excluding LULUCF in 2009 (0.52% of the total GHG emissions in CO_2e, including LULUCF), methane emissions from cattle (IPCC Sub-category 4B1) is a key source from 1995 to 2006 and for 2008, when LULUCF is excluded. Including LULUCF, 4B1 is not a key source and has never been.

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.

Table 6-15 – CH_4 emission trends for IPCC Category 4B – Manure Management: 1990-2009

CH_4 emissions (Mg) – 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	4B Total
1990	1 244.10	1 017.04	*157.36*	*37.45*	*281.20*	*541.02*	NO	1.35	0.06	NO	2.39	IE	1 472.97	55.36	0.18	0.53	0.06	**3 794.04**
1991	1 453.99	1 282.73	*219.32*	*46.97*	*339.80*	*676.65*	NO	1.43	0.06	NO	2.53	IE	1 299.81	50.98	0.17	0.53	0.06	**4 092.31**
1992	1 447.16	1 298.75	*232.96*	*41.30*	*337.50*	*686.99*	NO	1.28	0.05	NO	2.54	IE	1 324.11	48.35	0.16	0.53	0.06	**4 123.01**
1993	1 480.34	1 323.55	*251.08*	*41.78*	*339.78*	*690.90*	NO	1.26	0.05	NO	2.67	IE	1 401.47	50.89	0.16	0.53	0.06	**4 260.97**
1994	1 490.28	1 368.47	*274.13*	*38.87*	*365.31*	*690.17*	NO	1.44	0.05	NO	2.94	IE	1 343.97	48.49	0.15	0.53	0.06	**4 256.38**
1995	1 541.38	1 454.11	*297.78*	*46.12*	*370.28*	*739.93*	NO	1.40	0.04	NO	3.00	IE	1 417.86	44.61	0.14	0.53	0.06	**4 463.15**
1996	1 526.77	1 495.83	*309.96*	*47.31*	*380.15*	*758.40*	NO	1.33	0.04	NO	3.05	IE	1 415.01	49.62	0.15	0.53	0.06	**4 492.39**
1997	1 539.64	1 508.80	*308.10*	*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	**4 612.97**
1998	1 589.97	1 530.74	*316.77*	*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	**4 769.76**
1999	1 776.20	1 706.65	*369.53*	*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	**5 214.05**
2000	1 704.64	1 661.28	*370.52*	*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	**4 994.34**
2001	1 672.20	1 624.60	*366.53*	*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	**4 904.08**
2002	1 640.58	1 516.00	*352.65*	*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	**4 780.95**
2003	1 547.73	1 393.72	*323.96*	*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	**4 654.79**
2004	1 497.05	1 326.55	*309.60*	*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	**4 541.60**
2005	1 527.08	1 353.64	*321.50*	*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	**4 715.76**
2006	1 545.89	1 374.13	*329.07*	*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	**4 636.35**
2007	1 377.88	1 276.70	*311.06*	*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	**4 353.79**
2008	1 436.94	1 332.55	*339.55*	*28.83*	*324.82*	*639.36*	NO	1.57	0.34	NO	5.97	0.17	1 588.34	65.27	0.05	0.33	0.07	**4 431.62**
2009	1 490.70	1 355.63	*348.07*	*35.14*	*332.89*	*639.53*	NO	1.64	0.36	NO	6.05	0.15	1 565.76	78.14	0.07	0.33	0.07	**4 498.89**
Trend 1990-2009	*19.82%*	*33.29%*	*121.19%*	*-6.18%*	*18.38%*	*18.21%*	*NA*	*21.19%*	*518.58%*	*NA*	*153.48%*	*62.81%*	*6.30%*	*41.14%*	*-63.16%*	*-37.95%*	*18.02%*	*18.58%*

Table 6-16 – N_2O emission trends for IPCC Category 4B – Manure Management: 1990-2009 by livestock category

N_2O emissions (Mg) – 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	4B Total
1990	52.11	73.14	*15.10*	*3.73*	*17.60*	*36.72*	NO	1.56	0.11	NO	1.33	NE	2.35	0.74	0.08	1.70	0.03	**133.15**
1991	40.77	66.11	*14.98*	*3.33*	*15.05*	*32.75*	NO	1.65	0.10	NO	1.42	NE	2.10	0.68	0.07	1.70	0.03	**114.64**
1992	35.40	61.49	*14.58*	*2.68*	*13.74*	*30.49*	NO	1.48	0.10	NO	1.42	NE	2.17	0.65	0.07	1.70	0.03	**104.52**
1993	34.12	61.15	*15.27*	*2.63*	*13.43*	*29.82*	NO	1.45	0.09	NO	1.49	NE	2.28	0.68	0.07	1.70	0.03	**103.07**
1994	31.81	58.97	*15.62*	*2.30*	*13.48*	*27.58*	NO	1.66	0.09	NO	1.65	NE	2.18	0.65	0.07	1.70	0.03	**98.80**
1995	33.64	60.23	*16.24*	*2.61*	*13.06*	*28.31*	NO	1.61	0.08	NO	1.68	NE	2.31	0.60	0.06	1.70	0.03	**101.94**
1996	33.19	62.08	*16.91*	*2.68*	*13.41*	*29.08*	NO	1.53	0.08	NO	1.70	NE	2.25	0.66	0.06	1.70	0.03	**103.29**
1997	30.63	58.20	*15.74*	*2.85*	*12.21*	*27.41*	NO	1.71	0.08	NO	1.78	NE	2.40	0.71	0.07	1.84	0.02	**97.44**
1998	28.73	54.99	*15.04*	*2.58*	*11.41*	*25.95*	NO	1.76	0.06	NO	1.82	NE	2.44	0.73	0.05	1.72	0.03	**92.33**
1999	22.15	46.81	*13.38*	*2.01*	*9.61*	*21.82*	NO	1.76	0.06	NO	2.18	NE	2.57	0.73	0.03	1.56	0.04	**77.89**
2000	20.93	45.91	*13.50*	*1.80*	*9.38*	*21.23*	NO	1.70	0.06	NO	2.44	NE	2.43	0.85	0.03	1.69	0.04	**76.08**
2001	20.57	45.97	*13.66*	*1.98*	*9.17*	*21.16*	NO	1.81	0.07	NO	2.42	NE	2.45	1.00	0.03	1.67	0.04	**76.03**
2002	19.61	42.94	*13.13*	*1.68*	*8.89*	*19.23*	NO	1.95	0.24	NO	2.42	NE	2.45	0.92	0.03	1.78	0.04	**72.36**
2003	21.14	42.10	*12.87*	*1.56*	*8.76*	*18.91*	NO	2.02	0.40	NO	2.67	NE	2.57	0.96	0.03	1.66	0.03	**73.58**
2004	20.82	41.38	*12.72*	*1.46*	*8.61*	*18.58*	NO	2.08	0.43	NO	2.86	NE	2.99	0.90	0.04	1.68	0.03	**73.21**
2005	19.40	40.00	*12.46*	*1.35*	*8.19*	*17.99*	NO	2.20	0.47	NO	3.16	0.06	3.18	0.97	0.04	1.66	0.03	**71.16**
2006	17.99	38.25	*12.02*	*1.21*	*7.99*	*17.04*	NO	2.06	0.42	NO	3.33	0.09	2.97	0.95	0.04	1.74	0.03	**67.87**
2007	23.98	48.05	*15.43*	*1.28*	*9.97*	*21.37*	NO	2.00	0.60	NO	3.30	0.08	2.96	0.98	0.03	1.22	0.02	**83.20**
2008	23.61	47.83	*16.04*	*1.41*	*9.65*	*20.72*	NO	1.81	0.62	NO	3.41	0.12	2.89	1.06	0.02	1.05	0.04	**82.45**
2009	23.13	46.87	*15.79*	*1.65*	*9.50*	*19.93*	NO	1.89	0.67	NO	3.45	0.11	2.92	1.19	0.03	1.05	0.04	**81.34**
Trend 1990-2009	*-55.60%*	*-35.92%*	*4.58%*	*-55.64%*	*-46.04%*	*-45.73%*	*NA*	*21.19%*	*518.58%*	*NA*	*158.29%*	*62.81%*	*24.03%*	*61.40%*	*-63.16%*	*-37.95%*	*18.02%*	*-38.91%*

Source for Tables 6-15 and 6-16: MDDI-DEV.

Notes for Tables 6-15 and 6-16:

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.

Looking at methane emissions from manure management – Table 6-15 – an increase of 18.6% can be observed for the period 1990-2009. 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 6-16 – a decrease of 38.9% is observed for the period 1990-2009. These emissions are mainly due to cattle. However, if cattle were responsible for 94% of manure related N_2O emissions in 1990, this share dropped to a bit less than 86% in 2009. This evolution is the result of a declining (dairy) cattle population at the same time as other farm animal categories, such as sheeps and swines, saw their number grow. Here too, for some livestock categories, the observed nitrous oxide emissions developments between 1990 and 2009 are identical to those of their population size: it is the case for all categories except cattle, horses, swine and poultry. 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 horses, swine and poultry, 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 6-17, solid storage is the main source of N_2O (96% in 1990, 91% in 2009). In the same time, liquid system share more than doubled (from 3.8% to 8.2%). 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.

Combining both gases – CH_4 and N_2O – manure management related emissions, expressed in CO_2e, remained fairly stable between 1990 and 2009: 119.69 Gg CO_2e in 2009, i.e. 1.04% lower than the value obtained for the base year (120.95 Gg CO_2e) – see Table 6-18. Beside livestock population developments, the methane emission increase is mainly driven by the changes in the AWMS for cattle: looking at nitrogen excretion in kg N/year, the liquid system share in AWMS went from 23% to 34.2% for dairy cattle and from 18.9% to 26.3 % for non-dairy cattle.[134] 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 still raise over the period 1990-2009.[135] Nevertheless, at the end of the day, the higher variation in absolute terms recorded for nitrous oxide between 1990 and 2009 counterbalanced the increasing methane emissions from manure management (|38.91%| for N_2O and |18.58%| for CH_4), leading to a, nowadays, fairly stable emission trend for manure management.[136]

Table 6-17 – N_2O emission trends for IPCC Category 4B – Manure Management: 1990-2009 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	128.00	NO	*189.64*	0.08	**133.15**
1991	NO	5.94	NO	108.62	NO	*191.32*	0.07	**114.64**
1992	NO	5.97	NO	98.47	NO	*182.09*	0.07	**104.52**
1993	NO	6.09	NO	96.91	NO	*182.06*	0.07	**103.07**
1994	NO	6.17	NO	92.57	NO	*180.79*	0.07	**98.80**
1995	NO	6.68	NO	95.19	NO	*191.38*	0.07	**101.94**
1996	NO	6.73	NO	96.49	NO	*194.17*	0.07	**103.29**
1997	NO	6.80	NO	90.56	NO	*188.65*	0.08	**97.44**
1998	NO	6.96	NO	85.29	NO	*186.44*	0.08	**92.33**
1999	NO	7.73	NO	70.09	NO	*185.97*	0.08	**77.89**
2000	NO	7.41	NO	68.41	NO	*183.45*	0.27	**76.08**
2001	NO	7.26	NO	68.32	NO	*183.64*	0.45	**76.03**
2002	NO	6.94	NO	64.81	NO	*177.38*	0.61	**72.36**
2003	NO	6.74	NO	66.05	NO	*176.52*	0.79	**73.58**
2004	NO	6.66	NO	65.59	NO	*174.05*	0.96	**73.21**
2005	NO	6.86	NO	63.34	NO	*174.15*	0.96	**71.16**
2006	NO	6.83	NO	60.10	NO	*172.29*	0.95	**67.87**
2007	NO	6.28	NO	75.95	NO	*178.11*	0.98	**83.20**
2008	NO	6.48	NO	74.98	NO	*182.22*	1.00	**82.45**
2009	NO	6.64	NO	73.69	NO	*183.75*	1.01	**81.34**
Trend 1990-2009	*NA*	*31.09%*	*NA*	*-42.43%*	*NA*	*-3.11%*	*1192.17%*	*-38.91%*

Source: MDDI-DEV.

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.

134 See previous paragraph: liquid system share in AWMS more than doubled over the period.

135 Except for male mature cattle for which the sharp population decrease over the period has not been counterbalanced by the increasing methane emissions generated by the AWMS in place.

136 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).

Table 6-18 – CH_4 & N_2O emission trends for IPCC Category 4B – Manure Management: 1990-2008

Year	*CO_2 e emissions (Gg)* 4B - Manure Management		
	CH_4	N_2O	Total
1990	79.67	41.28	**120.95**
1991	85.94	35.54	**121.48**
1992	86.58	32.40	**118.98**
1993	89.48	31.95	**121.43**
1994	89.38	30.63	**120.01**
1995	93.73	31.60	**125.33**
1996	94.34	32.02	**126.36**
1997	96.87	30.21	**127.08**
1998	100.16	28.62	**128.79**
1999	109.49	24.15	**133.64**
2000	104.88	23.59	**128.47**
2001	102.99	23.57	**126.55**
2002	100.40	22.43	**122.83**
2003	97.75	22.81	**120.56**
2004	95.37	22.70	**118.07**
2005	99.03	22.06	**121.09**
2006	97.36	21.04	**118.40**
2007	91.43	25.79	**117.22**
2008	93.06	25.56	**118.62**
2009	94.48	25.22	**119.69**
Trend 1990-2009	*18.58%*	*-38.91%*	*-1.04%*

Source: MDDI-DEV.

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 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 judgment 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 diverse information and its knowledge on agricultural practices in Luxembourg. These percentages are presented in theTable 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 judgment (not published): prepared on 7 June 2007.

Note: for the other livestock categories (4B10), percentages are first expert judgments discussed between the SER and the MDDI-DEV.

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 6-22 and 6-23).[137]

Consequently, due to the uncertainty going along with the first AWMS expert judgment, ASTA and SER decided to improve the AWMS breakdown for the main emitting animal category, i.e. cattle.[138] The result of this exercise is presented in Table 6-20.

Table 6-20 – Revised AWMS for cattle: 1990-2009

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%
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%
2008	33.50%	16.50%	45.00%	5.00%
2009	34.20%	15.80%	45.00%	5.00%

137 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 judgment). 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.

138 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.

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%
2008	25.80%	19.20%	50.00%	5.00%
2009	26.30%	18.70%	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%
2008	25.80%	19.20%	50.00%	5.00%
2009	26.30%	18.70%	50.00%	5.00%

Source: SER & ASTA calculations (not published): prepared on 19 June 2007 and updated by the MDDI-DEV in December 2010.

These revised AWMS shares for cattle were produced by SER using information collected in the framework of the yearly agricultural census.[139] Cowshed numbers and capacity (in number of

139 See http://www.ser.public.lu/statistik/agrarstrukturen/statec_15_mai_pluriannuel.pdf, section 3.2.

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 judgment 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 judgment 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 6-20 (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 judgment recorded inTable 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 %):

$$IEF_i = VS_i \bullet 365 \bullet Bo_i \bullet 0.67 \bullet [\Sigma_j MCF_j \bullet AWMS_{ij}]$$

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.

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 is obtained by combining national AD and default coefficients/parameters from the IPCC Guidelines; DE is based on table 10.2 of the 2006 IPCC Guidelines and table A-2 of the 1996 Revised IPCC Guidelines: see Table 6-22 for details*
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 Guideline: it refers to deer*

Source: MDDI-DEV.

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 100422)	AD (see Table 6-4)
Live Weight	kg	SER, not published (provided 070601)	AD (see Table 6-7), invariable
Gross Energy Intake (average)	MJ/day	equation 4.11 – 2000 IPCC-GPG	calculated
Digestible Energy	%	- mature dairy & non-dairy cattle: based on table 10.2 - 2006 IPCC Guidelines - young cattle: table A-2 – Revised 1996 IPCC Guidelines	- expert judgment, invariable: see explanations in Table 6-9 - 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^3CH_4/kg VS	table B-1 – 1996 Revised IPCC Guidelines	default for Western Europe
Manure System/AWMS	%	SER & ASTA, not published (prepared 070619, updated 1012)	expert judgment (see Table 6-20), 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 judgment 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[140]

AD, parameter, coefficient	Unit	Source(s)	Type of value
Livestock (# of heads)	#	SER & STATEC (updated 100422)	AD (see Table 6-4)
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 6-7), invariable
Gross Energy Intake (average)	MJ/day	- 4A3 to 4A8: table A-4 – Revised 1996 IPCC Guidelines - 4A9: derived from the GHG inventory of Austria - 4A10 – rabbits: obtained from the GHG inventory of Italy	- 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	$m^3 CH_4$/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 & MDDI-DEV	expert judgment (see Table 6-19), 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 judgment 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.

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.

140 CRF Categories 4B2 – Buffalo and 4B5 – Camels & Llamas do not exist in Luxembourg.

Table 6-24 – CH_4 IEFs trends for IPCC Category 4B – Manure Management: 1990-2009

Year	IEF for CH_4 (kg CH_4/head/year) – 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
1990	21.14	6.41	*7.14*	*6.88*	*4.72*	*7.56*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
1991	26.15	7.82	*8.66*	*8.35*	*5.73*	*9.18*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
1992	28.31	8.21	*9.06*	*8.74*	*6.00*	*9.60*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
1993	29.50	8.34	*9.19*	*8.86*	*6.10*	*9.74*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
1994	30.43	8.57	*9.49*	*9.15*	*6.30*	*10.06*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
1995	31.72	8.80	*9.69*	*9.34*	*6.43*	*10.27*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
1996	31.84	8.80	*9.69*	*9.34*	*6.43*	*10.27*	NO	0.19	0.12	NO	1.39	IE	19.52	0.80	0.08	0.08	0.22
1997	33.25	9.09	*9.99*	*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	34.60	9.40	*10.32*	*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	39.38	10.49	*11.51*	*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	39.33	10.27	*11.27*	*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	39.02	10.01	*10.97*	*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	38.99	9.77	*10.76*	*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	38.12	9.35	*10.28*	*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	37.54	9.03	*9.94*	*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	38.82	9.28	*10.18*	*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	40.03	9.48	*10.41*	*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	35.35	8.35	*9.18*	*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
2008	35.95	8.56	*9.38*	*9.05*	*6.24*	*9.95*	NO	0.19	0.12	NO	1.39	0.76	19.52	0.80	0.08	0.08	0.22
2009	36.69	8.70	*9.55*	*9.21*	*6.35*	*10.13*	NO	0.19	0.12	NO	1.39	0.76	19.52	0.80	0.08	0.08	0.22
Trend 1990-2009	*73.51%*	*35.66%*	*33.76%*	*33.76%*	*34.52%*	*33.96%*	*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: MDDI-DEV.

Notes:

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).

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 6-19 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 [141] 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.[142] Since they are not officially published in Luxembourg, Nex_i values should therefore be considered as an expert judgment.

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	[49.46;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	2005 - …: [61.65;63.71] 1990-2004: 61.65	*weighted average using population size:* *Nex_i = 42.50 for horses of less than 6 months and ponys;* *Nex_i = 68.00 for for horses older than 6 months.* *For the period 1990-2004 due to a lack of consistent data, the 2005 value has been used*
4B7 – Mules & Asses	42.50	

141 Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources.

142 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.

4B8 – Swine	[9.77;11.62]	*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	1997 - …: [0.65;0.79] 1990-1996: 0.65	*weighted average using population size:* *Nex_i = 0.85 for layers chickens;* *Nex_i = 0.25 for other chickens & roosters.* *For the period 1990-1996 due to a lack of consistent data, the 1997 value has been used*
4B10 – Other – Other Poultry	1.10	*taken from the Austrian 2009 NIR, table 162, p. 251: weighted average of turkeys and other (ducks, gooses) i.e. a mix very similar to the one Luxembourg has for this sub-category*
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.[143]

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

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 6-26. 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.

143 These EFs are labelled EF_3 in this table.

For each animal category, nitrogen excretion per AWMS was calculated using the following formula:[144]

$$Nex_{ij} = Nex_i \bullet (\#\ of\ heads)_i \bullet AWMS_{ij}$$

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 6-25)

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 6-26)

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 2010v2.1 and 2011v1.3 (see also CRF tables 8).

Table 6-27 – Changes in GHG inventories: submissions 2010v2.1 and 2011v1.3

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
4B – Manure Management	no recalculations	NA

144 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.

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 MDDI-DEV 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 MDDI-DEV and the sector experts, SER and ASTA.

Category specific checklists have also been filled in.

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	implementing ERT's recommendations on including in the NIR additional information on the parameters, coefficients and activity data used.
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 or, at least, use updated databases (notably for the OECD source).
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	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 (IPCC Source Category 4C)

This source category does not exist in Luxembourg.

6.5 Agricultural Soils (IPCC Source Category 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 2009, this source category was responsible for 92.4% of agricultural nitrous oxide emissions and for 68.1% of the total nitrous oxide emissions estimated for Luxembourg. It represented 45.7% of the total emissions due to agricultural activities and 2.64% of the total GHG emissions in CO_2e (excluding LULUCF).

6.5.1 Key source

With 2.64% of the total GHG emissions in CO_2e, excluding LULUCF in 2009 (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 1995, from 1998 to 2000 and in 2009 when LULUCF is included. For IPCC Sub-category 4D2, it has been a key source, excluding LULUCF, from 1996 to 2004 and in 2008, whereas it has never been a key source when LULUCF is included. Finally, Sub-category 4D3 has been a key source for all years if LULUCF is excluded and from 1990 to 1992, and from 1994 to 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, around 45%of the nitrous oxide emissions from agricultural soils stems from direct soil emissions. Some 40% 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 1990-2009 period, though an increasing trend can be identified for PRP. 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).

Table 6-29 – N_2O emission trends for IPCC Category 4D – Agricultural Soils: 1990-2009

Year	N₂O 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	525.30	*334.05*	*115.46*	*6.68*	*61.70*	*NO*	*7.41*	189.64	457.79	*72.93*	*384.86*	**1 172.73**
1991	540.49	*348.07*	*114.46*	*6.63*	*63.91*	*NO*	*7.41*	191.32	468.23	*74.15*	*394.08*	**1 200.04**
1992	562.41	*375.58*	*109.64*	*6.23*	*63.47*	*NO*	*7.50*	182.09	480.12	*74.72*	*405.40*	**1 224.62**
1993	530.45	*342.63*	*110.06*	*6.29*	*63.69*	*NO*	*7.79*	182.06	455.83	*71.92*	*383.91*	**1 168.33**
1994	503.16	*325.29*	*108.66*	*6.22*	*54.85*	*NO*	*8.14*	180.79	441.06	*70.03*	*371.03*	**1 125.01**
1995	505.87	*319.17*	*115.17*	*3.36*	*60.09*	*NO*	*8.09*	191.38	447.61	*71.84*	*375.77*	**1 144.86**
1996	518.24	*320.69*	*116.24*	*4.70*	*69.58*	*NO*	*7.02*	194.17	450.30	*72.29*	*378.00*	**1 162.70**
1997	506.43	*315.74*	*114.08*	*3.83*	*65.42*	*NO*	*7.36*	188.65	442.14	*70.92*	*371.21*	**1 137.22**
1998	500.34	*309.38*	*113.03*	*3.42*	*67.14*	*NO*	*7.38*	186.44	435.29	*69.93*	*365.36*	**1 122.08**
1999	509.95	*319.05*	*113.13*	*4.32*	*66.11*	*NO*	*7.34*	185.97	442.45	*70.76*	*371.69*	**1 138.37**
2000	500.14	*315.01*	*110.98*	*3.50*	*64.23*	*NO*	*6.42*	183.45	435.46	*69.57*	*365.89*	**1 119.06**
2001	450.36	*268.71*	*111.25*	*3.87*	*60.51*	*NO*	*6.02*	183.64	400.52	*65.46*	*335.06*	**1 034.52**
2002	466.97	*279.94*	*107.95*	*3.89*	*68.83*	*NO*	*6.37*	177.38	403.15	*65.23*	*337.92*	**1 047.50**
2003	410.09	*228.14*	*108.31*	*2.81*	*65.97*	*NO*	*4.86*	176.52	362.81	*60.37*	*302.44*	**949.42**
2004	480.85	*289.13*	*108.98*	*4.14*	*74.14*	*NO*	*4.46*	174.05	408.05	*65.61*	*342.43*	**1 062.95**
2005	434.48	*251.57*	*109.90*	*2.68*	*65.61*	*NO*	*4.73*	174.15	380.80	*62.51*	*318.28*	**989.43**
2006	430.04	*248.10*	*107.79*	*2.78*	*65.39*	*NO*	*5.98*	172.29	376.23	*61.80*	*314.44*	**978.56**
2007	417.88	*235.34*	*110.48*	*2.76*	*62.73*	*NO*	*6.57*	178.11	372.36	*61.88*	*310.48*	**968.34**
2008	431.76	*235.73*	*112.27*	*2.15*	*75.78*	*NO*	*5.84*	182.22	375.76	*62.56*	*313.19*	**989.74**
2009	432.73	*235.73*	*113.35*	*2.12*	*75.58*	*NO*	*5.95*	183.75	377.59	*62.95*	*314.64*	**994.07**
Trend 1990-2009	*-17.62%*	*-29.43%*	*-1.83%*	*-68.31%*	*22.50%*	*NA*	*-19.67%*	*-3.11%*	*-17.52%*	*-13.69%*	*-18.24%*	*-15.23%*

Source: MDDI-DEV.

Note:

2009 data are provisional for sub-categories 4D11, 4D13, 4D14 and 4D16 (hence 4D1) as well as 4D31 and 4D32 (hence 4D3), hence 4D.

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

Since 1990, agricultural soil N_2O related emissions declined by a bit more than 15%. Actually, all agricultural soil source categories showed decreasing emissions over the period 1990-2009 but one: nitrogen in crop residues returned to soils (sub-category 4D14). This positive evolution is the result of a 52.9% increase in non N-fixing crops between 1990 and 2009 (see Section 6.5.3.1).

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 2009. This is explained mainly by important changes in crops, as well as in fertilizer use, which showed a slack in 2003 and a peak in 2004 (see Table 6-31 and Table 6-32 in Section 6.5.3.1).

6.5.3 Methodological issues

According to IPCC Guideline, estimating nitrous oxide emissions from agricultural soils requests the use of certain **fractions**. For most of these fractions, as shown inTable 6-30, 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: see Table 6-31;
- various crop productions: see Table 6-32.

For emissions due to sewage sludge spreading on fields, data have been estimated by both the MDDI-DEV 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: 1990-2009

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	13312
2008	13334
2009	13334
Trend 1990-2009	***-29.43%***

Sources: SER: http://www.ser.public.lu/statistik/betriebsmittel/duenger.pdf
STATEC, *Statistical Yearbook*, Table D.2112:
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=707&IF_Language=fra&MainTheme=4&FldrName=2&RFPath=11 and MDDI-DEV simple assumption (2009).
data extracted on 20 September 2010 (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 2009, at the time calculations were made for submission 2011v1.3, fertilizers consumption was not yet known; hence the 2008 amount has been used as a proxy for the 2009 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 is presented in Table 6-32. 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.[145]

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. These estimates have been prepared by the Environment Agency with some corrections performed by the MDDI-DEV for the years 2000 to 2004;

145 See http://www.soil-concept.lu/.

Table 6-32 – Crop production and trends: 1990-2009

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	147 439	43 511	69 611	NE	18 757	2 366	NO	13 194	1 410	NO	50	NO	1 360	23 593	22 963	630
1991	156 376	44 301	73 480	NE	19 481	2 218	NO	16 896	1 678	NO	30	NO	1 648	20 009	19 499	510
1992	152 341	46 124	70 386	NE	17 237	1 923	NO	16 671	2 214	NO	30	NO	2 184	27 236	26 866	370
1993	151 880	48 534	68 059	NE	17 109	1 826	NO	16 352	2 202	NO	28	NO	2 174	26 079	25 654	425
1994	133 630	45 243	59 882	NE	12 369	1 519	NO	14 617	1 866	NO	30	NO	1 836	18 304	17 859	445
1995	147 585	52 745	62 822	NE	12 150	1 703	NO	18 165	1 410	NO	30	NO	1 380	23 292	22 857	435
1996	175 502	64 398	72 456	NE	13 278	2 326	NO	23 044	1 949	NO	32	NO	1 917	20 744	20 244	500
1997	162 008	57 378	68 627	2 285	13 247	2 715	NO	17 756	1 561	NO	30	NO	1 531	23 230	22 820	410
1998	167 217	60 073	63 203	4 293	11 693	4 051	NO	23 904	1 451	NO	31	NO	1 420	22 853	22 313	540
1999	153 795	46 379	67 775	3 112	12 246	3 535	NO	20 748	2 337	NO	30	NO	2 307	26 174	25 704	470
2000	152 830	61 184	53 533	2 040	9 217	3 603	NO	23 253	1 270	NO	35	NO	1 235	28 403	27 858	545
2001	144 299	54 022	53 566	4 331	7 799	4 803	NO	19 778	2 312	NO	35	NO	2 277	23 210	22 770	440
2002	168 788	71 656	51 823	2 317	10 219	7 470	NO	25 303	2 359	NO	32	NO	2 327	20 600	20 105	495
2003	164 139	68 648	55 330	1 902	11 414	4 606	NO	22 239	2 166	NO	20	NO	2 146	18 564	18 329	235
2004	178 983	79 978	52 761	3 611	9 458	7 921	NO	25 254	1 749	NO	20	NO	1 729	22 644	22 244	400
2005	160 569	71 745	52 853	2 060	7 734	5 715	NO	20 462	1 501	NO	13	NO	1 488	19 731	19 329	402
2006	161 462	75 603	50 061	1 875	6 650	6 156	NO	21 117	1 198	NO	13	NO	1 185	16 779	16 449	330
2007	148 352	70 469	44 640	2 120	5 634	6 953	NO	18 536	833	NO	9	NO	824	20 204	19 968	236
2008	189 703	97 240	52 450	2 274	6 241	8 727	NO	22 771	774	NO	9	NO	765	22 112	21 757	355
2009	188 562	90 903	54 398	2 453	7 197	6 924	NO	26 687	1 215	NO	9	NO	1 206	20 399	20 044	355
Trend 1990-2009	27.89%	108.92%	-21.85%	7.35%	-61.63%	192.65%	NA	102.27%	-13.83%	NA	-82.00%	NA	-11.32%	-13.54%	-12.71%	-43.65%

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	202 662	191 497	11 165	362 529	12 575	197 314	165 215
1991	NO	177 636	166 829	10 807	343 214	12 485	170 988	172 226
1992	NO	282 218	272 714	9 504	452 291	11 718	279 908	172 383
1993	NO	280 194	270 562	9 632	448 521	11 834	275 694	172 827
1994	NO	234 972	225 136	9 836	377 070	11 702	231 242	145 828
1995	NO	296 515	291 610	4 905	462 487	6 315	289 720	172 767
1996	NO	301 855	294 957	6 898	491 203	8 847	294 223	196 980
1997	NO	328 724	323 087	5 637	508 325	7 198	320 859	187 466
1998	NO	340 152	335 169	4 983	525 239	6 434	330 966	194 273
1999	NO	266 166	260 388	5 778	440 357	8 115	252 598	187 759
2000	NO	306 115	300 801	5 314	482 034	6 584	297 037	184 997
2001	NO	311 090	306 130	4 960	473 639	7 272	301 497	172 142
2002	NO	284 949	280 008	4 941	469 396	7 300	271 629	197 767
2003	NO	273 631	270 527	3 104	453 230	5 270	260 227	193 003
2004	NO	350 291	344 251	6 040	545 878	7 789	332 711	213 167
2005	NO	296 570	293 038	3 532	473 338	5 033	280 986	192 352
2006	NO	283 837	279 813	4 024	458 054	5 222	266 741	191 313
2007	NO	345 442	341 074	4 368	509 630	5 201	326 485	183 145
2008	NO	329 825	326 565	3 260	538 380	4 034	312 648	225 732
2009	NO	348 061	345 302	2 759	554 263	3 974	329 008	225 255
Trend 1990-2009	NA	71.74%	80.32%	-75.29%	52.89%	-68.40%	66.74%	36.34%

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 D.2104: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=699&IF_Language=fra&MainTheme=4&FldrName=2&RFPath=11 and Table D.2106: http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=701&IF_Language=fra&MainTheme=4&FldrName=2&RFPath=11

data extracted on 17 September 2010 (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: grain maize

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 !): 2009 data is provisional

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 !): 2009 data is provisional

4F4 – Sugar Cane: sugar cane

4F5 – Other – Non N-fixing Crops: rapeseed (colza), green maize, roots & beets, lucernes, fodder plants: grass & clovers (including clover-grass mixes)

4F5 – Other – N-fixing Crops: fodder leguminous

Total – Non N-fixing crops = 4F1 + 4F3 + 4F5(non N-fixing crops)

Total – N-fixing Crops = 4F2 + 4F5(N-fixing crops) !): 2009 data is provisional

Total – Fodder Crops = fodder plants, roots, green maize, fodder leguminous

Total - Non N-fixing Crops excluding Fodder Crops = Total-non N-fixing crops – Total-fodder crops.

- annual reports on sewage sludge that are regularly issued since 2003.[146] 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 judgment. They are summarized in Table 6-33**Error! Reference source not found.**. 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_LU_GHG_Estimates_1990-2009.xls**).

Table 6-33 – Sewage sludge estimates and trends: 1990-2009

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	14 007.16	7 503.94	*3 116.92*	**5 818.17**
2005	13 373.38	8 191.54	*3 780.15*	**6 171.41**
2006	15 176.40	8 298.83	*4 267.56*	**7 804.27**
2007	16 284.38	8 336.48	*4 387.21*	**8 569.91**
2008	14 394.37	9 051.57	*4 796.01*	**7 626.92**
2009	14 277.15	9 100.08	*4 949.97*	**7 766.03**
Trend 1990-2009	*47.67%*	*17.42%*	*30.00%*	*-19.67%*

Sources: columns (a) to (c): Environment Agency (1990-2005) and MDDI-DEV estimates (2009); column (d): Environment Agency & MDDI-DEV estimates (2009).

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 2008: (d) = [(c) / (b)] ● (a).

146 See http://www.environnement.public.lu/dechets/statistiques_indicateurs/index.html under "*Statistiques sur les boues d'épuration*".

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 (see Austrian 2009 NIR, p. 266)*
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: MDDI-DEV.
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 6-31)

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 1990-2009.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 6-32. 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[147]
F_{SSlu} in kg N calculated using the method proposed by Austria:

$$F_{SSlu} = SSlu_{DM}AS \bullet SSlu_N$$

[147] 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).

with $SSlu_{DM}AS$ = sewage sludge spreading on agricultural soils – dry matter (see Table 6.33, column (d))

$SSlu_N$ = N content in dry matter: default value from the Austrian inventory (3.90%)

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 Indirect Soil Emissions – 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 6-31), 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 6-30)

6.5.3.2.9 Indirect Soil Emissions – 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 6-31), 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 6-30)

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 6-36 presents the main revisions and recalculations between submissions 2010v2.1 and 2011v1.3 (see also CRF tables 8).

Table 6-36 – Changes in GHG inventories: submissions 2010v2.1 and 2011v1.3

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
4D11 – N Input Fertilizers	2008 –provisional activity data replaced by final data.	revised activity data.
4D13 – N Fixed N-fixing Crops	2008 – updated activity data for "other pulses production", part of sub-category 4F2 – "pulse".	revised activity data.
4D14 – N Crop Residues	2008 – updated activity data for "other pulses production", part of sub-category 4F2 – "pulse".	revised activity data.
4D16- N Input Sewage Sludge	2004 & 2006-2008 – new estimates of total sewage sludge produced.	revised activity data.
4D16- N Input Sewage Sludge	2008 –: new estimates of sewage sludge use per category (spreading, composting, incineration).	revised activity data.
4D31 – Atmospheric Deposition …	- 2004 & 2006-2008 – new estimates of total sewage sludge produced; - 2008 only –: new estimates of sewage sludge use per category (spreading, composting, incineration).	- revised activity data; - revised activity data.
4D32 – N Leaching & Run-off …	- 2004 & 2006-2008 – new estimates of total sewage sludge produced; - 2008 only –: new estimates of sewage sludge use per category (spreading, composting, incineration).	- revised activity data; - revised activity data.

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 MDDI-DEV 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 MDDI-DEV and the sector experts, SER and ASTA.

Category specific checklists have also been filled in.

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 6-37 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; - implementing ERT's recommendations on including in the NIR additional information on the parameters, coefficients and activity data used.
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 (IPCC Source Category 4E)

This source category does not exist in Luxembourg.

6.7 Field Burning of Agricultural Residues (IPCC Source Category 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[148] forbids clearing and burning[149] 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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148 See http://www.legilux.public.lu/leg/a/archives/2004/0010/a010.pdf#page=2.

149 "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.[150] 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 2010v2.1 and 2011v1.3 (see also CRF tables 8).

150 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.

Table 6-38 – Changes in GHG inventories: submissions 2010v2.1 and 2011v1.3

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
4F24 – Pulse: Other	2008 – updated activity data for crop production.	revised activity data.
4F3 – Tubers & Roots: Other	2008 – updated activity data for crop production.	revised activity data.

6.7.5 Category specific QA/QC procedures

Not applicable.

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 2009.

7.1 Sector Overview

In 2009, Sector 5 – *Land Use, Land Use Change and Forestry* was a net sink in Luxembourg (Table 7-1). An important sub-category is forest land, in particular its sub-category forest land remaining forestland. This category is a net sink, whereas the other sub-categories are net sources. However, total emissions arising from the other sub-categories only amount to 0.1-25% of removals from forest land.

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	349.03	126.20	38.60	31.64	12.27	138.93	1.40
1991	173.71	- 49.24	38.72	31.64	12.27	138.93	1.40
1992	- 194.47	- 417.54	38.84	31.64	12.27	138.93	1.40
1993	- 304.55	- 527.74	38.96	31.64	12.27	138.93	1.40
1994	- 134.68	- 358.29	39.38	31.64	12.27	138.93	1.40
1995	- 236.82	- 460.19	39.13	31.64	12.27	138.93	1.40
1996	- 409.36	- 632.59	39.00	31.64	12.27	138.93	1.40
1997	- 449.80	- 673.51	39.48	31.64	12.27	138.93	1.40
1998	- 194.22	- 418.49	40.04	31.64	12.27	138.93	1.40
1999	- 317.53	- 540.90	39.14	31.64	12.27	138.93	1.40
2000	- 386.84	- 557.07	32.71	7.67	10.77	118.35	0.72
2001	- 452.90	- 623.71	32.31	9.81	10.67	117.34	0.69
2002	- 452.51	- 624.13	32.12	11.95	10.56	116.32	0.66
2003	- 460.89	- 632.61	31.22	14.09	10.46	115.31	0.64
2004	- 415.56	- 587.07	30.02	16.23	10.35	114.30	0.61
2005	- 386.63	- 559.81	30.70	18.36	10.25	113.29	0.58
2006	- 276.47	- 448.98	29.04	20.50	10.14	112.27	0.55
2007	- 273.97	- 446.69	28.26	22.64	10.04	111.26	0.52
2008	- 273.04	- 445.73	27.24	24.78	9.94	110.25	0.49
2009	- 296.00	- 471.13	27.65	26.92	9.83	110.25	0.49
Trend 1990-2009	-184.81%	-473.33%	-28.38%	-14.92%	-19.86%	-20.65%	-64.70%
Trend 2008-2009	8.41%	5.70%	1.50%	8.63%	-1.05%	0.00%	0.00%

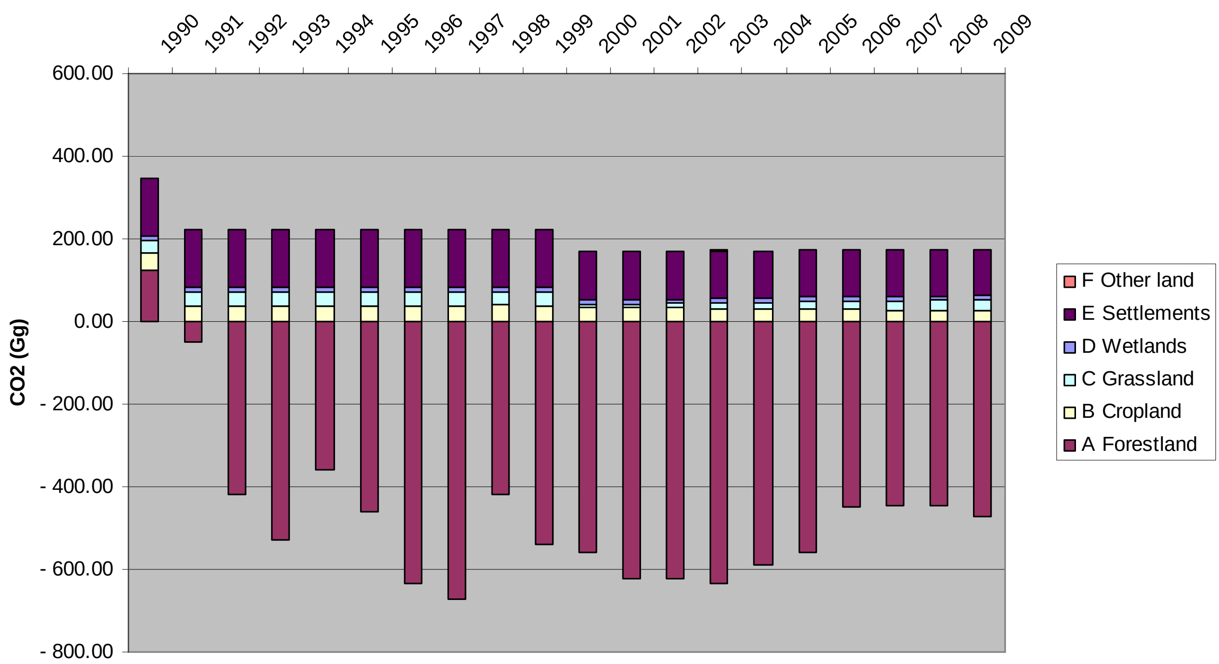
7.1.1 Emission Trends

In 2009, removals from category forest land corresponded to 4.1% of total GHG in Luxembourg (incl. LULUCF). The net removals increased by 473% from the base year to 2009, mainly due to the fact that in 1990 forestland was a net emission source due to the heavy windfall during the winter 1990/1991, but also due to an increase of the carbon stock in forest land (Figure 7-1).

The net carbon stock changes in forest biomass (sector 5.A.1) have a major impact on the overall results in sector 5. These changes vary considerable between single years. The reason is that the figures for annual growth and for annual harvest of forest biomass differ significantly year by year due to annual variations of influencing factors on growth and harvest like weather conditions, timber demand and prices, insect infestation or wind throws. These reasons for different growth and different harvest in single years explain the high annual variations in the CO_2 net removals of this sector.

In order to be consistent with the IPCC GPG for LULUCF the area of all LUC categories in the land use transition matrix is followed and reported in the conversion status for 20 years. After these 20 years they are accounted in the remaining categories.

Figure 7-1 - Emissions and Removals from Sector 5 - LULUCF



7.1.2 Key categories

The methodology and results of the key category analyisis are presented in Chapter 1. Table 7-2 presents the key categories of IPCC Sector 5 - LULUCF.

Table 7-2 - Key categories of IPCC Sector 5 - LULUCF

5 - Land Use, Land Use Change and Forestry *Key sources*						
IPCC Category	Category Name	GHG	LA excl. LULUCF	LA incl. LULUCF	TA excl. LULUCF	TA incl. LULUCF
5A1	Forest Land remaining Forest Land	CO_2	*NA*	90, 92-09	*NA*	X
5A2	Land Use Change to Forest Land	CO_2	*NA*	90-91	*NA*	
5E2	Land Use Change to Settlements	CO_2	*NA*	90-91, 94-95, 98	*NA*	

Source: Environment Agency

Notes: LA = Level Assessement including respectively exluding LULUCF
TA = Trend Assessement 2007 including respectively excluding LULUCF

7.1.3 Methodology

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 water (1%)[151]. In 2009, the respective areas were 86%, 13% and 1%. Thus, 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.

Meteorologically, Luxembourg is situated in an area with temperate maritime climate, with an annual average temperature of 10.7°C[152] (year 2009), approximately.

7.1.3.1 Information on approaches used for representing land areas and on lans use databases used for the inventory preparation

Before deciding which activity data would be used, an inventory of the available activity data sources for Luxembourg was made. Until 2009, the only datasets available in Luxembourg for different time periods and covering all the land uses in the whole country was the CORINE Land cover database. It is available for the reference year 1989 and has been updated in 2000 and 2007. Land-use and land-use change areas of submissions until 2009 were estimated on the basis of the CORINE Landcover database.

The base data used since submission 2010 under the UNFCCC as well as under the Kyoto Protocol is the so-called OBS map data "Occupation Biophysiques du Sol". This is a detailed land use / land cover map in digital format covering the entire territory of Luxembourg. There exist three versions of the OBS map data set. The first OBS data set, the OBS89, was collected in the field for several years and published in 1989 by the Environment Ministry. The second data set for the year

151 Statec: Portail des Statistiques: www.statistiques.public.lu Table : « Utilisation du sol 1978-2009 » retrieved 14.4.2011.

152 Average yearly temperature of Luxembourg city: Portail des Statistiques: www.statistiques.public.lu Table : « A2100 - Températures moyennes à Luxembourg-Ville,1951-2009 » retrieved 14.4.2011.

1999, the OBS99, was collected based on aerial colour infra-red ortho-photos and some field surveying, the third set, covering the year 2007 and currently the most recent version, is the OBS07, which is an update of the OBS99 using very high resolution satellite images (1m pixel size) of the US commercial Earth observation satellite IKONOS.

7.1.3.2 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (e.g. land use and land-use change matrix)

The land use classification system used is in accordance with the Good practice Guidance on LULUCF. The categories are defined as presented in Table 7-3.

The OBS categories – that are different for OBS89 and OBS99/07 – have been assigned to the LULUCF categories, as defined in Table 7-3 according to the following matching table (Table 7-4 for OB89 to LULUCF, Table 7-5 for OBS99/07 to LULUCF).

Table 7-3 – LULUCF Nomenclature

Land Use Class	Definition
Forest Land	All forest and wooded land according to the FAO TBRA2000 definition: • tree crown cover >= 10 % • tree height >= 5 m. In the geodata set, Forest land has been sub-divided into the forest types as defined below.
Conifers:	Including all forest land with > 10 % crown cover and on which more than 75 percent of the tree crown cover consists of coniferous species.
Deciduous:	Including all forest land with > 10 % crown cover and on which more than 75 percent of the tree crown cover consists of broadleaved species
Mixed (coniferous and deciduous):	with > 10 % crown cover and less than 75 % crown cover of one class.
Annual Cropland	Includes agro-forestry systems where tree cover falls below the level used in the forest categories (IPCC GPG definition) with the following specifications: land on which different crops are grown in a yearly changed rhythm including artificial meadows (not permanent) including land temporarily set aside
Permanent Cropland	Includes agro-forestry systems where tree cover falls below the level used in the forest categories (IPCC GPG definition) with the following specifications: land on which different crops are grown in a permanent manner, i.e. not changing in a yearly rhythm
Grassland	All grassland that is not considered as cropland including systems with vegetation or tree cover below the density used in the forest category. This includes all grassland from wild lands, recreational areas as well as agricultural systems. (IPCC GPG definition).
Settlements	All developed land, including transportation and any size of human settlement unless already included under other categories.(IPCC GPG definition)
Wetland	Land that is covered or saturated by water for all or part of the year (e.g. peat land) and that does not fall into other categories.
Water	Land that is covered by water for all the year and that does not fall into other categories. This includes reservoirs. (IPCC GPG definition)
Other land	This category includes bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.

For more information on data processing, please also refer to Chapter 11 on KP-LULUCF.

Table 7-4 – OBS89 - LULUCF matching table

OBS89 Nomenclature (Part 1/3)						
Acronym	Code	Original in French	translated into German	LULUCF_v7	Forest Types_v7	Forest Areas v7
	31	forets	Wald			Forest Area
P	312	forets de coniferes	Nadelwald	Coniferous Forest	Coniferous Forest	Forest Area
Pe	3121	epiceas, sapins	Fichte, Tannen	Coniferous Forest	Coniferous Forest	Forest Area
Pm	3122	pins, mezeles	Kiefern, Lärchen	Coniferous Forest	Coniferous Forest	Forest Area
Pr	3123	autres resineux	Other Land Nadelbaeume	Coniferous Forest	Coniferous Forest	Forest Area
	311	forets de feuillus	Laubwald	Deciduous Forest	Deciduous Forest	Forest Area
F/Q	3111	forets acidophiles	Saure Wälder	Deciduous Forest	Deciduous Forest	Forest Area
Qb	31111	chenaie acidophile tres pauvre	artenarmer saurer Eichenwald	Deciduous Forest	Deciduous Forest	Forest Area
Fs	31112	hetraie et chenaie-hetraie acidophile	saurer Buchen und Eichen-Buchenwald	Deciduous Forest	Deciduous Forest	Forest Area
Qs	31113	chenaie acidophile	saurer Eichenwald	Deciduous Forest	Deciduous Forest	Forest Area
Fl	31114	hetraie a luzule blanche	Buchen mit weissen Luzernen	Deciduous Forest	Deciduous Forest	Forest Area
Ql	31115	chenaie a luzule blanche	Eichenwald mit Luzernen	Deciduous Forest	Deciduous Forest	Forest Area
Ff	31116	hetraie a grande fetuque	Buchenwald mit hohen Graesern	Deciduous Forest	Deciduous Forest	Forest Area
Qx	31117	chenaie a charmes xerophile sur schistes et gres	besondere trockenheitsliebende Eichenart auf Schiefer und Sandstein	Deciduous Forest	Deciduous Forest	Forest Area
F/Q	3112	forets neutroclines a mull	Wälder auf neutralen Bodenverhältnissen	Deciduous Forest	Deciduous Forest	Forest Area
Fm	31121	hetraie a melique et asperule	Buchenwald mit irgendeinem bestimmten Unterwuchs	Deciduous Forest	Deciduous Forest	Forest Area
Qa	31122	chenaie a charmes humide	besondere Eichenart auf feuchten Standorten	Deciduous Forest	Deciduous Forest	Forest Area
Qm	31123	chenaie-charmaie a melique et asperule	besondere Eichenart mit irgendeinem Unterwuchs	Deciduous Forest	Deciduous Forest	Forest Area
F/Q	3113	forets basiclines	Wälder auf basischen Bodenverhältnissen	Deciduous Forest	Deciduous Forest	Forest Area
Fk	31131	hetraie calcicole	Buchenwald auf kalkhaltigem Substrat	Deciduous Forest	Deciduous Forest	Forest Area
Qk	31132	chenaie a charmes xerophile	trockenheitsliebende besondere Eichenart	Deciduous Forest	Deciduous Forest	Forest Area
R	3114	forets ruderales	Schuttwälder	Deciduous Forest	Deciduous Forest	Forest Area
Ru	31141	ormaie ruderale	Ulmenwald in Aufschuettungen	Deciduous Forest	Deciduous Forest	Forest Area
P	3115	plantation de feuillus	Laubwald Anpflanzung	Deciduous Forest	Deciduous Forest	Forest Area
Ps	31151	peupleraie en site sec	Pappelwald in trockenen Gebieten	Deciduous Forest	Deciduous Forest	Forest Area
Ph	31152	peupleraie en site humide	Pappelwald in feuchten Gebieten	Deciduous Forest	Deciduous Forest	Forest Area
Pf	31153	plantation d'autres essences feuillus	Anpflanzungen Other Landr Laubbaeume	Deciduous Forest	Deciduous Forest	Forest Area
E	3116	forets de ravins	Schluchtwälder	Deciduous Forest	Deciduous Forest	Forest Area
Ek	31161	foret de ravin sur substrat calcaire	Schluchtwald auf kalkhaltigem Substrat	Deciduous Forest	Deciduous Forest	Forest Area
Es	31162	foret de ravin sur substrat siliceux	Schluchtwald auf silikatischem Substrat	Deciduous Forest	Deciduous Forest	Forest Area
V	3117	forets alluviales sur sols mineraux	Auewald auf mineralischem Boden	Deciduous Forest	Deciduous Forest	Forest Area
Va	31171	ormaie-frenaie alluviale	Ulmen-Eschenwald in Flusssedimenten	Deciduous Forest	Deciduous Forest	Forest Area
Vb	31172	aulnaie-frenaie alluviale mesotrophe	Erlen-Eschenwaelder in Flusssedimenten	Deciduous Forest	Deciduous Forest	Forest Area
Vn	31173	aulnaie alluviale nitrophile	Erlenwaelder in nitratreichen Flusssedimenten	Deciduous Forest	Deciduous Forest	Forest Area
Vc	31174	aulnaie-frenaie des sources et ruisseaux	Erlen-Eschenwaelder in Quellgebieten und an Rinnsalen	Deciduous Forest	Deciduous Forest	Forest Area
V	3118	forets marecageuses a sedimentation organique	Moorbruchwälder	Deciduous Forest	Deciduous Forest	Forest Area
Vm	31181	aulnaie mesotrophe a laiches	Erlenwaelder mit Seggen	Deciduous Forest	Deciduous Forest	Forest Area
Vx	31182	boulaie marcageuse	sumpfiger Birkenwald	Deciduous Forest	Deciduous Forest	Forest Area
	323	vegetations sclerophylles	Holzartiges Gebüsch	Deciduous Forest	Deciduous Forest	Forest Area
S	324	forets et vegetation arbustive en mutation	Wald und Gehölz im übergang	Deciduous Forest	Deciduous Forest	Forest Area
	3241	fourres en sites secs	Wälder auf trockenen Standorten	Deciduous Forest	Deciduous Forest	Forest Area
Sp	32411	fourre d'epineux	dorniges Dickicht	Deciduous Forest	Deciduous Forest	Forest Area
Sk	32412	fourre calcaire	Dickicht auf kalkhaltigem Untergrund	Deciduous Forest	Deciduous Forest	Forest Area
Sx	32413	fourre de buis	Buchsbaumdickicht	Deciduous Forest	Deciduous Forest	Forest Area
Se	32414	vegetation des coupes forestiere	Vegetation der Waldrodungsflaechen	Deciduous Forest	Deciduous Forest	Forest Area - no trees
Sz	32415	recrus divers	verschiedene Pionierpflanzen nach Rodung	Deciduous Forest	Deciduous Forest	Forest Area - no trees
	3242	fourres en sites humides	Wälder auf feuchten Standorten	Deciduous Forest	Deciduous Forest	Forest Area
So	32421	saulaie humide sur sol tourbeux ou acide	Weidenbaeume auf einem feuchten, torfigen oder sauren Boden	Deciduous Forest	Deciduous Forest	Forest Area
Sf	32422	saulnaie humide mesotrophe ou eutrophe	Weidenbaeume auf einem feuchten, mittelmaessig oder gut mit Naehrstoffen versorgten Boden	Deciduous Forest	Deciduous Forest	Forest Area
P	313	forets melangees	Mischwald	Mixed Forest	Mixed Forest	Forest Area
Pl	3131	par pied ou par bouquet	truppenweise Mischung (uebernommen aus 1999)	Mixed Forest	Mixed Forest	Forest Area
Pp	3132	par parcelle	Mischung in Parzellen	Mixed Forest	Mixed Forest	Forest Area
H	23	prairies	Wiesen	Grassland	Non-Forest Area	Non-Forest Area
	231	prairies permanentes	Dauerwiesen	Grassland	Non-Forest Area	Non-Forest Area
	2311	prairies semi-naturelles, humides et non-amendees	Halbnatürliche Wiesen	Grassland	Non-Forest Area	Non-Forest Area
Hc	23111	prairie humide peu ou non fertilisee	Feuchtwiese kaum oder nicht geduengt	Grassland	Non-Forest Area	Non-Forest Area
Hj	23112	prairie humide peu ou non fertilisee à joncs	Feuchtwiese kaum oder nicht geduengt mit Binsen	Grassland	Non-Forest Area	Non-Forest Area
Hf	23113	prairie humide a reine des pres	Feuchtwiese mit einem krautigen Rosaceaengewaechs	Grassland	Non-Forest Area	Non-Forest Area
Hm	23114	prairie humide non fertilisee a molinie	ungeduengte Feuchtwiese mit bestimmtem Suessgrasgewaechs	Grassland	Non-Forest Area	Non-Forest Area
Hmo	231141	type oligotrophe	wenig Naehrstoffe	Grassland	Non-Forest Area	Non-Forest Area
Hmm	231142	type mesotrophe	mittelmaessig Naehrstoffe	Grassland	Non-Forest Area	Non-Forest Area
Hme	231143	type eutrophe	viel Naehrstoffe	Grassland	Non-Forest Area	Non-Forest Area
	2312	prairies mesophiles ameliorees	mesophile Weidewiese	Grassland	Non-Forest Area	Non-Forest Area
Hu	23121	prairie mesophile de fauche	mesophile Mahdwiese	Grassland	Non-Forest Area	Non-Forest Area
Hua	23122	prairie mesophile de fauche atypique	untypische mesophile Mahdwiese	Grassland	Non-Forest Area	Non-Forest Area
Hp	23123	pature a ray grass et trefle blanc	Futterpflanzen in breiten Streifen und Klee	Grassland	Non-Forest Area	Non-Forest Area
Hx	23124	prairie a flore tres pauvre	Wiesen mit geringer Biodiversitaet	Grassland	Non-Forest Area	Non-Forest Area
Hr	23125	prairie mesophile abandonnee a flore ruderale	aufgegebene mesophile Wiese mit Ruderalvegetation	Grassland	Non-Forest Area	Non-Forest Area
	32	milieux a vegetation arbustive et/ou herbacee	Gehölze und Buschwerk	Grassland	Non-Forest Area	Non-Forest Area
H	321	pelouses et paturages naturels	Naturnahe Weideflächen	Grassland	Non-Forest Area	Non-Forest Area
Ha	3211	pelouses silicicole a agrostis	Silikatrasen mit irgendeiner Viehfutterpflanze	Grassland	Non-Forest Area	Non-Forest Area
Hn	3212	pelouse silicicole a nard	Silikatraseen mit irgendeiner aromatischen Krautpflanze	Grassland	Non-Forest Area	Non-Forest Area
Hk	3213	pelouse calcaire	Kalkrasen	Grassland	Non-Forest Area	Non-Forest Area
Hkm	32131	sur marne	auf Mergel	Grassland	Non-Forest Area	Non-Forest Area
Hkx	32132	sur sol pierreux	auf steinreichem Boden	Grassland	Non-Forest Area	Non-Forest Area
Hks	32133	sur sol sableux	auf sandreichem Boden	Grassland	Non-Forest Area	Non-Forest Area
Hg	3214	pelouse pionniere des carrieres	Pionierrasen in Steinbruechen	Grassland	Non-Forest Area	Non-Forest Area
Hz	3215	pelouse sur sol intoxique	Rasen auf giftigem (vielleicht schwermetallbelasteten) Gelaende	Grassland	Non-Forest Area	Non-Forest Area
C	322	landes et broussailes	Heide und Buschwerk	Grassland	Non-Forest Area	Non-Forest Area
Cg	3221	lande seche a callune	trockene Heide mit irgendeinem speziellen Heidekrautgewaechs	Grassland	Non-Forest Area	Non-Forest Area
Cj	3222	lande a callune genevrier	Heidekrautgewaechse mit Strauch mit widerstaendigen, stacheligen Blaettern, der Beeren ausbildet	Grassland	Non-Forest Area	Non-Forest Area
Cd	3223	lande a callune degradee	degradierte Heide mit speziellem Heidekrautgewaechs	Grassland	Non-Forest Area	Non-Forest Area
Cdm	32231	a dominance de molinie	mit Dominanz irgendeines Suessgrasgewaechses	Grassland	Non-Forest Area	Non-Forest Area
Cdc	32232	a dominance de canche flexueuse	mit Dominanz einer flexible biegsamen Futterpflanze	Grassland	Non-Forest Area	Non-Forest Area
Cdf	32233	a dominance de fougere aigle	mit Dominanz eines bestimmten Farns	Grassland	Non-Forest Area	Non-Forest Area
Cv	3224	lande seche a myrtille	trockene Heide mit Heidelbeere	Grassland	Non-Forest Area	Non-Forest Area
Ct	3225	lande tourbeuse a myrtille	Torfheide mit Heidelbeere	Grassland	Non-Forest Area	Non-Forest Area
Cs	3226	lande a genets	Heide mit Ginster	Grassland	Non-Forest Area	Non-Forest Area

OBS89 Nomenclature (Part 2/3)						
Acronym	Code	Original in French	translated into German	LULUCF_v7	Forest Types_v7	Forest Areas v7
B	21	terres arables	Ackerland	Cropland annual	Non-Forest Area	Non-Forest Area
	211	terres arables hors perimetre d'irrigation	Ackerland, nicht bewässert	Cropland annual	Non-Forest Area	Non-Forest Area
Ba	2111	culture annuelle	jaehrliche Kulturen	Cropland annual	Non-Forest Area	Non-Forest Area
Bp	2112	pepiniere	Baumschule	Cropland permanent	Non-Forest Area	Non-Forest Area
B	22	cultures permanentes	Dauerkulturen	Cropland permanent	Non-Forest Area	Non-Forest Area
Bv	221	vignobles	Weinberge	Cropland permanent	Non-Forest Area	Non-Forest Area
Bvn	2211	vignobles en pentes	Weinberge in Steillagen	Cropland permanent	Non-Forest Area	Non-Forest Area
Bvt	2212	vignobels en terrasses	Weinberge in Terrassen	Cropland permanent	Non-Forest Area	Non-Forest Area
Bve	2213	vignobles en plaine	Weinberge in ebenen Gebieten	Cropland permanent	Non-Forest Area	Non-Forest Area
Be	222	verges et petits fruits	Streuobst und kleine/niedrigwachsende Fruechte	Cropland permanent	Non-Forest Area	Non-Forest Area
Beh	2221	verges, hautes tiges	Streuobst mit hohen Staemmen	Cropland permanent	Non-Forest Area	Non-Forest Area
Beb	2222	verges, basses tiges	Streuobst mit niedrigen Staemmen	Cropland permanent	Non-Forest Area	Non-Forest Area
U	11	zones urbanisees	Städtisches Gebiet	Settlements	Non-Forest Area	Non-Forest Area
	111	tissu urbain continu	Zusammenhängendes Stadtgebiet	Settlements	Non-Forest Area	Non-Forest Area
Uh	1111	zone urbaine dense	dicht besiedeltes Gebiet	Settlements	Non-Forest Area	Non-Forest Area
Uhh	11111	batiments hauts	mit hohen Gebaeuden	Settlements	Non-Forest Area	Non-Forest Area
Uhb	11112	batiments bas	mit niedrigen Gebaeuden	Settlements	Non-Forest Area	Non-Forest Area
	112	tissu urbain discontinu	Unzusammenhängendes Stadtgebiet	Settlements	Non-Forest Area	Non-Forest Area
Uf	1121	zone semi-urbaine	semiurbaner Raum	Settlements	Non-Forest Area	Non-Forest Area
Ufv	11211	avec vegetation importante	mit bedeutenden Vegetationsanteilen	Settlements	Non-Forest Area	Non-Forest Area
Ufs	11212	sans vegetation importante	ohne bedeutende Vegetationsanteile	Settlements	Non-Forest Area	Non-Forest Area
Ul	1122	extention de l'habitat le long des routes	Siedlungen entlang von Strassen	Settlements	Non-Forest Area	Non-Forest Area
Ue	1123	espace urbain ouvert sans verdure importante	unbebauter staedtischer Raum ohne bedeutende Vegetation	Settlements	Non-Forest Area	Non-Forest Area
Uea	11231	places	Plaetze	Settlements	Non-Forest Area	Non-Forest Area
Uep	11232	parkings	Parkplaetze	Settlements	Non-Forest Area	Non-Forest Area
Uef	11233	friche urbaine	Siedlungsbrache	Settlements	Non-Forest Area	Non-Forest Area
Ur	1124	zone d'habitat rural	laendlicher Siedlungsraum	Settlements	Non-Forest Area	Non-Forest Area
I/T	12	zones industrielles, commerciales et reseaux de communication	Industrie- und Handelsflächen sowie Transportgelände	Settlements	Non-Forest Area	Non-Forest Area
	121	zones industrielles, commerciales et socio-culturelles	Flächen genutzt von Industrie, Handel und Kultur	Settlements	Non-Forest Area	Non-Forest Area
	1211	industrie et commerce	Industrie- und Handelsflächen	Settlements	Non-Forest Area	Non-Forest Area
Il	12111	industrie lourde	Schwerindustrie	Settlements	Non-Forest Area	Non-Forest Area
Iz	12112	zoning industriel (+ domaine militaire)	Industriegebiet (+ militaerische Nutzung)	Settlements	Non-Forest Area	Non-Forest Area
Im	12113	zone d'activites multiples	Zone zahlreicher Nutzungen	Settlements	Non-Forest Area	Non-Forest Area
Is	12114	infrastructure agricole, horticole	Gartenbau- und Landwirtschaftsinfrastruktur	Settlements	Non-Forest Area	Non-Forest Area
	1212	installations socio-culturelles	Flächen für Freizeit- und Kulturnutzung	Settlements	Non-Forest Area	Non-Forest Area
Iu	12121	campus universitaire/ecole	Universitaetscampus und Schulhof	Settlements	Non-Forest Area	Non-Forest Area
If	12122	expositions et foires	Ausstellungen und Messen	Settlements	Non-Forest Area	Non-Forest Area
Ih	12123	hopitaux	Krankenhaeuser	Settlements	Non-Forest Area	Non-Forest Area
Ic	12124	centre culturel et/ou sportif	Zentrum fuer Kultur und Sport	Settlements	Non-Forest Area	Non-Forest Area
	1213	installations specialisees	Sonderflächen	Settlements	Non-Forest Area	Non-Forest Area
It	12131	distribution haute tension	Stromversorgung	Settlements	Non-Forest Area	Non-Forest Area
Ik	12132	installation d'assainissement des eaux usees	Klaeranlage	Settlements	Non-Forest Area	Non-Forest Area
Ir	12133	stockage d'hydrocarbures ou gaz	Gas- oder Kohlenwasserstofftanks	Settlements	Non-Forest Area	Non-Forest Area
	122	reseau routier, ferroviaire et espaces associes	Schienewegenetz und zugehörige Flächen	Settlements	Non-Forest Area	Non-Forest Area
	1221	routes	Strassennetz	Settlements	Non-Forest Area	Non-Forest Area
Ta	12211	autoroutes	Autobahnen	Settlements	Non-Forest Area	Non-Forest Area
Tn	12212	route nationale	Bundesstrasse	Settlements	Non-Forest Area	Non-Forest Area
Tr	12213	chemin repris	Weg zur Entnahme	Settlements	Non-Forest Area	Non-Forest Area
Tc	12214	route communale	Landstrasse	Settlements	Non-Forest Area	Non-Forest Area
Te	12215	chemin d'exploitation	Betriebsstrassen ?	Settlements	Non-Forest Area	Non-Forest Area
Ts	12216	aires et surfaces carrossables	befahrbare Oberflaechen und Plaetze	Settlements	Non-Forest Area	Non-Forest Area
	1222	chemins de fer	schienewegenetz	Settlements	Non-Forest Area	Non-Forest Area
Tg	12221	gare importante	wichtiger Bahnhof	Settlements	Non-Forest Area	Non-Forest Area
Tt	12222	tirage	Zug	Settlements	Non-Forest Area	Non-Forest Area
Tv	12223	voies ferrees	Schienennetz	Settlements	Non-Forest Area	Non-Forest Area
Ip	123	zones portuaires	Hafengebiete	Settlements	Non-Forest Area	Non-Forest Area
Ipi	1231	installation portuaire industrielle	Industriehafen	Settlements	Non-Forest Area	Non-Forest Area
Ipp	1232	zone portuaire de plaisance	Yachthaften	Settlements	Non-Forest Area	Non-Forest Area
Ia	124	aeroports	Flughafen	Settlements	Non-Forest Area	Non-Forest Area
Iah	1241	terminal, hangar	Terminals, Hangar	Settlements	Non-Forest Area	Non-Forest Area
Iaa	1242	piste et taxiways	Landebahnen	Settlements	Non-Forest Area	Non-Forest Area
K	13	mines, decharges et chantiers	Minen, Schutthalden und Baustellen	Settlements	Non-Forest Area	Non-Forest Area
	131	extraction de materiaux (en activite)	Abbauflächen	Settlements	Non-Forest Area	Non-Forest Area
Ks	1311	carriere (sable, pierres …)	Steinbruch	Settlements	Non-Forest Area	Non-Forest Area
Kg	1312	graviere	Kiesgrube	Settlements	Non-Forest Area	Non-Forest Area
Km	1313	mines a ciel ouvert (minerais)	Tagebau	Settlements	Non-Forest Area	Non-Forest Area
	132	decharges et friches	Brachflächen	Settlements	Non-Forest Area	Non-Forest Area
Ko	1321	depotoir	Muelldeponie	Settlements	Non-Forest Area	Non-Forest Area
Ki	1322	crassier et friche industrielle	Halde und industrielle Brache	Settlements	Non-Forest Area	Non-Forest Area
Ky	1323	friche hors zone urbaine et industrielle	Brachen ausserhalb besiedelter und industrieller Gebiete	Settlements	Non-Forest Area	Non-Forest Area
	133	chantiers	Baustellen	Settlements	Non-Forest Area	Non-Forest Area
Kc	1331	chantier en cours	aktuelle Baustellen	Settlements	Non-Forest Area	Non-Forest Area
Ku	1332	surface ruderale ou remblais	Aufschuettungen	Settlements	Non-Forest Area	Non-Forest Area
N	14	espcaes verts artificialises, non agricoles	Grünflachen, nicht landwirtschaftlich genutzt	Settlements	Non-Forest Area	Non-Forest Area
	141	espaces verts urbains	städtische Grünflächen	Settlements	Non-Forest Area	Non-Forest Area
Nc	1411	cimetiere	Friedhof	Settlements	Non-Forest Area	Non-Forest Area
Nv	1412	zone vertes, parcs	Gruenanlagen, Parks	Settlements	Non-Forest Area	Non-Forest Area
Nb	1413	route bordee d'espace vert important	Strasse mit bedeutenden Gruenstreifen	Settlements	Non-Forest Area	Non-Forest Area
Np	1414	parking avec verdure important	Parkplatz mit bedeutender Vegetation	Settlements	Non-Forest Area	Non-Forest Area
	142	equipements sportifs et de loisir	Sport- und Freizeitanlagen	Settlements	Non-Forest Area	Non-Forest Area
Nj	1421	plaine de sport et/ou de jeux	Sport- oder Spielplatz	Settlements	Non-Forest Area	Non-Forest Area
Nr	1422	zone recreative	Erholungsgebiet	Settlements	Non-Forest Area	Non-Forest Area
Ns	1423	amenagement particulier	besondere Einrichtung	Settlements	Non-Forest Area	Non-Forest Area
Ng	1424	cite jardiniere	Kleingartenanlagen	Settlements	Non-Forest Area	Non-Forest Area

OBS89 Nomenclature (Part 3/3)						
Acronym	**Code**	**Original in French**	**translated into German**	**LULUCF_v7**	**Forest Types_v7**	**Forest Areas v7**
M	41	zones humides interieures	Feuchtflächen im Binnenland	Wetland	Non-Forest Area	Non-Forest Area
	411	marais interieurs	Sumpfgebiete	Wetland	Non-Forest Area	Non-Forest Area
Mr	4111	roseliere	Schilf	Wetland	Non-Forest Area	Non-Forest Area
Mrp	41111	a baldingere	mit Rohrglanzgras (aehnlich Schilfrohr)	Wetland	Non-Forest Area	Non-Forest Area
Mrg	41112	a glycerie	wasserliebendes Suessgras mit langen Blaettern	Wetland	Non-Forest Area	Non-Forest Area
Mrs	41113	a jonc des chaisiers	wasserliebendes Kraut mit langem Stengel	Wetland	Non-Forest Area	Non-Forest Area
Mrt	41114	a massette	mit schmalblaettrigem Rohrkolben	Wetland	Non-Forest Area	Non-Forest Area
Mrm	41115	melangee	gemischt	Wetland	Non-Forest Area	Non-Forest Area
Mrr	41116	a roseaux	Schilf	Wetland	Non-Forest Area	Non-Forest Area
Mc	4112	magnocaricaie	Feuchtgebietsvegetation	Wetland	Non-Forest Area	Non-Forest Area
Ms	4113	bas-marais acide	saures Niedermoor	Wetland	Non-Forest Area	Non-Forest Area
Ma	4114	bas-marais alcalin	basisches Niedermoor	Wetland	Non-Forest Area	Non-Forest Area
Mb	4115	bas-marais alcalin ruderalise	basisches Niedermoor (ruderal)	Wetland	Non-Forest Area	Non-Forest Area
	33	espaces ouverts sans ou avec peu de vegetation	Offene Flächen mit wenig oder keiner Vegetation	Other Land	Non-Forest Area	Non-Forest Area
	332	roches nues	Offener Fels	Other Land	Non-Forest Area	Non-Forest Area
G	3321	carriere abondonnee	aufgegebener Steinbruch	Other Land	Non-Forest Area	Non-Forest Area
A	51	eaux continentales	Wasserflächen im Binnenland	Water	Non-Forest Area	Non-Forest Area
	511	cours et voies d'eaux	Wasserläufe und -strassen	Water	Non-Forest Area	Non-Forest Area
An	5111	cours d'eau natuels	natuerliche Wasserlaeufe	Water	Non-Forest Area	Non-Forest Area
Ac	5112	voies d'eau artificielles	kuenstliche Wasserlaeufe	Water	Non-Forest Area	Non-Forest Area
	512	plans d'eau	Wasserflächen (Seen, Teiche etc.)	Water	Non-Forest Area	Non-Forest Area
Al	5121	plan d'eau naturel	natuerliche Wasserflaeche	Water	Non-Forest Area	Non-Forest Area
Alh	51211	plus ou mojns sale	mehr oder weniger salzhaltig	Water	Non-Forest Area	Non-Forest Area
Alo	51212	oligotrophe	wenig Naehrstoffe	Water	Non-Forest Area	Non-Forest Area
Alm	51213	mesotrophe	mittelmaessig Naehrstoffe	Water	Non-Forest Area	Non-Forest Area
Ale	51214	eutrophe	viel Naehrstoffe	Water	Non-Forest Area	Non-Forest Area
Aa	5122	plan d'eau artificiel	kuenstliche Wasserflaeche	Water	Non-Forest Area	Non-Forest Area
Aah	51221	plus ou mojns sale	mehr oder weniger salzhaltig	Water	Non-Forest Area	Non-Forest Area
Aao	51222	oligotrophe	wenig Naehrstoffe	Water	Non-Forest Area	Non-Forest Area
Aam	51223	mesotrophe	mittelmaessig Naehrstoffe	Water	Non-Forest Area	Non-Forest Area
Aae	51224	eutrophe	viel Naehrstoffe	Water	Non-Forest Area	Non-Forest Area
Ab	5123	bras mort	Altarm	Water	Non-Forest Area	Non-Forest Area
?	5124	petit plan d'eau, mardelle	Teich	Water	Non-Forest Area	Non-Forest Area
Ar	5125	bassin, reservoir, etc. …	Becken, Reservoir	Water	Non-Forest Area	Non-Forest Area
Aro	51251	oligotrophe	wenig Naehrstoffe	Water	Non-Forest Area	Non-Forest Area
Arm	51252	mesotrophe	mittelmaessig Naehrstoffe	Water	Non-Forest Area	Non-Forest Area
Are	51253	eutrophe	viel Naehrstoffe	Water	Non-Forest Area	Non-Forest Area
Arz	51254	sans valeur biologique	ohne biologischen Wert	Water	Non-Forest Area	Non-Forest Area

Table 7-5 – OBS99/07 - LULUCF matching table

OBS99/07 Nomenclature							
German Acronym	French Acronym	Code	Original in French	translated into German	LULUCF_v7	Forest Types_v7	Forest Areas v7
WLE	FFC	3.1.1.1	Laubwald, Eiche	Futaie feuillue α dominance de chene	Deciduous Forest	Deciduous Forest	Forest
WLB	FFH	3.1.1.2	Laubwald, Buche	Futaie feuillue α dominance de hetre	Deciduous Forest	Deciduous Forest	Forest
WLS	FFD	3.1.1.3	Laubwald, sonstige Laubbaumarten	Futaie de feuillus divers	Deciduous Forest	Deciduous Forest	Forest
WLM	FFM	3.1.1.4	Laubwald, gemischt, Eiche, Buche	Futaie feuillue melangee de chenes et de hetres	Deciduous Forest	Deciduous Forest	Forest
WLN	FTC	3.1.1.5	Eichen-Niederwald	Taillis de chene	Deciduous Forest	Deciduous Forest	Forest
WL0	FFP	3.1.1.6.1	Laubwald, Pappel-Monokulturen	Peupleraie et autres monocultures feuillues	Deciduous Forest	Deciduous Forest	Forest
SBT	BPS	3.2.4.1	Buschwerk, Vorwaelder trockener Standorte	Buissons, prebois sur sols secs	Deciduous Forest	Deciduous Forest	Forest
SBM	BPF	3.2.4.2	Buschwerk, Vorwaelder mittlerer Standorte	Buissons, prebois sur sols frais	Deciduous Forest	Deciduous Forest	Forest
SBF	BPH	3.2.4.3	Buschwerk, Vorwaelder feuchter Standorte	Buissons, prebois sur sols humides	Deciduous Forest	Deciduous Forest	Forest
SBG	BPE	3.2.4.4	Blockschutt- und Geroellwaelder	Forets, prebois sur eboulis	Deciduous Forest	Deciduous Forest	Forest
SBP	BPA	3.2.4.5	Gehoelzplanzungen	Plantations cubustives	Deciduous Forest	Deciduous Forest	Forest
WNF	FRE	3.1.2.1	Nadelwald, Fichte/Douglasie/Tanne	Foret resineuse (epiceas, douglas, sapins)	Coniferous Forest	Coniferous, Spruce/Douglas Fir/Fir	Forest
WNK	FRP	3.1.2.2	Nadelwald, Kiefer/Laerche	Foret resineuse (pins, melezes et autres resineux)	Coniferous Forest	Coniferous Pine/Larch	Forest
WNM	FRM	3.1.2.3	Nadelwald, gemischt	Foret resineuse melangee	Coniferous Forest	Coniferous mixed	Forest
WMT	FMP	3.1.3.1	Mischwald (Laub/Nadel), truppweise Mischung	Foret melangee (feuillus/resineux) par pied, par bouquet	Mixed forest	Mixed forest	Forest
WMF	FMM	3.1.3.2	Mischwald (Laub/Nadel), fliessende Mischung	Foret melangee (feuillus/resineux), melange intime	Mixed forest	Mixed forest	Forest
WAU	FCD	3.1.3.3	Aufforstungen, Landungen, Dickungen (Baumart nicht erkennbar)	Culture forestiere d'essences non definies	Mixed forest	Mixed forest	Forest
WSF	FSD	3.1.3.4	Sonstige Forest Landflaechen (Schlagflur, Windbruch)	Autres surfaces forestieres (coupes rases, chablis)	Mixed forest	Mixed forest	Forest
LAA	RAA	2.1.1.1	Acker	Terres agricoles, cultures annuelles	Cropland annual	Non-Forest	Non-Forest
LBG	RAH	2.1.1.2	Baumschule, Gartenbau	Pepinieres, horticulture, arbres de Noδl	Cropland permanent	Non-Forest	Non-Forest
LWT	RVT	2.2.1.1	Weinbau, Terrasse	Vignoble en terrasse	Cropland permanent	Non-Forest	Non-Forest
LWS	RVA	2.2.1.2	Weinbau, sonstige	Autres vignoble	Cropland permanent	Non-Forest	Non-Forest
LSH	RHT	2.2.2.1	Streuobst, Hochstamm	Verger α hautes tiges	Cropland permanent	Non-Forest	Non-Forest
LSN	RBT	2.2.2.2	Obst, Niederstamm	Verger α basses tiges	Cropland permanent	Non-Forest	Non-Forest
LFG	RPR	2.3.1.1	Feuchtgruenland	Prairie humide	Grassland	Non-Forest	Non-Forest
LMG	RPM	2.3.1.2	Mesophiles Gruenland	Prairie mesophile	Grassland	Non-Forest	Non-Forest
KSI	PSI	3.2.1.1	Silicattrockenrasen	Pelouse silicicole	Grassland	Non-Forest	Non-Forest
KKA	PCA	3.2.1.2	Kalkmagerrasen	Pelouse calcaire	Grassland	Non-Forest	Non-Forest
KFE	PSR	3.2.1.3	Fels- und Schotterrasen, Pionierfluren	Pelouses pionnieres (sur substrat rocheux ou graveleux)	Grassland	Non-Forest	Non-Forest
KHE	PLR	3.2.2	Heiden, Rohbodenstandorte	Landes, sols nus	Grassland	Non-Forest	Non-Forest
KRM	PFR	3.2.3.1	Ruderalstandorte, Staudenfluren mittlerer bis trock	Surfaces ruderalisees et friches sur sols secs α frais	Grassland	Non-Forest	Non-Forest
KRF	PFH	3.2.3.2	Ruderalstandorte, Staudenfluren feuchter Standorte	Surfaces ruderalisees et friches sur sols humides	Grassland	Non-Forest	Non-Forest
BSC	UAD	1.1.1	Siedlungsgebiet, Verdichtungsgrad >80%, City	Tissu urbain dense (degree de l'imperméabilisation des sols >80%)	Settlements	Non-Forest	Non-Forest
BSM	UAA	1.1.2.1.1	Siedlungsgebiet mit Verdichtunggrad von 50-80%	Zone semi-urbaine, degree de l'imperméabilisation des sols 50-80%	Settlements	Non-Forest	Non-Forest
BSO	UAS	1.1.2.1.2	Siedlungsgebiet Verdichtungsgrad 30-50%	Zone semi-urbaine, degree de l'imperméabilisation des sols 30-50%	Settlements	Non-Forest	Non-Forest
BSB	UAL	1.1.2.2	Siedlungsbaender entlang von Strassen	Urbanisation longiligne, Bandes urbanisees le long des routes	Settlements	Non-Forest	Non-Forest
BSP	UAP	1.1.2.3.1	Oeffentliche Plaetze	Place	Settlements	Non-Forest	Non-Forest
BSR	UAF	1.1.2.3.2	Siedlungsbrachen ohne/geringe Vegetation	Friche urbaine, Espace urbain ouvert sans verdure importante	Settlements	Non-Forest	Non-Forest
BSE	UAH	1.1.2.4	Einzelhaeuser, Hoefe etc. ausserhalb Bebauung	Habitat dissemine en zone rurale, hameau	Settlements	Non-Forest	Non-Forest
BII	UIL	1.2.1.1.1	Industrie	Industrie lourde	Settlements	Non-Forest	Non-Forest
BIG	UIA	1.2.1.1.2	Gewerbe, Militaer, Dienstleistung	Zone d'activites economiques, terrain militaire	Settlements	Non-Forest	Non-Forest
BIO	UPS	1.2.1.2	Oeffentliche Bebauung	BΓtiments et installations α destination socio-culturelle	Settlements	Non-Forest	Non-Forest
BIS	UPE	1.2.1.3.1	Sondergebiete, Stromversorgung	Installations de distribution electrique	Settlements	Non-Forest	Non-Forest
BIW	UPU	1.2.1.3.2	Sondergebiete, Wasserversorgung	Installation de traitement des eaux usees	Settlements	Non-Forest	Non-Forest
BIA	UPH	1.2.1.3.3	Sondergebiete, Gasversorgung	Installations de stockage d'hydrocarbures et de gaz	Settlements	Non-Forest	Non-Forest
BIL	UAC	1.2.1.4	gewerbliche Landwirtschaft (Stallanlagen, Gewaechshaeuser)	Constructions agricoles et horticoles, etables, serres	Settlements	Non-Forest	Non-Forest
BVS	UTR	1.2.2.1.1	bedeutende Strassen (>20m)	Routes importantes (>20m), voies rapides	Settlements	Non-Forest	Non-Forest
BVP	UTS	1.2.2.1.2	Parkplatz	Zones de stationnement	Settlements	Non-Forest	Non-Forest
BVB	UTF	1.2.2.2	Bahnanlage	Infrastructure ferroviaire, gare	Settlements	Non-Forest	Non-Forest
BVH	UTP	1.2.3	Hafengebiete	Zone portuaire	Settlements	Non-Forest	Non-Forest
BVT	UTA	1.2.4.1	Flughafen, Gebaeude, Terminal	Aeroport; terminal, hangar	Settlements	Non-Forest	Non-Forest
BVL	UTT	1.2.4.2	Flughafen, Landebahn	Aeroport; piste et taxiways	Settlements	Non-Forest	Non-Forest
BAF	UEM	1.3.1	Abbauflaeche, Tagebau	Zone d'extraction de materiaux	Settlements	Non-Forest	Non-Forest
BAA	UER	1.3.2.1	Aufschuettung, Deponie	Remblais et decharges	Settlements	Non-Forest	Non-Forest
BAH	UEC	1.3.2.2	Halden	Crassier	Settlements	Non-Forest	Non-Forest
BAB	UEF	1.3.2.3	Brachen industrieller Gebiete	Friche industrielle	Settlements	Non-Forest	Non-Forest
BAU	UEH	1.3.2.4	Baustellen	Chantier	Settlements	Non-Forest	Non-Forest
BGF	UVC	1.4.1.1	Friedhoefe	Cimetiere	Settlements	Non-Forest	Non-Forest
BGG	UVV	1.4.1.2	Gruenanlagen, Parks	Zones de verdure, parcs	Settlements	Non-Forest	Non-Forest
BGS	UVS	1.4.2.1	Sport-, Spiel-, Camping-, Golfplaetze	Terrain de sport, espace recreatif, camping, golf etc.	Settlements	Non-Forest	Non-Forest
BGK	UVJ	1.4.2.2	Kleingartenanlagen	Cite jardiniere	Settlements	Non-Forest	Non-Forest
FRO	ROS	4.1.1.1	Roehrichte	Roseliere	Wetland	Non-Forest	Non-Forest
FGS	MAG	4.1.1.2	Grossseggenrieder	Magnocaricaie	Wetland	Non-Forest	Non-Forest
FKS	MBA	4.1.1.3	Kleinseggenrieder	Bas marais	Wetland	Non-Forest	Non-Forest
OFF	RNU	3.3.2	Offene Felsflaechen	Roche nue	Other Land	Non-Forest	Non-Forest
OFK	RNU	3.3.2	Offene Felsflaechen < 1500m2	Roche nue < 1500m2	Other Land	Non-Forest	Non-Forest
OBS	REN	3.3.2.1	Offene Blockschutt- und Schotterflaechen	Eboulis et graviers non colonises	Other Land	Non-Forest	Non-Forest
GFN	ECN	5.1.1.1.1	Fliessgewaesser natuerlicher Entstehung, naturnah	Cours d'eau naturel	Water	Non-Forest	Non-Forest
GFF	ECA	5.1.1.1.2	Fliessgewaesser natuerlicher Entstehung, naturfern	Cours d'eau artificialise	Water	Non-Forest	Non-Forest
GFK	EEA	5.1.1.2	Fliessgewaesser kuenstlicher Entstehung	Cours d'eau artificiels	Water	Non-Forest	Non-Forest
GSN	EPN	5.1.2.1	Stillgewaesser natuerlicher Entstehung	Plans d'eau anthropogene proche de l'etat naturel	Water	Non-Forest	Non-Forest
GSK	EPA	5.1.2.2	Stillgewaesser kuenstlicher Entstehung	Plan d'eau artificiel	Water	Non-Forest	Non-Forest
GAA	EBM	5.1.2.3	Altarme, Altwasser	Bras mort	Water	Non-Forest	Non-Forest
GMD	EMA	5.1.2.4	"Mardelle"	Mardelle	Water	Non-Forest	Non-Forest
GBB	BRE	5.1.2.5.1	Becken, Reservoir von biol. Interesse	Bassin, reservoir ayant un interet ecologique	Water	Non-Forest	Non-Forest
GBO	BRS	5.1.2.5.2	Becken, Reservoir ohne biol. Wert	Bassin, reservoir α ciel ouvert sans interet ecologique	Water	Non-Forest	Non-Forest

7.1.3.3 Methodology used to develop the land transition matrix

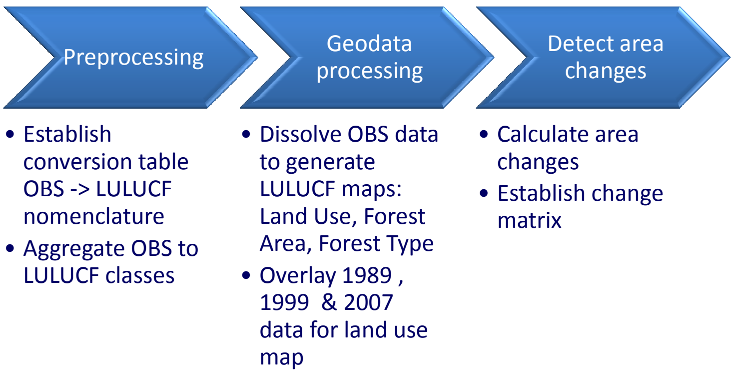
The generation of the LULUCF maps is based on the OBS data, i.e. data processing OBS89, OBS99 and OBS07 follows the same processing scheme.

The original OBS categories for the years 1989, 1999 and 2007 were assigned to the relevant classes of the LULUCF nomenclatures. The correspondence of OBS89 respectively OBS99/07 classification to the LULUCF nomenclature has been established in close collaboration with the relevant administrations and experts. The conversion tables from OBS89-99-07 to LULUCF are presented in the above section.

After aggregation of the class assignments according to the LULUCF nomenclature, the next step in geo data processing (using Geographic Information System software "ArcGIS") is to dissolve the polygons to the respective classes, i.e. all neighbouring polygons belonging to the same LULUCF class were aggregated to one single polygon. This process results in land use maps, i.e. LU89, LU99 and LU07.

In order to preserve the detail in the data for the generation of the area statistics, no generalisation was performed before the change detection. Change detection of Land Use / Forest types between the selected reference years 1989, 1999 and 2007 has been carried out by overlay (intersect) of the Land Use maps LU89, LU99 and the LU07 data sets. Figure 4 shows the processing steps.

Figure 7-2 – Processing chain for the creation of LULUCF maps



The resulting maps of the intersection show the differences in land use and the changes from which land use class to which other one. The total area as computed from the GIS data sets differs slightly from the official area of the Luxembourg territory. This is simply due to resolution /scale and data processing inaccuracies in the data sets. Therefore, the areas derived from the geodata have been put in relation to the official area of Luxembourg (258600ha). It means that all areas resulting from the geodata processing are proportional to the official territory of Luxembourg that is 2586km². From this data the change statistics are derived and illustrated in the change matrix.

An exception to the use of OBS has been made for LUC areas between cropland and grassland. When using OBS figures, the LUC areas between cropland and grassland are too high because the areas with more than one land use change within 20 years are taken into account as LUC areas, whereas, according to IPCC-GPG-LULUCF, they should stay in their main category. In Luxembourg, and especially in the northern part of Luxembourg (Oesling), a crop rotation including temporary grass is largely used by the farmers. In this crop rotation, the changes from temporary grass to annual crops are recorded as LUC grassland to cropland and the changes from annual crops to temporary grass as LUC grassland to cropland when using OBS. An alternative way to estimate the LUC between cropland and grassland was found, using administrative data of the Ministry of Agriculture coming from the administration of the "aid scheme for the maintenance of the landscape and the natural environment and for encouraging an agriculture respecting the environment", an agri-environmental aid scheme administered by the "Service d'Economie Rurale", an administration of the Ministry of Agriculture. As a land use change from permanent grassland to cropland is not allowed within this aid scheme, except in special circumstances and after a special authorization and as this aid scheme is largely taken up by the farmers, it was possible to estimate the annual LUC grassland to cropland (269 ha). As the part of permanent grassland in the utilized agricultural area is relatively stable, the annual LUC cropland to grassland is estimated to be of the same amount (269 ha). Thus, the LUC areas grassland to cropland respectively cropland to grassland going beyond 269 ha according to OBS are allocated to the category "grassland remaining grassland".

7.1.3.4 Surface statistics according to LULUCF categories

Table 7-6 represents the land cover surfaces in ha for the different LULUCF categories, for the period from 1989 to 2009.

The OBS maps (OBS89, OBS99, OBS07) on which the LU maps are based, are highlighted in yellow. The years in between have been estimated by linear interpolation. From 2008 onwards, surfaces have been estimated by linear extrapolation based on the average increase or decrease for the period 1999 (OBS99) to 2007 (OBS07).

At the end of the Kyoto period (2012), it is foreseen to produce an update of the OBS maps. Several options are currently being analysed such as the use of the latest ortho-photos shot in 2010, or the use of satellite images which could be shot in 2012. Currently, a test run using Rapid Eye satellite images is being carried out, to see whether the resolution is sufficient enough for the change detection.

Table 7-6 - Land Cover surfaces (ha) according to LULUCF categories

5 - Land Use, Land Use Change & Forestry
Land cover surfaces (ha)

Year	A Forestland	B Cropland	C Grassland	D Wetlands	E Settlements	F Other land	Note
1989	93'047	45'589	95'416	1'405	22'250	893	OBS89
1990	93'306	45'424	95'338	1'377	22'345	810	linear interpolation
1991	93'566	45'258	95'261	1'349	22'439	726	
1992	93'826	45'093	95'183	1'321	22'534	643	
1993	94'086	44'928	95'106	1'293	22'628	559	
1994	94'346	44'763	95'028	1'265	22'723	476	
1995	94'605	44'598	94'951	1'236	22'817	392	
1996	94'865	44'432	94'873	1'208	22'912	309	
1997	95'125	44'267	94'796	1'180	23'006	225	
1998	95'385	44'102	94'718	1'152	23'101	142	
1999	95'645	43'937	94'641	1'124	23'195	58	OBS99
2000	95'533	44'670	93'828	1'138	23'374	58	linear interpolation
2001	95'421	45'404	93'015	1'151	23'552	58	
2002	95'309	46'137	92'202	1'165	23'730	57	
2003	95'196	46'871	91'389	1'179	23'908	57	
2004	95'084	47'604	90'576	1'193	24'086	57	
2005	94'972	48'337	89'763	1'206	24'264	57	
2006	94'860	49'071	88'950	1'220	24'442	56	
2007	94'748	49'804	88'137	1'234	24'620	56	OBS07
2008	94'636	50'537	87'324	1'248	24'798	56	linear extrapol.
2009	94'524	51'271	86'511	1'261	24'977	56	based on 99-07
Trend 1990-2009	1.31%	12.87%	-9.26%	-8.40%	11.78%	-93.14%	NA
Trend 2008-2009	-0.12%	1.45%	-0.93%	1.10%	0.72%	-0.50%	NA

7.1.4 Completeness

Table 7-7 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 7-7– 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	NO	NO
5A2	land converted to forest land	X	NO	NO
5B1	cropland remaining cropland	X	NO	NO
5B2	land converted to cropland	X	NO	X
5C1	grassland remaining grassland	IE*, X**	NO	NO
5C2	land converted to grassland	X	NO	NO
5D1	wetlands remaining wetlands	NE,NO	NO	NO
5D2	land converted to wetlands	X	NO	NO
5E1	settlements remaining settlements	NE	NE	NE
5E2	land converted to settlements	X	NE	NE
5F1	other land remaining other land			
5F2	land converted to other land	X	NO	NO
5G	Other (Harvested wood products)	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.
(*) CO_2 emissions from lime application on grassland are included in cropland.
(**) emissions and removals from grassland remaining grassland have been estimated but they equal to zero, hence NO is being used 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 acres per person.

7.2.1 Category description

With regard to forest land the annual net CO_2 emissions/removals under sector 5 of the reported period 1990-2009 range from +126 Gg CO_2 (emission) to -471 Gg CO_2 (removal). The most important sub-category is forest land remaining forest land (5.A.1), whereas land use changes to forests (5.A.2) and from forests (5.B.2 to 5.F.2) have only minor influence on the net CO_2 balance.

For the reported period 1990 to 2009, the total annual net CO_2 removals (biomass and soil) from land use changes to forest range from about 78 Gg CO_2 to 113 Gg CO_2. The total annual emissions (biomass and soil) from land use changes from forests vary between 208 Gg CO_2 and 141 Gg CO_2 (Table 7-8).

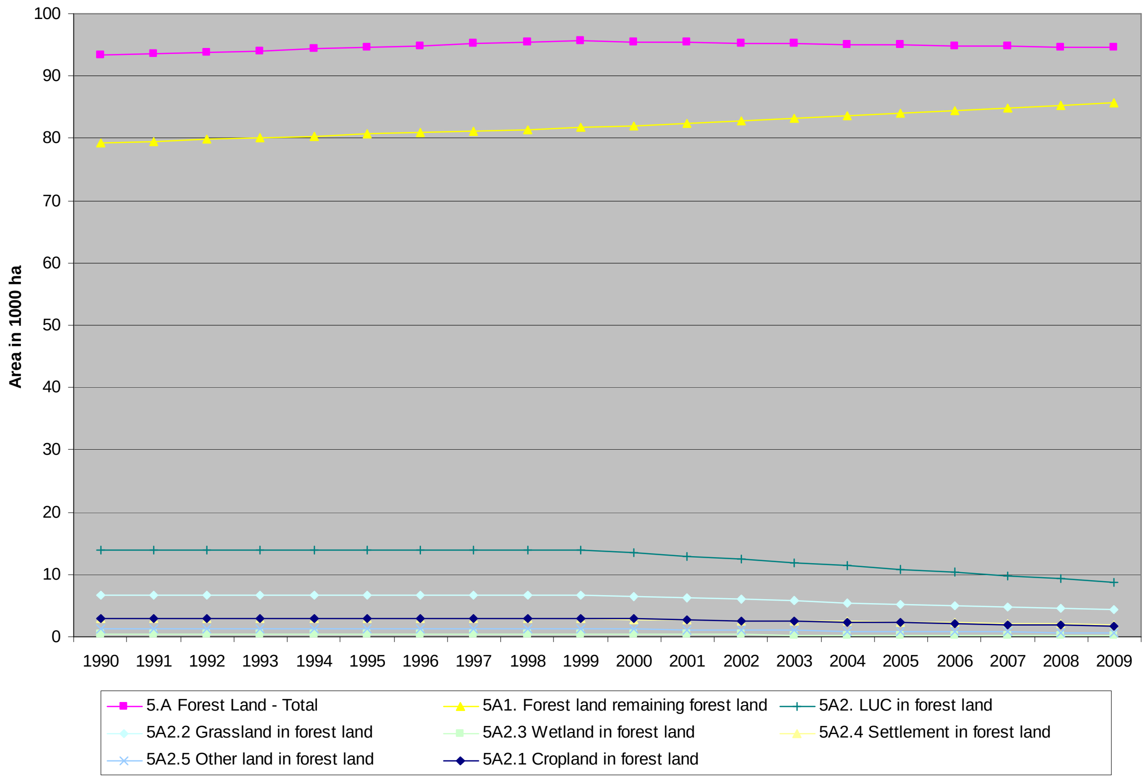
Table 7-8– CO_2 removals/emissions from IPCC category 5A – Forest Land from 1990-2009

5A - Forestland *Greenhouse gas emissions/removals (Gg CO_2 e)*								
Year	**5A Total Forest Land**	**5A1 FL remaining FL**	**5A2 Land converted to FL**	**5A2.1 Cropland converted to FL**	**5A2.2 Grassland converted to FL**	**5A2.3 Wetland converted to FL**	**5A2.4 Settlement converted to FL**	**5A2.5 Other land converted to FL**
1990	*126.20*	*239.26*	*- 113.06*	*- 15.26*	*- 23.28*	*- 8.10*	*-39.96*	*-26.46*
1991	*- 49.24*	*63.82*	*- 113.06*	*- 15.26*	*- 23.28*	*- 8.10*	*-39.96*	*-26.46*
1992	*- 417.54*	*- 304.48*	*- 113.06*	*- 15.26*	*- 23.28*	*- 8.10*	*-39.96*	*-26.46*
1993	*- 527.74*	*- 414.68*	*- 113.06*	*- 15.26*	*- 23.28*	*- 8.10*	*-39.96*	*-26.46*
1994	*- 358.29*	*- 245.23*	*- 113.06*	*- 15.26*	*- 23.28*	*- 8.10*	*-39.96*	*-26.46*
1995	*- 460.19*	*- 347.12*	*- 113.06*	*- 15.26*	*- 23.28*	*- 8.10*	*-39.96*	*-26.46*
1996	*- 632.59*	*- 519.53*	*- 113.06*	*- 15.26*	*- 23.28*	*- 8.10*	*-39.96*	*-26.46*
1997	*- 673.51*	*- 560.45*	*- 113.06*	*- 15.26*	*- 23.28*	*- 8.10*	*-39.96*	*-26.46*
1998	*- 418.49*	*- 305.42*	*- 113.06*	*- 15.26*	*- 23.28*	*- 8.10*	*-39.96*	*-26.46*
1999	*- 540.90*	*- 427.84*	*- 113.06*	*- 15.26*	*- 23.28*	*- 8.10*	*-39.96*	*-26.46*
2000	*- 557.07*	*- 431.03*	*- 126.04*	*- 25.26*	*- 27.85*	*- 7.73*	*-40.05*	*-25.15*
2001	*- 623.71*	*- 503.01*	*- 120.70*	*- 24.04*	*- 26.77*	*- 7.36*	*-38.70*	*-23.83*
2002	*- 624.13*	*- 508.76*	*- 115.36*	*- 22.82*	*- 25.69*	*- 6.99*	*-37.35*	*-22.52*
2003	*- 632.61*	*- 522.58*	*- 110.03*	*- 21.60*	*- 24.61*	*- 6.62*	*-36.00*	*-21.20*
2004	*- 587.07*	*- 482.38*	*- 104.69*	*- 20.37*	*- 23.53*	*- 6.25*	*-34.64*	*-19.89*
2005	*- 559.81*	*- 460.46*	*- 99.35*	*- 19.15*	*- 22.45*	*- 5.88*	*-33.29*	*-18.57*
2006	*- 448.98*	*- 354.97*	*- 94.01*	*- 17.93*	*- 21.37*	*- 5.51*	*-31.94*	*-17.26*
2007	*- 446.69*	*- 358.02*	*- 88.67*	*- 16.71*	*- 20.29*	*- 5.14*	*-30.58*	*-15.94*
2008	*- 445.73*	*- 362.40*	*- 83.33*	*- 15.49*	*- 19.21*	*- 4.77*	*-29.23*	*-14.63*
2009	*- 471.13*	*- 393.14*	*- 78.00*	*- 14.27*	*- 18.14*	*- 4.40*	*-27.88*	*-13.31*
Trend 1990-2009	*-473.33%*	*-264.31%*	*-31.01%*	*-6.50%*	*-22.10%*	*-45.67%*	*-30.23%*	*-49.69%*
Trend 2008-2009	*5.70%*	*8.48%*	*-6.41%*	*-7.89%*	*-5.62%*	*-7.75%*	*-4.63%*	*-8.99%*

The net carbon stock changes in forest biomass (sector 5.A.1) have a major impact on the overall results in sector 5. These changes vary considerable between single years. The reason is that the figures for annual growth and for annual harvest of forest biomass differ significantly year by year due to annual variations of influencing factors on growth and harvest like weather conditions, timber demand and prices, insect infestation or wind throws. These reasons for different growth and different harvest in single years explain the high annual variations in the CO_2 net removals of this sector.

The variation within the time trend for LUCs to forest land is mainly due to the change of LUC areas and its composition of previous land use types across the time series.

Figure 7-3 – Trend of forest land and LUC to forest land (covering a conversion period of 20 years) from 1990-2009



7.2.2 Information on approaches used for representing land areas and on land-use databases used for the inventory approach

In Luxembourg statistical data about forests are established and updated by the Nature and Forest Administration (Administration de la Nature et des Forêts (ANF)) of the Ministry of sustainable Development and Infrastructures. The forest inventory is partly based on photography from the air and partially based on territorial measurements (field-work).

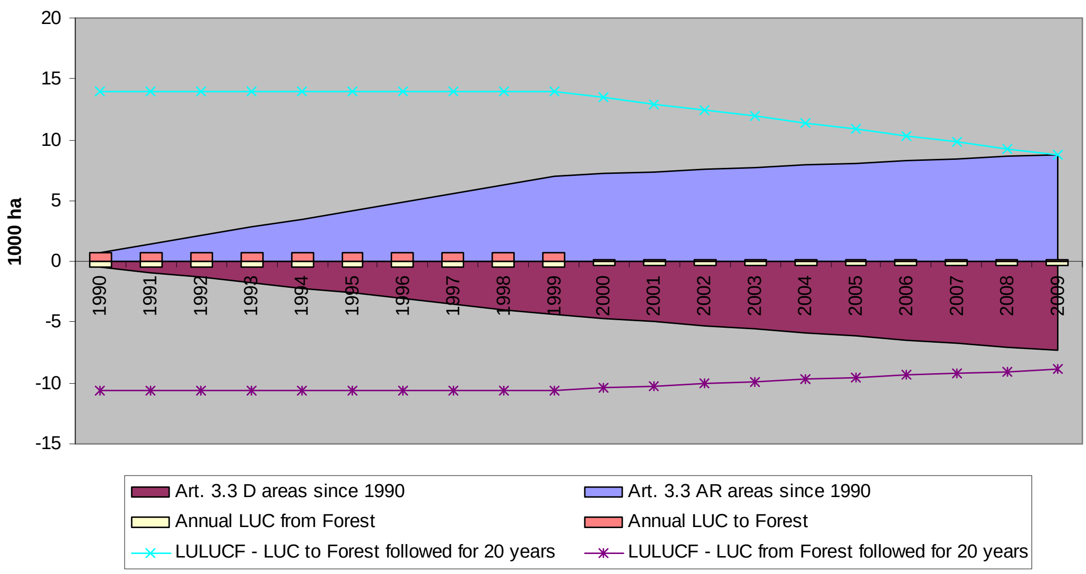
The forest area comprises all territories which are used for wood production, environment protection and recreation. In these areas are included land covered by trees, but also for example land covered by bushes, rocks or land no more used by agriculture.

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 %

Figure 7-4 gives an overview of the LUCs to and from forests from 1970 and 1990 on, respectively. LUC areas are in the LUC subcategory for a transition period of 20 years starting 20 years before 1990.

Figure 7-4 – Areas of LUC from and to forests and ARD areas since 1990



7.2.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The OBS89, OBS99 and OBS07 land use maps are the main data providers for the greenhouse gas reporting of IPCC category forestland. The National Forest Inventory (IFL) of Luxembourg is the main data provider for the development of carbon stock factors. Consequently and for reason of consistency, the applied forest definition for the reporting follows the definition used within the IFL and the OBS maps. The selected parameters are:

Land Use Class	Definition
Forest Land	All forest and wooded land according to the FAO TBRA2000 definition: • tree crown cover >= 10 % • tree height >= 5 m. In the geodata set, Forest land has been sub-divided into the forest types as defined below.
Conifers:	Including all forest land with > 10 % crown cover and on which more than 75 percent of the tree crown cover consists of coniferous species.
Deciduous:	Including all forest land with > 10 % crown cover and on which more than 75 percent of the tree crown cover consists of broadleaved species
Mixed (coniferous and deciduous):	with > 10 % crown cover and less than 75 % crown cover of one class.

Permanently unstocked basal areas that are directly connected with forest in terms of space and forestry enterprise and contribute directly to its management (such as forestal hauling systems, wood storage places, forest glades, forest roads) also represent forests. Areas which are used in short rotation with a rotation period of up to thirty years as well as forest arboretums, forest seed orchards, Christmas tree plantations and plantations of woody plants for the purpose of obtaining fruits such as walnut or sweet chestnut do not account as forests but represent cropland. Rows of trees (except shelter belts for wind protection) and areas with woody plants in a park structure are not forest land.

7.2.4 Methodological issues

7.2.4.1 Forest Land remaining Forest Land (5A1)

7.2.4.1.1 Change of carbon stock in biomass

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. The biomass decrease due to harvest was based on:

a) Basic wood densities were calculated using the values in Table 7-9, which are based on the mean densities (absolute dry) and volume shrinkage values provided by WAGENFÜHR und SCHEIBER 1974, KOLLMANN 1982, LOHMANN 1987.

Table 7-9 - 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 7-10).

Table 7-10 - 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.

7.2.4.1.2 Change of carbon stock in soil

For the changes in soil carbon stock the IPCC GPG Tier 1 approach was used (no changes in the soil carbon stock).

7.2.4.1.3 Change of carbon stock in dead wood

For the changes in dead wood, the IPCC GPG Tier 1 approach was used, assuming that there are no changes in dead wood, as no data between two time-points are available. Indeed, data collection for the second national forest inventory is currently under way, so that changes in dead wood can be estimated when the second national forest inventory (NFI-2) will be available (see chapter "planned improvements").

7.2.4.2 Land Use Changes to Forest Land (5A2)

7.2.4.2.1 Change of carbon stock in biomass of land converted to forest land

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 § 7.2.4.1, 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 § 7.2.4.1, 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.

7.2.4.2.2 Change of carbon stock in soil of land converted to forest land

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.

7.2.5 Uncertainties and time-series consistency

Uncertainties of IPCC category *5A – Forestland* have not yet been estimated. This is a planned improvement and an updated uncertainty analysis including LULUCF should be included in the next submission.

However, one can say that in the context of forest land remaining forest land, 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.).*

7.3 Cropland (5.B)

7.3.1 Category description

In Sector 5.B the estimate of emissions from cropland remaining cropland, land converted t cropland and liming is carried out. The calculations were made for the individual years from 1990 to

2009. Some management practices (e.g. slash and burn etc.) and organic soils do not occur in Luxembourg. Dead wood is considered in forestland converted to cropland areas, but litter is not considered in the remaining areas converted to cropland.

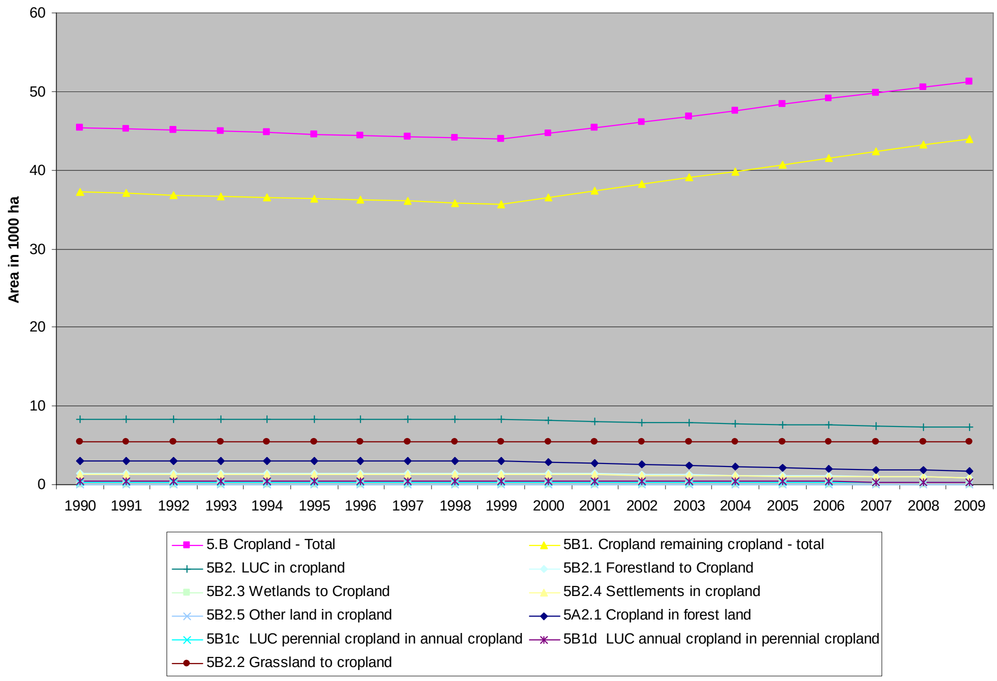
Emissions/Removals were estimated for the sub categories and related sources/sinks as shown in Table 7-11.

Table 7-11 – Sources (or sinks) considered for cropland management.

Category/source or sink
5B Cropland - total
5B1 Cropland remaining cropland
- carbon stock change in living biomass of perennial cropland and LUC between annual and perennial copland
- CO_2 emissions due to liming of cropland and grassland
5B2 Land converted to cropland
5B2.1 Forest land converted to cropland
- carbon stock change in living biomass and dead wood of annual/perennial cropland
5B2.2 Grassland converted to cropland
- carbon stock change in living biomass of annual/perennial cropland
- carbon stock change due to changes in organic matter input to cropland soils
5B2.3 Wetland converted to cropland
5B2.4 Settlement converted to cropland
5B2.5 Other land converted to cropland

In 2009, 51 271 ha of Luxembourg were arable land including annual and permanent crops. The land use changes are derived from land transition matrix (obtained using the OBS89, OBS99 and OBS07 land use maps), in 2009, the land use change area to cropland was 7 249 ha (Figure 7-5).

Figure 7-5 – Trend of cropland and LUC to cropland (covering a conversion period of 20 years) from 1990-2009



The annual emissions from 1990-2009 range between 27.2 Gg CO_2 equivalent and 38.6 Gg CO_2 equivalent (Table 7-12). The source is mainly caused by soil C stock changes of land use change areas, particularly by grassland converted to cropland.

Table 7-12– CO_2 removals/emissions from IPCC category 5B – Cropland from 1990-2009

5B - Cropland *Greenhouse gas emissions/removals (Gg CO_2 e)*										
Year	5B Total Cropland	5B1 CL remaining CL	Liming	5B2 Land converted to CL	5B2.1 Forestland converted to CL	5B2.2 Grassland converted to CL	5B2.3 Wetland converted to CL	5B2.4 Settlement converted to CL	5B2.5 Other land converted to CL	N_2O (in CO_2 eq)
1990	38.60	- 5.29	0.59	43.30	35.23	16.35	- 0.77	-10.12	-0.24	2.85
1991	38.72	- 5.29	0.71	43.30	35.23	16.35	- 0.77	-10.12	-0.24	2.85
1992	38.84	- 5.29	0.83	43.30	35.23	16.35	- 0.77	-10.12	-0.24	2.85
1993	38.96	- 5.29	0.95	43.30	35.23	16.35	- 0.77	-10.12	-0.24	2.85
1994	39.38	- 5.28	1.37	43.30	35.23	16.35	- 0.77	-10.12	-0.24	2.85
1995	39.13	- 5.28	1.12	43.30	35.23	16.35	- 0.77	-10.12	-0.24	2.85
1996	39.00	- 5.28	0.99	43.30	35.23	16.35	- 0.77	-10.12	-0.24	2.85
1997	39.48	- 5.28	1.47	43.30	35.23	16.35	- 0.77	-10.12	-0.24	2.85
1998	40.04	- 5.28	2.02	43.30	35.23	16.35	- 0.77	-10.12	-0.24	2.85
1999	39.14	- 5.28	1.13	43.30	35.23	16.35	- 0.77	-10.12	-0.24	2.85
2000	32.71	13.02	1.89	17.80	9.91	16.13	- 0.70	-10.14	-0.22	2.82
2001	32.31	11.92	2.29	18.10	9.84	16.15	- 0.67	-9.81	-0.21	2.80
2002	32.12	10.82	2.90	18.39	9.77	16.17	- 0.64	-9.48	-0.20	2.77
2003	31.22	9.72	2.82	18.68	9.70	16.19	- 0.61	-9.16	-0.19	2.75
2004	30.02	8.62	2.42	18.98	9.62	16.21	- 0.57	-8.83	-0.18	2.72
2005	30.70	7.52	3.91	19.27	9.55	16.23	- 0.54	-8.50	-0.16	2.70
2006	29.04	6.42	3.05	19.57	9.48	16.25	- 0.51	-8.17	-0.15	2.67
2007	28.26	5.32	3.08	19.86	9.41	16.26	- 0.48	-7.84	-0.14	2.65
2008	27.24	4.22	2.86	20.15	9.34	16.28	- 0.45	-7.51	-0.13	2.62
2009	27.65	3.12	4.07	20.45	9.27	16.30	- 0.41	-7.19	-0.12	2.59
Trend 1990-2009	-28.38%	-159.07%	591.04%	-52.77%	-73.69%	-0.28%	-46.35%	-28.98%	-52.15%	-8.93%
Trend 2008-2009	1.50%	-26.05%	42.46%	1.46%	-0.76%	0.11%	-7.18%	-4.37%	-9.09%	-0.97%

7.3.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

An exception to the use of the OBS land use maps has been made for LUC areas between cropland and grassland. When using OBS figures, the LUC areas between cropland and grassland are too high because the areas with more than one land use change within 20 years are taken into account as LUC areas, whereas, according to IPCC-GPG-LULUCF, they should stay in their main category. In Luxembourg, and especially in the northern part of Luxembourg (Oesling), a crop rotation including temporary grass is largely used by the farmers. In this crop rotation, the changes from temporary grass to annual crops are recorded as LUC grassland to cropland and the changes from annual crops to temporary grass as LUC grassland to cropland when using OBS. An alternative way to estimate the LUC between cropland and grassland was found, using administrative data of the Ministry of Agriculture coming from the administration of the "aid scheme for the maintenance of the landscape and the natural environment and for encouraging an agriculture respecting the environment", an agri-environmental aid scheme administered by the "Service d'Economie Rurale", an administration of the Ministry of Agriculture. As a land use change from permanent grassland to cropland is not allowed within this aid scheme, except in special circumstances and after a special authorization and as this aid scheme is largely taken up by the farmers, it was possible to estimate the annual LUC grassland to cropland (269 ha). As the part of permanent grassland in the utilized agricultural area is relatively stable, the annual LUC cropland to grassland is estimated to be of the same amount (269 ha). Thus, the LUC areas grassland to cropland respectively cropland to grassland going beyond 269 ha according to OBS are allocated to the category "grassland remaining grassland".

For a detailed description of the development of the land transition matrix, please refer to section 7.1.3.3.

7.3.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The OBS89, OBS99 and OBS07 land use maps are the main data providers for the greenhouse gas reporting of IPCC category cropland, with the exception that for LUC between cropland and grassland, the land transitions matrix needed to be adapted due to special national circumstances as explained in the previous section and in section 7.1.3.3. The selected parameters defining annual and perennial cropland are:

Land Use Class	Definition
Annual Cropland	Includes agro-forestry systems where tree cover falls below the level used in the forest categories (IPCC GPG definition) with the following specifications: land on which different crops are grown in a yearly changed rhythm including artificial meadows (not permanent) including land temporarily set aside

Land Use Class	Definition
Permanent Cropland	Includes agro-forestry systems where tree cover falls below the level used in the forest categories (IPCC GPG definition) with the following specifications: land on which different crops are grown in a permanent manner, i.e. not changing in a yearly rhythm

7.3.4 Methodological issues

7.3.4.1 Cropland remaining Cropland (5B1)

7.3.4.1.1 Change of carbon stock of 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.

c) Changes of carbon stock in organic soils:

Organic soils are not occurring in Luxemburg.

d) Changes of carbon stock in mineral soils of annual cropland remaining annual cropland:

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.

e) Changes of carbon stock in mineral soils of perennial cropland converted to annual cropland:
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).

7.3.4.1.2 Change of carbon stock of perennial cropland

a) Changes of carbon stock in biomass of perennial cropland remaining perennial cropland:
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:

$$\text{Annual change in carbon stock in biomass} = \text{annual area of converted land} * (L_{conversion} + \Delta C_{growth})$$

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 § 7.3.4.1.1 point c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according to § 7.3.4.1.1 point c).

7.3.4.1.3 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.

7.3.4.2 Land Use Changes to Cropland (5B2)

7.3.4.2.1 Change of carbon stock of land converted to 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.

a) Changes of carbon stock in biomass of forest land converted to cropland:
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.

b) Changes of carbon stock in biomass of grassland converted to annual cropland:

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} = 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.

c) Changes of carbon stock in mineral soils of forest land converted to cropland:

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 :

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -0.4\ t\ C/ha * yr$$

SOC_0 = soil organic carbon stock in the inventory year (t C/ha) according to § 7.3.4.1.1 point c).

SOC_{0-T} = soil organic carbon stock T years prior to the inventory (t C/ha) according to § 7.3.4.1.1 point c).

d) Changes of carbon stock in mineral soils of grassland converted to annual cropland:

According to IPCC GPG (Tier 1), annual change in carbon stock of mineral soils of grassland converted to annual cropland = ΔSOC * conversion area, where :

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -0.75\ t\ C/ha * yr.$$

SOC_0 = soil organic carbon stock in the inventory year (t C/ha) according to § 7.3.4.1.1 point c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according to § 7.3.4.1.1 point c).

7.3.4.2.2 Change of carbon stock of land converted to 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.

a) Changes of carbon stock in biomass of grassland converted to perennial cropland:

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:

$$\text{Annual change in carbon stock in biomass} = \text{annual area of converted land} * (L_{conversion} + \Delta C_{growth})$$

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.

b) Changes of carbon stock in mineral soils of grassland converted to perennial cropland:

According to IPCC GPG (Tier 1), annual change in carbon stock of mineral soils of grassland converted to perennial cropland = ΔSOC * conversion area, where :

$$\Delta SOC = (SOC_0 - SOC_{0-T})/20 = -2.45 \text{ t C/ ha *yr.}$$

SOC_0 = soil organic carbon stock in the inventory year (t C/ha) according to § 7.3.4.1.1 point c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according to § 7.3.4.1.1 point c).

7.3.4.2.3 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) :

$$N_2O_{net-min}\text{-}N = EF_1 * \Delta C_{LCmineral} * 1/(C/N \text{ ratio})$$

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 § 7.3.4.2.1 point d) and § 0 point b) above).

C/N ratio = ratio by mass of C to N in the soil organic matter = 10/12.

7.4 Grassland (5C)

7.4.1 Category description

In this category emissions/removals from grassland management (grassland remaining grassland and land converted to grassland) are considered.

Some management practices (e.g. slash and burn etc.) do not occur in Luxembourg. Some management practices (e.g. slash and burn etc.) and organic soils do not occur in Luxembourg. Dead wood is considered in forestland converted to grass land areas, but litter is not considered for the remaining land categories converted to grassland.

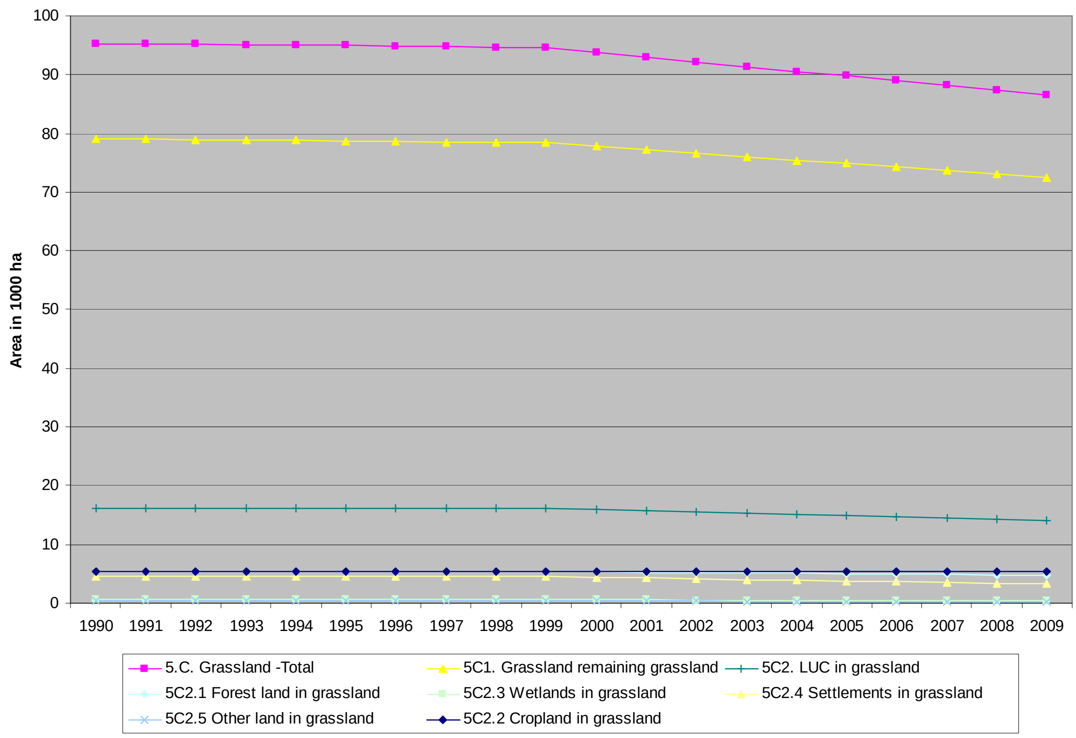
Emissions/Removals were estimated for the sub categories and related sources/sinks as shown in Table 7-13.

Table 7-13 – Sources (or sinks) considered for grassland management.

Category/source or sink
5C Grassland - total
5C1 Grassland remaining grassland
- carbon stock change due to changes in organic matter input to grassland soils
5C2 Land converted to grassland
5C2.1 Forest land converted to grassland
5C2.2 Cropland converted to grassland
- carbon stock change in living biomass of grassland
- carbon stock change due to changes in organic matter input (harvest residues) to grassland soils
5C2.3 Wetland converted to grassland
5C2.4 Settlement converted to grassland
5C2.5 Other land converted to grassland

In 2009, 86 511 ha of Luxembourg were grassland (Figure 7-6). Total grassland includes one cut meadows; two and more cut meadows, cultivated pastures, litter meadows, rough pastures and pastures and abandoned grassland.

Figure 7-6 – Trend of grassland and LUC to grassland (covering a conversion period of 20 years) from 1990-2009



The annual emissions of grassland in Luxembourg amounted to 31.6 Gg CO_2 in 1990 and 26.9 Gg CO_2 in 2009 (Table 7-14). The source is mainly caused by soil C stock changes in land use change areas, particularly by forestland converted to grassland.

Table 7-14– CO_2 removals/emissions from IPCC category 5C – Grassland from 1990-2009

5C - Grassland *Greenhouse gas emissions/removals (Gg CO_2 e)*								
Year	5C Total Grassland	5C1 GL remaining GL	5C2 Land converted to GL	5C2.1 Forestland converted to GL	5C2.2 Cropland converted to GL	5C2.3 Wetland converted to GL	5C2.4 Settlement converted to GL	5C2.5 Other land converted to GL
1990	*31.64*	*NO*	*31.64*	*111.31*	*- 14.79*	*- 10.31*	*-47.75*	*-6.82*
1991	*31.64*	*NO*	*31.64*	*111.31*	*- 14.79*	*- 10.31*	*-47.75*	*-6.82*
1992	*31.64*	*NO*	*31.64*	*111.31*	*- 14.79*	*- 10.31*	*-47.75*	*-6.82*
1993	*31.64*	*NO*	*31.64*	*111.31*	*- 14.79*	*- 10.31*	*-47.75*	*-6.82*
1994	*31.64*	*NO*	*31.64*	*111.31*	*- 14.79*	*- 10.31*	*-47.75*	*-6.82*
1995	*31.64*	*NO*	*31.64*	*111.31*	*- 14.79*	*- 10.31*	*-47.75*	*-6.82*
1996	*31.64*	*NO*	*31.64*	*111.31*	*- 14.79*	*- 10.31*	*-47.75*	*-6.82*
1997	*31.64*	*NO*	*31.64*	*111.31*	*- 14.79*	*- 10.31*	*-47.75*	*-6.82*
1998	*31.64*	*NO*	*31.64*	*111.31*	*- 14.79*	*- 10.31*	*-47.75*	*-6.82*
1999	*31.64*	*NO*	*31.64*	*111.31*	*- 14.79*	*- 10.31*	*-47.75*	*-6.82*
2000	*7.67*	*NO*	*7.67*	*86.23*	*- 17.40*	*- 9.29*	*-45.36*	*-6.51*
2001	*9.81*	*NO*	*9.81*	*86.30*	*- 17.32*	*- 8.88*	*-44.11*	*-6.19*
2002	*11.95*	*NO*	*11.95*	*86.38*	*- 17.24*	*- 8.47*	*-42.85*	*-5.87*
2003	*14.09*	*NO*	*14.09*	*86.45*	*- 17.16*	*- 8.06*	*-41.59*	*-5.56*
2004	*16.23*	*NO*	*16.23*	*86.52*	*- 17.08*	*- 7.65*	*-40.33*	*-5.24*
2005	*18.36*	*NO*	*18.36*	*86.60*	*- 17.00*	*- 7.24*	*-39.07*	*-4.92*
2006	*20.50*	*NO*	*20.50*	*86.67*	*- 16.92*	*- 6.83*	*-37.81*	*-4.61*
2007	*22.64*	*NO*	*22.64*	*86.74*	*- 16.84*	*- 6.42*	*-36.55*	*-4.29*
2008	*24.78*	*NO*	*24.78*	*86.82*	*- 16.77*	*- 6.01*	*-35.29*	*-3.97*
2009	*26.92*	*NO*	*26.92*	*86.89*	*- 16.69*	*- 5.60*	*-34.04*	*-3.66*
Trend 1990-2009	*-14.92%*	*NA*	*-21.68%*	*-22.00%*	*13.38%*	*-41.73%*	*-26.09%*	*-41.76%*
Trend 2008-2009	*8.63%*	*NA*	*9.44%*	*0.08%*	*-0.47%*	*-6.40%*	*-3.44%*	*-7.38%*

7.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

An exception to the use of the OBS land use maps has been made for LUC areas between cropland and grassland. When using OBS figures, the LUC areas between cropland and grassland are too high because the areas with more than one land use change within 20 years are taken into account as LUC areas, whereas, according to IPCC-GPG-LULUCF, they should stay in their main category. In Luxembourg, and especially in the northern part of Luxembourg (Oesling), a crop rotation including temporary grass is largely used by the farmers. In this crop rotation, the changes from temporary grass to annual crops are recorded as LUC grassland to cropland and the changes from annual crops to temporary grass as LUC grassland to cropland when using OBS. An alternative way to estimate the LUC between cropland and grassland was found, using administrative data of the Ministry of Agriculture coming from the administration of the "aid scheme for the maintenance of the landscape and the natural environment and for encouraging an agriculture respecting the environment", an agri-environmental aid scheme administered by the "Service d'Economie Rurale", an administration of the Ministry of Agriculture. As a land use change from permanent grassland to cropland is not allowed within this aid scheme, except in special circumstances and after a special authorization and as this aid scheme is largely taken up by the farmers, it was possible to estimate the annual LUC grassland to cropland (269 ha). As the part of permanent grassland in the utilized agricultural area is relatively stable, the annual LUC cropland to grassland is estimated to be of the same amount (269 ha). Thus, the LUC areas grassland to cropland respectively cropland to grassland going beyond 269 ha according to OBS are allocated to the category "grassland remaining grassland".

For a detailed description of the development of the land transition matrix, please refer to section 7.1.3.3.

7.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The OBS89, OBS99 and OBS07 land use maps are the main data providers for the greenhouse gas reporting of IPCC category grassland, with the exception that for LUC between grassland and cropland, the land transitions matrix needed to be adapted due to special national circumstances as explained in the previous section and in section 7.1.3.3. The selected parameters defining grassland are:

Land Use Class	Definition
Grassland	All grassland that is not considered as cropland including systems with vegetation or tree cover below the density used in the forest category. This includes all grassland from wild lands, recreational areas as well as agricultural systems. (IPCC GPG definition).

7.4.4 Methodological issues

7.4.4.1 Grassland remaining Grassland (5C1)

7.4.4.1.1 Carbon stock change of grassland

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.

Consequently, there are neither 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).

7.4.4.2 Land Use Changes to Grassland (5C2)

7.4.4.2.1 Carbon stock change of land converted to grassland

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.

<u>c) Changes in carbon stock in biomass of perennial cropland converted to grassland:</u>

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:

*Annual change in carbon stock in biomass = annual area of converted land * ($L_{conversion}$ + ΔC_{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.

<u>d) Changes in carbon stock in mineral soil of forest land converted to grassland:</u>

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).

<u>e) Changes in carbon stock in mineral soil of annual cropland converted to grassland:</u>

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 § 7.3.4.1.1 point c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according to § 7.3.4.1.1 point c).

<u>f) Changes in carbon stock in mineral soil of perennial cropland converted to grassland:</u>

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 § 7.3.4.1.1 point c).

SOC_{0-T} = soil organic carbon stock *T* years prior to the inventory (t C/ha) according to § 7.3.4.1.1 point c).

7.5 Wetlands (5D)

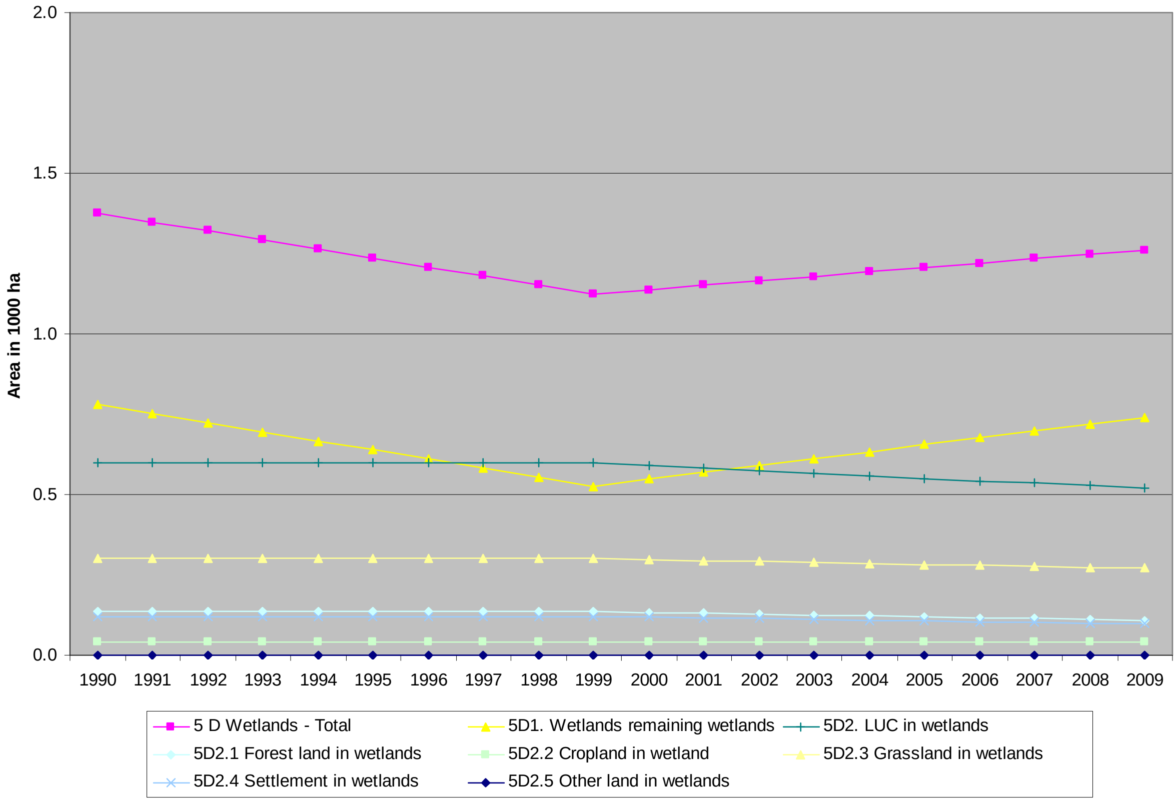
7.5.1 Category description

In this category emissions/removals from land converted to wetland are considered.

Due to the lack of information, it is assumed that the C stock in biomass, dead organic matter and soil of surface waters is zero.

In 2009, 1 261 ha of Luxembourg were wetland (Figure 7-7). Total wetland includes any areas covered by water (rivers, lakes, etc.) or saturated by water (marshes, mires, etc.). There is no peatland, hence no organic soils in wetlands in Luxembourg.

Figure 7-7 – Trend of wetland and LUC to wetland (covering a conversion period of 20 years) from 1990-2009



The annual emissions from wetland in Luxembourg amounted to 12.3 Gg CO_2 in 1990 and 9.8 Gg CO_2 in 2009 (Table 7-14). The source is mainly caused by soil C stock changes in land use change areas, particularly by forestland and grassland converted to wetland.

Table 7-15– CO_2 removals/emissions from IPCC category 5D – Wetland from 1990-2009

5D - Wetland *Greenhouse gas emissions/removals (Gg CO_2 e)*								
Year	5D Total Wetland	5D1 WL remaining WL	5D2 Land converted to WL	5D2.1 Forestland converted to WL	5D2.2 Cropland converted to WL	5D2.3 Grassland converted to WL	5D2.4 Settlement converted to WL	5D2.5 Other land converted to WL
1990	12.27	NE	12.27	5.30	0.62	5.44	0.91	NO
1991	12.27	NE	12.27	5.30	0.62	5.44	0.91	NO
1992	12.27	NE	12.27	5.30	0.62	5.44	0.91	NO
1993	12.27	NE	12.27	5.30	0.62	5.44	0.91	NO
1994	12.27	NE	12.27	5.30	0.62	5.44	0.91	NO
1995	12.27	NE	12.27	5.30	0.62	5.44	0.91	NO
1996	12.27	NE	12.27	5.30	0.62	5.44	0.91	NO
1997	12.27	NE	12.27	5.30	0.62	5.44	0.91	NO
1998	12.27	NE	12.27	5.30	0.62	5.44	0.91	NO
1999	12.27	NE	12.27	5.30	0.62	5.44	0.91	NO
2000	10.77	NE	10.77	3.98	0.61	5.32	0.86	NO
2001	10.67	NE	10.67	3.94	0.61	5.27	0.85	NO
2002	10.56	NE	10.56	3.90	0.61	5.22	0.83	NO
2003	10.46	NE	10.46	3.86	0.61	5.17	0.82	NO
2004	10.35	NE	10.35	3.81	0.61	5.13	0.80	NO
2005	10.25	NE	10.25	3.77	0.61	5.08	0.79	NO
2006	10.14	NE	10.14	3.73	0.61	5.03	0.77	NO
2007	10.04	NE	10.04	3.69	0.61	4.98	0.76	NO
2008	9.94	NE	9.94	3.64	0.61	4.93	0.75	NO
2009	9.83	NE	9.83	3.60	0.61	4.89	0.73	NO
Trend 1990-2009	-19.86%	NA	-19.86%	-32.07%	-0.57%	-10.11%	-20.04%	NA
Trend 2008-2009	-1.05%	NA	-1.05%	-1.17%	0.14%	-0.97%	-1.99%	NA

7.5.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

For a detailed description of the development of the land transition matrix, please refer to section 7.1.3.3.

7.5.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The OBS89, OBS99 and OBS07 land use maps are the main data providers for the greenhouse gas reporting of IPCC category wetland. The selected parameters defining wetland are:

Land Use Class	Definition
Wetland	Land that is covered or saturated by water for all or part of the year (e.g. peat land) and that does not fall into other categories.
Water	Land that is covered by water for all the year and that does not fall into other categories. This includes reservoirs. (IPCC GPG definition)

7.5.4 Methodological issues

7.5.4.1 Wetlands remaining Wetlands (5D1)

Due to a lack of required data on carbon stock changes, this category has not yet been estimated. Thus, it is assumed that the C stock in biomass, dead organic matter and soil of surface waters is 0. However, it should be noted, that areas next to rivers or lakes which can be flooded, are considered as grassland, as these areas are used as grassland for animals.

7.5.4.2 Land Use Changes to Wetlands (5D2)

7.5.4.2.1 <u>Forest Land converted to Wetland (5.D.2.1)</u>

The area in conversion status from forest land to wetland for a time period of 20 years ranges from 137 ha to 109 ha between the years 1990 and 2009 causing annual emission rates due to the loss of biomass and C stock changes in soil from 5.3 Gg CO_2 to 3.6 Gg CO_2.

For the calculation of the annual change of carbon stocks IPCC Tier 2 approach is used. Emissions/removals were calculated by country specific values (Chapter 7.2.4.2).

7.5.4.2.2 <u>Cropland converted to Wetland (5.D.2.2)</u>

The area in conversion status from cropland to wetland for a time period of 20 years has been constant between 1990 and 2009 and equals to 40 ha.

<u>Changes in carbon stocks in biomass of cropland converted to wetland</u>

For the calculation of the annual change in carbon stocks of living biomass in cropland converted to wetland the following equation was applied (equation 3.5.6 GPG):

Annual change in carbon stocks of living biomass in land converted to wetland (tonnes C/year):

$$LW\ flood = Sum(A_i*(B\ after - B\ before))$$

Ai = annual area of land actually converted to flooded land from original land use, ha

B before = living biomass in land immediately before conversion to wetland = for annual cropland 5.7 t C/ha*y and for perennial cropland 5.7 t C/ha*y

B after = living biomass in land immediately after conversion to wetland (default = 0 t C/ha*y)

<u>Changes in carbon stocks in soil of cropland converted to wetland</u>

Calculation:

$$LW\ flood = (Sum\ Ai*(B\ after - B\ before)/20$$

Ai = area of land converted to flooded land for a transition period of 20 years, ha

B before = carbon stock in soil immediately before conversion to wetland = for annual cropland 77.0 t C/ha*y and for perennial cropland 43.0 t C/ha*y

B after = carbon stock in soils 20 years after conversion to wetland (default = 0 t C/ha*y)

7.5.4.2.3 Grassland converted to Wetland (5.D.2.3)

The area in conversion status from cropland to wetland for a time period of 20 years ranges from 300 ha to 272 ha between 1990 and 2009.

Changes in carbon stocks in biomass of grassland converted to wetland

For the calculation of the annual change in carbon stocks of living biomass in grassland converted to wetland the following equation was applied (equation 3.5.6 GPG).

Annual change in carbon stocks of living biomass in land converted to wetland (tonnes C/year):

$$LW\ flood = Sum(A_i*(B\ after\text{-}B\ before))$$

Ai = annual area of land actually converted to flooded land from original land use, ha

B before = living biomass in land immediately before conversion to wetland = for grassland 6.8 t C/ha*y

B after = living biomass in land immediately after conversion to wetland (default = 0 t C/ha*y)

Changes in carbon stocks in soil of grassland converted to wetland

Calculation:

$$LW\ flood= (Sum\ Ai*(B\ after\text{-}B\ before)/20$$

Ai = area of land converted to flooded land for a transition period of 20 years, ha

B before = carbon stock in soil immediately before conversion to wetland = for grassland 92 t C/ha*y

B after = carbon stock in soils 20 years after conversion to wetland (default = 0 t C/ha*y)

7.5.4.2.4 Settlement converted to Wetland (5.D.2.4)

The area in conversion status from other land to wetland for a time period of 20 years ranges from 120 ha to 99 ha for the period 1990 to 2009.

Changes in carbon stocks in biomass of settlements converted to wetland

For the calculation of the annual change in carbon stocks of living biomass in other land converted to wetland the following equation according to IPCC GPG was applied (equation 3.5.6 GPG).

Annual change in carbon stocks of living biomass in land converted to wetland (tons C.a-1):

$$LW\ flood= (Sum\ A_i*(B_{after}\text{-}B_{before})$$

A_i = annual area of land converted actually to flooded land from original land use, ha

B_{before} = living biomass in land immediately before conversion to wetland = for settlement 4.3 t C/ha*y (see chapter 7.6)

B_{after} = living biomass in land immediately after conversion to wetland (default = 0 t C/ha*y)

Changes in carbon stocks in soil of settlements converted to wetland

Calculation:

LW flood= (Sum Ai(Bafter-B before)/20*

Ai = area of land converted to flooded land for a transition period of 20 years, ha

Bbefore = carbon stock in soil immediately before conversion to wetland = for settlement 37.0 t C/ha*y see chapter 7.6

Bafter = carbon stock in soils 20 years after conversion to wetland (default = 0 t C/ha*y)

7.5.4.2.5 Other Land converted to Wetland (5.D.2.5)

The area in conversion status from other land to wetland for a time period of 20 years ranges from 0.52 ha to 0.26 ha for the period 1990 to 2009.

Changes in carbon stocks in biomass of other land converted to wetland

For the calculation of the annual change in carbon stocks of living biomass in other land converted to wetland the following equation according to IPCC GPG was applied (equation 3.5.6 GPG).

Annual change in carbon stocks of living biomass in land converted to wetland (tons C.a-1):

LW flood= (Sum Ai(B after-B before)*

Ai = annual area of land converted actually to flooded land from original land use, ha

Bbefore = living biomass in land immediately before conversion to wetland = for other land 0 t C/ha*y (see chapter 7.7)

Bafter = living biomass in land immediately after conversion to wetland (default = 0 t C/ha*y)

Changes in carbon stocks in soil of other land converted to wetland

Calculation:

LW flood= (Sum Ai(Bafter-B before)/20*

Ai = area of land converted to flooded land for a transition period of 20 years, ha

Bbefore = carbon stock in soil immediately before conversion to wetland = for other land 0 t C/ha*y (see chapter 7.7)

Bafter = carbon stock in soils 20 years after conversion to wetland (default = 0 t C/ha*y)

7.6 Settlements (5E)

7.6.1 Category description

In this category emissions/removals from land converted to settlements are considered.

In 2009, 24 977 ha of Luxembourg were settlement (Figure 7-8). The area in conversion status from “Land converted to Settlement” for a time period of 20 years ranges from 10 717 ha to 8 975 ha between the years 1990 and 2009 causing annual emission rates due to C stock changes of biomass and soils from 138.9 Gg CO_2 to 110.3 Gg CO_2 (Table 7-16).

Annual LUCs to settlement occur from the sub-categories "Forest Land", "Cropland", "Grassland", "Wetland" and "Other land".

Figure 7-8 – Trend of wetland and LUC to settlement (covering a conversion period of 20 years) from 1990-2009

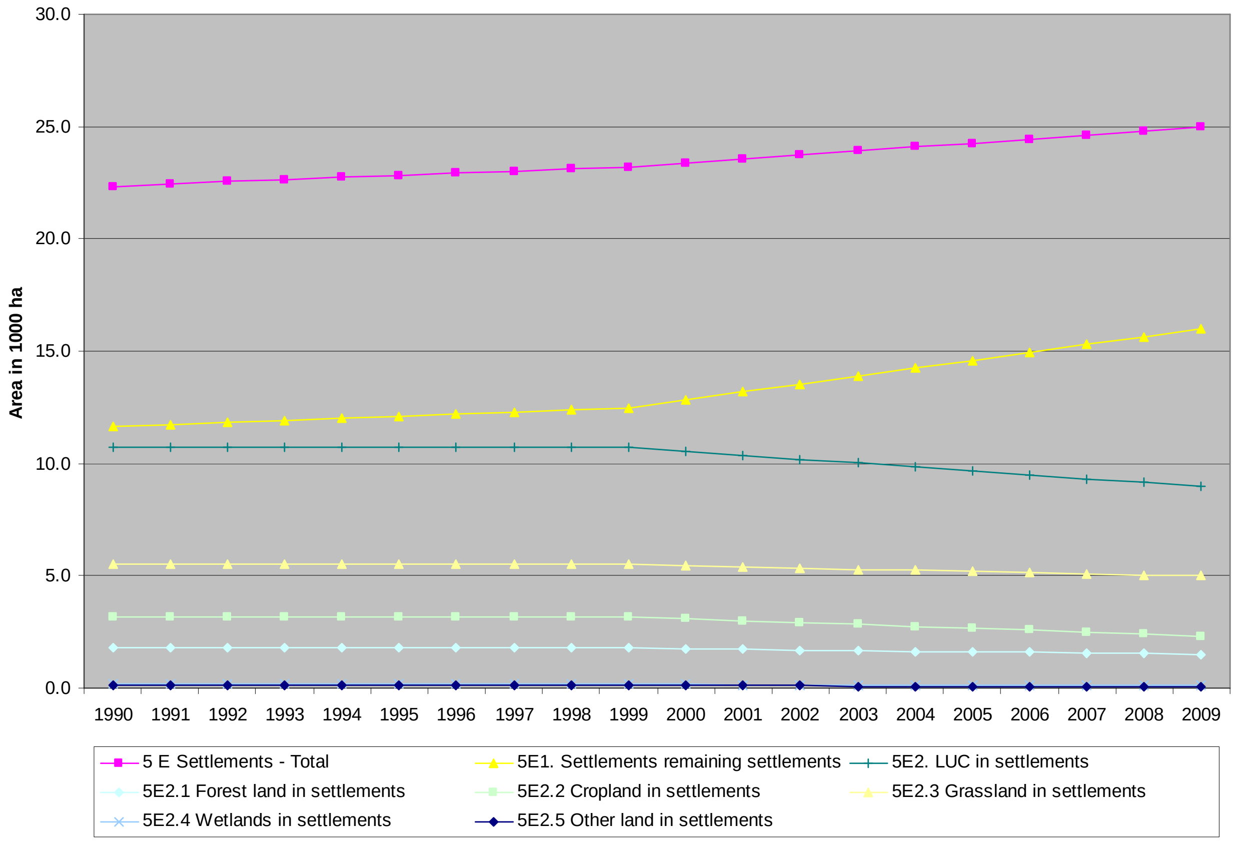


Table 7-16– CO_2 removals/emissions from IPCC category 5E – Settlement from 1990-2009

5E - Settlement *Greenhouse gas emissions/removals (Gg CO_2 e)*								
Year	**5E Total Settlement**	**5E1 Settlement remaining Settlement**	**5E2 Land converted to Settlement**	**5E2.1 Forestland converted to Settlement**	**5E2.2 Cropland converted to Settlement**	**5E2.3 Grassland converted to Settlement**	**5E2.4 Wetland converted to Settlement**	**5E2.5 Other land converted to Settlement**
1990	*138.93*	*NE*	*138.93*	*55.26*	*27.89*	*57.86*	*-1.25*	*-0.83*
1991	*138.93*	*NE*	*138.93*	*55.26*	*27.89*	*57.86*	*-1.25*	*-0.83*
1992	*138.93*	*NE*	*138.93*	*55.26*	*27.89*	*57.86*	*-1.25*	*-0.83*
1993	*138.93*	*NE*	*138.93*	*55.26*	*27.89*	*57.86*	*-1.25*	*-0.83*
1994	*138.93*	*NE*	*138.93*	*55.26*	*27.89*	*57.86*	*-1.25*	*-0.83*
1995	*138.93*	*NE*	*138.93*	*55.26*	*27.89*	*57.86*	*-1.25*	*-0.83*
1996	*138.93*	*NE*	*138.93*	*55.26*	*27.89*	*57.86*	*-1.25*	*-0.83*
1997	*138.93*	*NE*	*138.93*	*55.26*	*27.89*	*57.86*	*-1.25*	*-0.83*
1998	*138.93*	*NE*	*138.93*	*55.26*	*27.89*	*57.86*	*-1.25*	*-0.83*
1999	*138.93*	*NE*	*138.93*	*55.26*	*27.89*	*57.86*	*-1.25*	*-0.83*
2000	*118.35*	*NE*	*118.35*	*42.85*	*20.06*	*57.38*	*-1.17*	*-0.77*
2001	*117.34*	*NE*	*117.34*	*42.63*	*19.66*	*56.91*	*-1.13*	*-0.73*
2002	*116.32*	*NE*	*116.32*	*42.41*	*19.26*	*56.43*	*-1.09*	*-0.69*
2003	*115.31*	*NE*	*115.31*	*42.19*	*18.86*	*55.95*	*-1.04*	*-0.65*
2004	*114.30*	*NE*	*114.30*	*41.98*	*18.46*	*55.48*	*-1.00*	*-0.61*
2005	*113.29*	*NE*	*113.29*	*41.76*	*18.05*	*55.00*	*-0.96*	*-0.57*
2006	*112.27*	*NE*	*112.27*	*41.54*	*17.65*	*54.53*	*-0.91*	*-0.53*
2007	*111.26*	*NE*	*111.26*	*41.32*	*17.25*	*54.05*	*-0.87*	*-0.49*
2008	*110.25*	*NE*	*110.25*	*41.10*	*16.85*	*53.57*	*-0.83*	*-0.46*
2009	*110.25*	*NE*	*110.25*	*41.10*	*16.85*	*53.57*	*-0.83*	*-0.46*
Trend 1990-2009	*-20.65%*	*NA*	*-20.65%*	*-25.62%*	*-39.58%*	*-7.40%*	*-33.70%*	*-45.42%*
Trend 2008-2009	*0.00%*	*NA*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*

7.6.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

For a detailed description of the development of the land transition matrix, please refer to section 7.1.3.3.

7.6.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The OBS89, OBS99 and OBS07 land use maps are the main data providers for the greenhouse gas reporting of IPCC category settlements. The selected parameters defining settlements are:

Land Use Class	**Definition**
Settlements	All developed land, including transportation and any size of human settlement unless already included under other categories.(IPCC GPG definition)

The settlement area in correspondence to the LULUCF category comprises the following subcategories:

- building land : sealed, partly sealed and unsealed area,
- parks and gardens,
- road, railway, track and excavation area,
- other, not further differentiated settlement area.

7.6.4 Methodological issues

7.6.4.1 Settlements remaining Settlements (5E1)

Due to a lack of data, this category has not yet been estimated.

7.6.4.2 Land Use Changes to Settlements (5E2)

7.6.4.2.1 Biomass

For the estimation of biomass stock and biomass growth in settlements, data from the municipality of Luxembourg were used. According to the magazine "EcoLogique n°1 2010"[153] the municipality of Luxembourg has 18500 trees in public unsealed areas which belong to the settlement category (i.e. are not forest or agricultural land). This amount was multiplied with annual growth rates of settlement trees as published in the IPCC GPG (Table 3A.4.1). It was assumed that 75 % of these trees represent hardwood species for which according to this table 0.0100 t C/ha*y as annual growth rate per tree was taken. The other 25 % were assumed to be represented half-half by pine and spruce (0.0087 and 0.0092 t C/ha*y, respectively). The resulting annual growth rate was then divided by the related public unsealed area of Luxemburg town to get a per ha value. This resulted in an annual growth of trees at unsealed settlement areas of 0.25 t C/ha*y. For shrubs (each year 10 000 shrubs are planted at public areas of Luxembourg city[154]) and annual plants, an annual growth rate of 0,125 and 3.2 t C/ha*y, respectively, at unsealed settlement areas was taken. Due to the lack of own data sources, these values were derived from the related estimates for Austria which are a based on a study for the city of Vienna[155]. From these values and the percentage of unsealed area per ha settlement (40 % - derived by the composition of the settlement area according to OBS99 and OBS07) the annual C stock growth rate of biomass per settlement area (sealed

153 EcoLogique n°1, 2010, Ville de Luxembourg, p.6

154 EcoLogique n°1, 2010, Ville de Luxembourg, p.11

155 DÖRFLINGER, A.; HIETZ, P.; MAIER, R.; PUNZ, W.; FUSSENEGGER, K. (1995): Ökosystem Großstadt Wien - Quantifizierung ökologischer Parameter unter besonderer Berücksichtigung der Vegetation; Bundesministerium für Wissenschaft und Forschung und MA 22. See also: Austria's National Inventory Report, Umweltbundesamt, REP-0265, Vienna, 2010, p.352.

plus unsealed) was estimated: 0.15 t C/ha*y for perennial plants and 1.29 t C/ha*y for annual plants. These annual biomass growth rates were assumed to be a valid average for settlement areas in Luxembourg and were used for areas of LUCs to settlement and for the 20 years of transition period after LUC (perennial plants) or for the first year after LUC only (annual plants).

For the biomass losses at LUC areas from settlements to other land uses the same data origins were used. The average biomass C stock at these areas was estimated to represent an equivalent of 20 years of growth of the tree and shrub biomass with the annual growth rates above and one biomass of annual plants. This results in a total biomass stock of 4.34 t C/ha to be present per ha settlement area.

7.6.4.2.2 Soils

The following assumptions were taken to estimate the soil C stock in settlements. Sealed areas were assumed to have a soil C stock of 0 t C/ha. The unsealed settlement area (on average 40 % according to OBS99 and OBS07) was assumed to have the same soil C stock as grassland in Luxembourg (92 t C/ha). This resulted for total settlement in a soil C stock of 37 t C/ha which was used as initial soil C stock before LUC from settlement to other land uses or as final soil C stock after 20 years of transition after LUC to settlement.

7.6.4.2.3 Forest Land converted to Settlement (5.E.2.1)

The methodology and activity data are described in chapter 7.2.4. However, the perennial plants in the settlement areas are estimated with a continued annual growth during the whole LUC transition period of 20 years as described in chapter 7.6.4.2.1. The area in conversion status from Forest Land to settlement for a time period of 20 years ranges from 1 770 ha to 1 505 ha between the years 1990 and 2009 causing annual emission rates due to the loss of biomass and C stock changes in soil and litter from 55.3 Gg CO_2 to 41.1 Gg CO_2.

Changes in carbon stocks in biomass of forest land converted to settlement

The annual net emission rates due to loss of forest biomass and increase of biomass on settlement area range from 10.8 to 7.54 Gg CO_2 in the years 1990 to 2009.

Changes in carbon stocks in soil of forest land converted to settlement

For the calculation of the annual change of carbon stocks in forest soils converted to soils of settlements the IPCC Tier 2 approach is used. Emissions/removals were calculated by country specific values for carbon stocks in soils of forest land (85 t C/ha, mineral soil 0 - 50 cm plus the humus layer (litter) above mineral soil) and settlement areas (37.5 t C/ha area weighted mean value for mineral soil of 0-50 cm according to the input data described in chapter 7.2.4.2.2). Therefore, the estimated changes in soil also account for the loss of litter. The annual emission rates due to C stock changes in soil and litter range from 4.25 to 3.61 Gg CO_2 in the years 1990 - 2009.

7.6.4.2.4 Cropland converted to Settlement (5.E.2.2)

The area in conversion status from cropland to settlement for a time period of 20 years ranges from 3 177 to 2 313 ha in the years 1990 - 2009.

Changes in carbon stocks in biomass of cropland converted to settlement

For the calculation of the annual change in carbon stocks of living biomass in cropland converted to settlement the IPCC Tier 2 approach is used. The method follows the approaches as in chapters 7.3.4 and 7.4.4 with the use of country specific biomass data for settlements as described in chapter 7.6.4.1.1. The perennial plants in the settlement areas are estimated with a continued annual growth during the whole LUC transition period of 20 years as described in chapter 7.6.4.1.1.

The annual emission rates due to loss of biomass on settlement area ranges from 2.89 to 1.00 Gg CO_2 in the years 1990 to 2009.

Changes in carbon stocks in soil of cropland converted to settlement

The estimates for soil carbon stocks in annual and perannual cropland and in settlement areas are, respectively, 77 t C/ha and 43 t C/ha, (see chapter 7.3.4) and 37 t C/ha, (see chapter 7.6.4.2.1). Consequently, emissions from carbon stock changes in soils due to land use conversion from cropland to settlement range from 4.71 Gg CO_2 to 3.49 Gg CO_2 in the period 1990 - 2009.

7.6.4.2.5 Grassland converted to Settlement (5.E.2.3)

The area in conversion status from grassland to settlement for a time period of 20 years ranges from 5 496 to 4 995 ha in the years 1990 - 2009 resulting in annual emission rates due to C stock changes of biomass and soils from 57.86 Gg CO_2 to 53.57 Gg CO_2.

Changes in carbon stocks in biomass of grassland converted to settlement

For the calculation of the annual change in carbon stocks of living biomass in grassland converted to settlement the IPCC Tier 2 approach is used. The method follows the approaches as in chapters 7.3.4 and 7.4.4 with the country specific biomass data for settlements as described in chapter 7.6.4.1.1. The perennial plants in the settlement areas are estimated with a continued annual growth during the whole LUC transition period of 20 years as described in chapter 7.6.4.1.1.

The annual emission rates due to loss of biomass on settlement area ranges from 0.68 to 0.75 Gg CO_2 in the years 1990 - 2009.

Changes in carbon stocks in soil of grassland converted to settlement

For the calculation of the annual change in carbon stocks of soils in grassland converted to settlement the IPCC Tier 2 approach is used. The method follows the approaches as in Chapters 7.3.4 and 7.4.4 with a soil C stock for settlements as described in chapter 7.6.4.1.2.

The annual emission rate due to loss of soil carbon in soils ranges from 15.1 to 13.7 Gg CO_2 in the years 1990 - 2009.

7.6.4.2.6 Wetland converted to Settlement (5.E.2.4)

The area in conversion status from wetland to settlement for a time period of 20 years ranges from 164 to 105 ha in the years 1990 - 2009 resulting in annual removal rates due to C stock changes of biomass and soils from 1.25 Gg CO_2 to 0.83 Gg CO_2.

Changes in carbon stocks in biomass of wetland converted to settlement

For the calculation of the annual change in carbon stocks of living biomass in grassland converted to settlement the IPCC Tier 2 approach is used. The method follows the approaches as in chapter 7.5.4 with the country specific biomass data for settlements as described in chapter 7.6.4.1.1. The perennial plants in the settlement areas are estimated with a continued annual growth during the whole LUC transition period of 20 years as described in chapter 7.6.4.1.1.

The annual removal rates due to increase of biomass on settlement area ranges from 0.04 to 0.02 Gg CO_2 in the years 1990 - 2009.

Changes in carbon stocks in soil of wetland converted to settlement

For the calculation of the annual change in carbon stocks of soils in grassland converted to settlement the IPCC Tier 2 approach is used. The method follows the approaches as in chapter 7.5.4 with a soil C stock for settlements as described in chapter 7.6.4.1.2.

The annual emission rate due to loss of soil carbon in soils ranges from 0.30 to 0.19 Gg CO_2 in the years 1990 - 2009.

7.6.4.2.7 Other land converted to Settlement (5.E.2.5)

The area in conversion status from other land to settlement for a time period of 20 years ranges from 811 to 56 ha in the years 1990 - 2009 resulting in annual removals due to C stock changes of biomass and soils from 0.83 Gg CO_2 to 0.46 Gg CO_2.

Changes in carbon stocks in biomass of other land converted to settlement

For the calculation of the annual change in carbon stocks of living biomass in grassland converted to settlement the IPCC Tier 2 approach is used. The method follows the approaches as in chapters 7.3.4 and 7.4.4 with country specific biomass data for settlements as given in chapter 7.6.4.1.1 and country specific biomasses for other land as described in chapter 7.7.4.2.1.

The annual removal rates due to increase of biomass on settlement area ranges from 0.02 to 0.01 Gg CO_2 in the years 1990 - 2009.

Changes in carbon stocks in soil of other land converted to settlement

For the calculation of the annual change in carbon stocks of soils in grassland converted to settlement the IPCC Tier 2 approach is used. The method follows the approaches as in Chapters 7.3.4. and 7.4.4 with a soil C stock for settlements as described in chapter 7.6.4.1.2 and country specific soil C pools for other land as described in chapter 7.7.4.2.1.

The annual removal rates due to increase of soil carbon in soils ranges from 0.20 and 0.10 Gg CO_2 in the years 1990 - 2009.

7.7 Other Land (5F)

7.7.1 Category description

In this category emissions/removals from land converted to other land are considered.

In 2009, 56 ha of Luxembourg were considered as other land (Figure 7-9). The area in conversion status from "Land converted to Other Land" for a time period of 20 years ranges from 56 ha to 31 ha between the years 1990 and 2009 causing annual emission rates due to C stock changes of biomass and soils from 1.4 Gg CO_2 to 0.5 Gg CO_2 (Table 7-17).

Annual LUCs to other land occur from the sub-categories "Forest Land", "Cropland", "Grassland", "Settlements" and "Other land".

Figure 7-9 – Trend of wetland and LUC to Other Land (covering a conversion period of 20 years) from 1990-2009

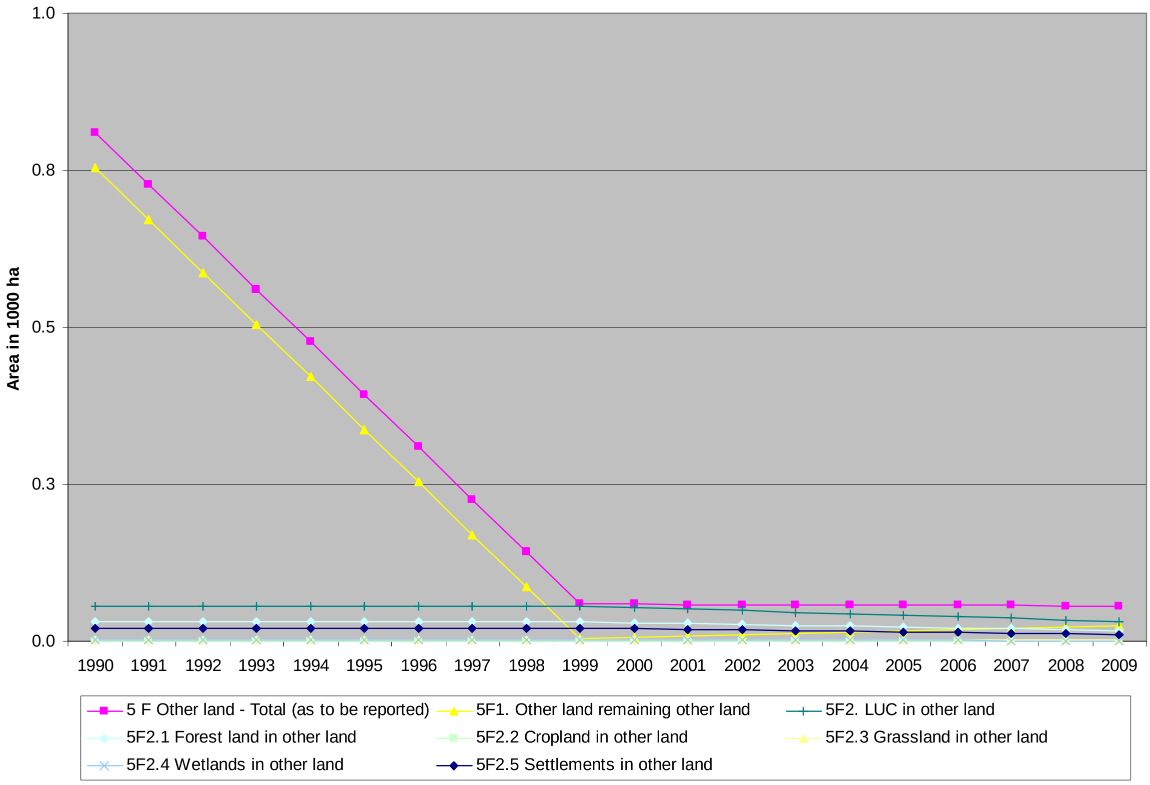


Table 7-17– CO_2 removals/emissions from IPCC category 5F – Other land from 1990-2009

Year	5F Total Other land	5F1 OL remaining OL	5F2 Land converted to OL	5F2.1 Forestland converted to OL	5F2.2 Cropland converted to OL	5F2.3 Grassland converted to OL	5F2.4Wetland converted to OL	5F2.5 Settlement converted to OL
	5F - Other land *Greenhouse gas emissions/removals (Gg CO 2 e)*							
1990	1.40	NE	1.40	1.19	0.01	0.03	NO	0.16
1991	1.40	NE	1.40	1.19	0.01	0.03	NO	0.16
1992	1.40	NE	1.40	1.19	0.01	0.03	NO	0.16
1993	1.40	NE	1.40	1.19	0.01	0.03	NO	0.16
1994	1.40	NE	1.40	1.19	0.01	0.03	NO	0.16
1995	1.40	NE	1.40	1.19	0.01	0.03	NO	0.16
1996	1.40	NE	1.40	1.19	0.01	0.03	NO	0.16
1997	1.40	NE	1.40	1.19	0.01	0.03	NO	0.16
1998	1.40	NE	1.40	1.19	0.01	0.03	NO	0.16
1999	1.40	NE	1.40	1.19	0.01	0.03	NO	0.16
2000	0.72	NE	0.72	0.54	0.01	0.03	NO	0.14
2001	0.69	NE	0.69	0.52	0.01	0.03	NO	0.13
2002	0.66	NE	0.66	0.50	0.01	0.03	NO	0.13
2003	0.64	NE	0.64	0.48	0.01	0.03	NO	0.12
2004	0.61	NE	0.61	0.46	0.01	0.03	NO	0.11
2005	0.58	NE	0.58	0.44	0.01	0.03	NO	0.11
2006	0.55	NE	0.55	0.42	0.01	0.03	NO	0.10
2007	0.52	NE	0.52	0.40	0.01	0.03	NO	0.09
2008	0.49	NE	0.49	0.37	0.01	0.03	NO	0.08
2009	0.49	NE	0.49	0.37	0.01	0.03	NO	0.08
Trend 1990-2009	-64.70%	NA	-64.70%	-68.65%	-14.58%	-17.16%	NA	-47.61%
Trend 2008-2009	0.00%	NA	-5.48%	-5.34%	-1.97%	-1.94%	NA	-7.42%

7.7.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

For a detailed description of the development of the land transition matrix, please refer to section 7.1.3.3.

7.7.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

The OBS89, OBS99 and OBS07 land use maps are the main data providers for the greenhouse gas reporting of IPCC category other land. The selected parameters defining other land are:

Land Use Class	Definition
Other land	This category includes bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.

The other land area in correspondence to the LULUCF category comprises the following subcategories:

- Rocks and screes
- Land with no vegetation,
- Abandoned quarries.

7.7.4 Methodological issues

7.7.4.1 Other Land remaining Other Land (5F1)

Due to a lack of data, this category has not yet been estimated.

7.7.4.2 Land Use Changes to Other Land (5F2)

7.7.4.2.1 Biomass and soil

According to the land use assessment systems OBS89, OBS99 and OBS07, other land in Luxembourg is constituted by rocks, scree slopes and gravel areas. It is assumed that these areas have no C stock in biomass and soil, so 0 was used as previous or final C stock at areas of LUCs from or to other land, respectively.

7.7.4.2.2 Methodology

Please refer to the chapters 7.3 to 7.6 for methodological and C stock change parameters for the relevant sub-categories.

7.8 Uncertainties and time-series consistency

No uncertainty analysis has been performed yet on Sector 5. This is a planned improvement for the next submission.

7.9 Category-specific QA/QC and verification

The calculations of the data for category 5 are embedded in the overall QA/QC-system of the GHG inventory (see Chapter 1.6) of which important elements include:

- ✓ Are the correct values used (check for transcription errors, …)?
- ✓ Check of plausibility of input data (time-series, order of magnitude, …)
- ✓ Is the data set complete for the whole time series?
- ✓ Check of calculations, units ...
- ✓ Check of plausibility of results (time-series, order of magnitude, …)
- ✓ Correct transformation/transcription into CRF
- ✓ Where possible, data is checked with data from other sources, order of magnitude checks, …
- ✓ Are all references clearly made?
- ✓ Are all assumptions documented?

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

7.10 Category-specific recalculations

Table 7-18 presents the main revisions and recalculations done since submission 2010v2.1 relevant to CRF Sector 5.

Table 7-18 – Changes in GHG inventories: submissions 2010v2.1 and 2011v1.3

GHG source & sink category	Revisions 2009v1.4 ➔ 2010v1.2	Type of revision
5	no recalculations	NA

7.11 Category-specific 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 7-19 will be explored.

Table 7-19 – Planned improvements for IPCC Sector 5 – LULUCF

GHG source & sink category	Planned improvement
5E	investigate whether the level of sealing of settlement areas, which is now based on expert judgement, could be updated using data from the European Urban Atlas project.
5A-5F	perform T1 and T2 uncertainty analysis.

8 Waste (CRF Sector 6)

8.1 Sector Overview

This chapter 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 2009.

Emissions from this sector comprise emissions for the main three 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 2009 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 **Error! Reference source not found.**, that provide a quick overview on waste and wastewater handling related emission trends between 1990 and 2009 and Figure 8-2 depicting the shares of each IPCC Category under CRF Sector 6 for both the years 1990 and 2009 – total waste related GHG emissions have decreased by 25% from 1990 to 2009 and by 5.4% between 2008 and 2009. This evolution was mainly driven by the fact that, for IPCC Category *6A – Solid Waste Disposal on Land*, emissions have been reduced by 50% between 1990 and 2009 due to:

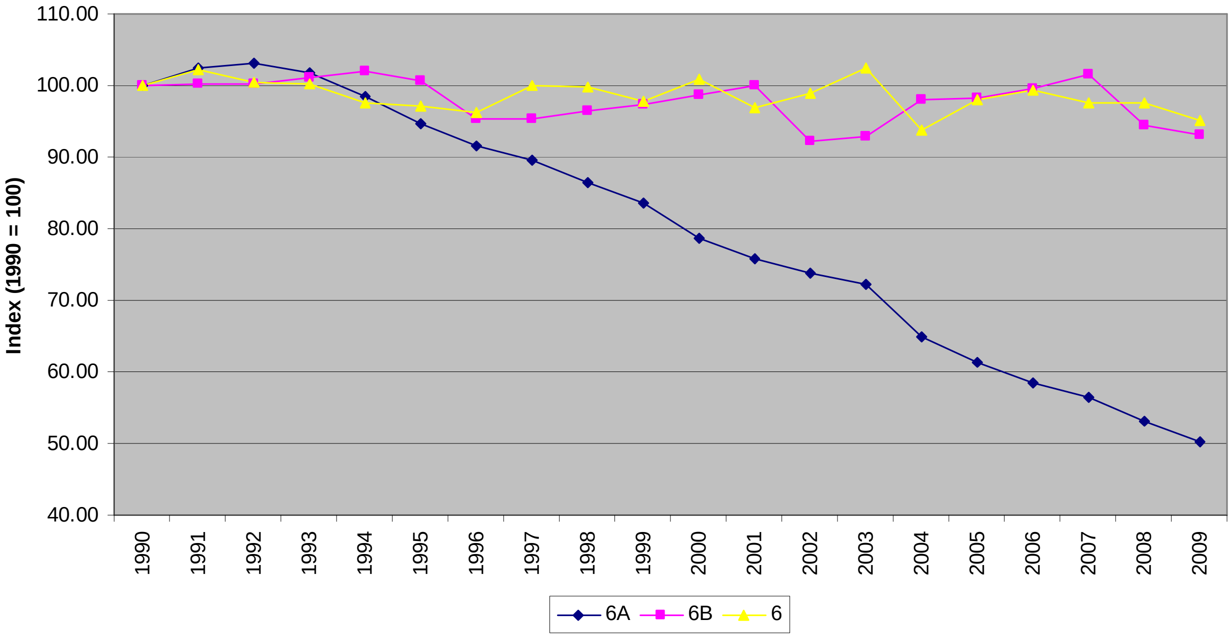
- a decrease in the quantity of waste being landfilled, notably through the development of recycling schemes and the expansion of both the numbers of and the various waste categories collected by recycling centres;
- the aerobic pre-treatment before landfilling;
- the recent installation of methane recovery systems at waste dumping sites.

For IPCC category *6B – Wastewater Handling*, emissions decreased by 6.9% in 2009 compared to the base year (1990) and by 1.5% when compared to 2008. 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 80% (Table 8-10) over the period 1990 to 2009[156], whereas nitrous oxide emissions, as shown in Table 8-1, increased by 20%. Therefore, technical changes, with regard to wastewater treatment, have an unquestionable role too, as the evolution of methane emissions (-49%) demonstrates.

For category *6D – Other – Compost Production*, unlike IPCC Category 6A, an increase of emissions is recorded for the years 1990 to 2009. With regard to compost production, this activity started on an "industrial scale" only in the early 1990s. This accelerated development, from 1993-2003[157] 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 – indexes – for CRF Sector 6 – Waste: 1990-2009



[156] This increase is notably explained by the significant population growth between 1990 and 2009 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.

[157] It stabilized since 2003 (see Section 8.5.2).

Table 8-1 - GHG emission trends in CO_2 eq for CRF Sector 6 – Waste: 1990-2009

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	74.59	*NA,NO*	*74.59*	*NA*	15.47	*NA*	*6.13*	*9.34*	0.00	*NO*	*NO*	*NO*	90.06	*NA,NO*	*80.73*	*9.34*
1991	76.49	*NA,NO*	*76.49*	*NA*	15.49	*NA*	*5.98*	*9.51*	0.00	*NO*	*NO*	*NO*	91.98	*NA,NO*	*82.47*	*9.51*
1992	76.91	*NA,NO*	*76.91*	*NA*	15.52	*NA*	*5.83*	*9.69*	0.00	*NO*	*NO*	*NO*	92.43	*NA,NO*	*82.74*	*9.69*
1993	75.94	*NA,NO*	*75.94*	*NA*	15.64	*NA*	*5.67*	*9.97*	1.03	*NO*	*0.49*	*0.54*	92.61	*NA,NO*	*82.11*	*10.51*
1994	73.40	*NA,NO*	*73.40*	*NA*	15.77	*NA*	*5.52*	*10.25*	1.19	*NO*	*0.57*	*0.63*	90.36	*NA,NO*	*79.49*	*10.88*
1995	70.66	*NA,NO*	*70.66*	*NA*	15.58	*NA*	*5.37*	*10.21*	1.49	*NO*	*0.71*	*0.78*	87.73	*NA,NO*	*76.74*	*10.99*
1996	68.33	*NA,NO*	*68.33*	*NA*	14.76	*NA*	*5.18*	*9.57*	1.30	*NO*	*0.62*	*0.68*	84.39	*NA,NO*	*74.13*	*10.26*
1997	66.72	*NA,NO*	*66.72*	*NA*	14.76	*NA*	*5.00*	*9.76*	2.85	*NO*	*1.35*	*1.50*	84.32	*NA,NO*	*73.07*	*11.25*
1998	64.47	*NA,NO*	*64.47*	*NA*	14.92	*NA*	*4.81*	*10.11*	4.72	*NO*	*2.24*	*2.48*	84.12	*NA,NO*	*71.52*	*12.59*
1999	62.37	*NA,NO*	*62.37*	*NA*	15.04	*NA*	*4.62*	*10.42*	4.91	*NO*	*2.33*	*2.58*	82.32	*NA,NO*	*69.32*	*13.00*
2000	58.67	*NA,NO*	*58.67*	*NA*	15.28	*NA*	*4.44*	*10.84*	9.11	*NO*	*4.46*	*4.64*	83.05	*NA,NO*	*67.57*	*15.48*
2001	56.52	*NA,NO*	*56.52*	*NA*	15.48	*NA*	*4.31*	*11.17*	8.50	*NO*	*4.17*	*4.33*	80.51	*NA,NO*	*65.01*	*15.50*
2002	55.01	*NA,NO*	*55.01*	*NA*	14.28	*NA*	*4.18*	*10.10*	10.32	*NO*	*5.10*	*5.23*	79.61	*NA,NO*	*64.29*	*15.33*
2003	53.94	*NA,NO*	*53.94*	*NA*	14.38	*NA*	*4.06*	*10.33*	13.19	*NO*	*6.47*	*6.72*	81.52	*NA,NO*	*64.47*	*17.05*
2004	48.33	*NA,NO*	*48.33*	*NA*	15.15	*NA*	*3.93*	*11.22*	12.88	*NO*	*6.32*	*6.56*	76.36	*NA,NO*	*58.58*	*17.78*
2005	45.83	*NA,NO*	*45.83*	*NA*	15.20	*NA*	*3.78*	*11.42*	13.75	*NO*	*6.75*	*7.00*	74.78	*NA,NO*	*56.35*	*18.42*
2006	43.52	*NA,NO*	*43.52*	*NA*	15.40	*NA*	*3.72*	*11.69*	15.44	*NO*	*7.62*	*7.82*	74.36	*NA,NO*	*54.86*	*19.50*
2007	42.10	*NA,NO*	*42.10*	*NA*	15.70	*NA*	*3.70*	*12.00*	14.68	*NO*	*7.21*	*7.47*	72.47	*NA,NO*	*53.01*	*19.47*
2008	39.63	*NA,NO*	*39.63*	*NA*	14.62	*NA*	*3.45*	*11.17*	16.38	*NO*	*8.10*	*8.28*	70.63	*NA,NO*	*51.18*	*19.45*
2009	37.51	*NA,NO*	*37.51*	*NA*	14.40	*NA*	*3.15*	*11.25*	15.20	*NO*	*7.43*	*7.77*	67.10	*NA,NO*	*48.09*	*19.02*
Trend 1990-2009	*-49.72%*	*NA*	*-49.72%*	*NA*	*-6.92%*	*NA*	*-48.60%*	*20.47%*	*NA*	*NA*	*NA*	*NA*	*-25.49%*	*NA*	*-40.43%*	*103.67%*
Trend 2008-2009	*-5.37%*	*NA*	*-5.37%*	*NA*	*-1.50%*	*NA*	*-8.53%*	*0.67%*	*-7.22%*	*NA*	*-8.26%*	*-6.20%*	*-5.00%*	*NA*	*-6.04%*	*-2.26%*

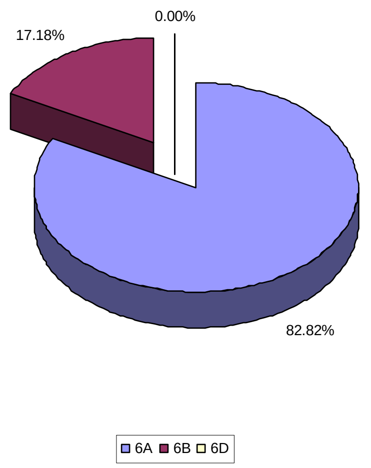
Source: Environment Agency

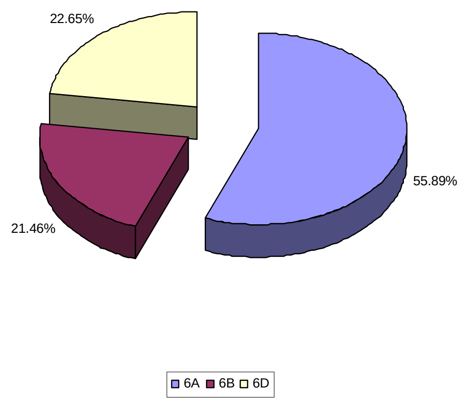
Notes: CH_4 emissions are converted in CO_2e by multiplying the emissions by 21, i.e. the global warming potential (*GWP*) value for methane based on the effects of GHG over a 100-year time horizon.

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 – IPCC Categories weights for CRF Sector 6 – Waste: 1990 and 2009

<u>*1990*</u> <u>*2009*</u>





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 (1993-2009)	NO (1990-1992) X (1993-2009)

<u>Note:</u> **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.

8.2 Solid Waste Disposal on Land (6A)

8.2.1 Source category description

This section describes GHG emissions resulting from solid waste disposal on land, which, in Luxembourg, only originate from managed waste disposal sites. There are no unmanaged waste disposal sites. Hence, IPCC Sub-Category *6A – Solid Waste Disposal on Land* = IPCC Sub-category *6A1 – Managed Waste Disposal on Land*.

In 2009, this source category was responsible for 78% of waste treatment methane related emissions – excluding waste incineration – and for 11% of the total methane emissions estimated for Luxembourg (17% in 1990). It represented 0.4% of the total GHG emissions (excluding LULUCF) (0.6% 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. Neither CO_2, nor N_2O emissions are occurring in this category. Table 8-3 details methane emissions generated by each of the solid waste disposal sites, as well as the implied emission factor.

The source category *6A1 – Managed Waste Disposal on Land* has been identified as a key category for CH_4 for the period 1990-2003 (level assessment excluding LULUCF).

Table 8-3- CH4 emissions from 6A1 - Managed Waste Disposal on Land (1990-2009)

6A - Solid Waste Disposal on Land								
	MSW deposited	*CH_4 - Emissions*				*CH_4 - Recovery*		
Year	Total Gg	Total *Gg*	SIDEC, SIGRE, SIDA *tonnes*	Ronnebierg *tonnes*	IEF *kg/t MSW*	Total *Gg*	SIDEC, SIGRE, SIDA *tonnes*	Ronnebierg *tonnes*
1990	87.24	3.552	*3 552*	*NE*	*40.531*	NO	*0.000*	*NO*
1991	73.76	3.642	*3 642*	*NE*	*48.862*	NO	*0.000*	*NO*
1992	52.91	3.662	*3 662*	*NE*	*68.238*	NO	*0.000*	*NO*
1993	42.74	3.616	*3 616*	*NE*	*54.769*	NO	*0.000*	*NO*
1994	41.72	3.495	*3 495*	*NE*	*54.548*	NO	*0.000*	*NO*
1995	44.30	3.365	*3 365*	*NE*	*49.001*	NO	*0.000*	*NO*
1996	61.82	3.254	*3 254*	*NE*	*34.593*	NO	*0.000*	*NO*
1997	49.71	3.177	*3 177*	*NE*	*41.251*	NO	*0.000*	*NO*
1998	48.77	3.070	*3 070*	*NE*	*40.536*	NO	*0.000*	*NO*
1999	43.36	2.970	*2 970*	*NE*	*44.251*	NO	*0.000*	*NO*
2000	39.89	2.794	*2 720*	*74*	*45.259*	0.153	*152.711*	*NO*
2001	41.60	2.692	*2 632*	*59*	*41.334*	0.153	*152.711*	*NO*
2002	42.22	2.619	*2 575*	*44*	*39.716*	0.135	*135.013*	*NO*
2003	43.56	2.569	*2 536*	*33*	*38.152*	0.102	*101.636*	*NO*
2004	37.13	2.301	*2 271*	*30*	*38.706*	0.302	*302.381*	*NO*
2005	46.13	2.182	*2 151*	*31*	*29.817*	0.312	*311.705*	*NO*
2006	40.84	2.072	*2 042*	*31*	*32.112*	0.344	*344.385*	*NO*
2007	32.59	2.005	*1 985*	*19*	*38.351*	0.321	*321.321*	*NO*
2008	32.08	1.887	*1 875*	*12*	*36.420*	0.309	*308.896*	*NO*
2009	29.27	1.786	*1 778*	*8*	*37.127*	0.271	*270.518*	*NO*
Trend 1990-2009	*-66.45%*	*-49.72%*	*-49.94%*	*NA*	*-8.40%*	*NA*	*NA*	*NA*

Source: Environment Agency

Note: The amount of MSW deposited is the amount of MSW containing degradable organic carbon and thus excludes inert waste such as

8.2.2 Methodological issues

8.2.2.1 Luxembourg's waste collection system

IPCC Category 6A covers waste disposal on land – or landfilled waste – whether generated by households or enterprises. Luxembourg's GHG inventory covers all waste disposals 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.[158]

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 deposited, exist.

In Luxembourg, the collection of municipal waste falls within the competence of municipalities which joined to municipal waste management associations. These associations are:

- SIDEC[159] = association for the management of household and similar to household waste for the municipalities of the regions Diekirch, Ettelbruck and Colmar-Berg;
- SIDOR[160] = association for the management of household and similar to household waste for the municipalities of the districts Luxembourg, Esch-sur-Alzette and Capellen;
- SIGRE[161] = association for the management of household and similar to household waste for the municipalities of the regions Grevenmacher, Remich and Echternach;
- SIDA[162] = 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,

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158 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).

159 *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*.

160 *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*.

161 *Syndicat Intercommunal pour la collecte, l'évacuation et l'élimination des ordures provenant des communes de la région de Grevenmacher, Remich et Echternach*.

162 *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*.

there are two controlled landfill sites (one managed by SIDEC and one managed by SIGRE) and 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.

Before these managed waste dumping sites were installed, the waste was dumped to local unmanaged dumping sites within the municipalities. The controlled landfill of SIDEC opened in 1972, the landfill of SIGRE in 1979.

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	1972-2009
SIDOR	incineration	1976-2009
SIGRE	landfill	1979-2009
SIDA	landfill	till 1993

Source: Environment Agency.

To summarize:

- IPCC Category 6A covers methane emissions from waste disposal on land. No CO_2 emissions derived from non-biological or inorganic waste sources have been identified so far;
- only uncategorised waste disposal on land is relevant for Luxembourg. There are no unmanaged or other waste disposal sites any more (➔ 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 2009 .[163]

8.2.2.2 Data origin

Waste disposal is organized via three regional disposal districts, which originally have been formed due to hygienic considerations (see also section 8.2.2.1). The southern district (SIDOR) operates a waste incinerator (MWI), which is considered in the "energy" section. About two thirds of

163 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).

Luxembourg's waste is 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 gas started in 2002 (flaring) and 2000 (electricity and heat plant), respectively.

Amounts of waste have originally been estimated by volume only, but since the 1990's waste is systematically weighted. Waste fractions have been analysed in specific campaigns (mid-1990's, mid-2000's, 2009/2010 and around 2000 and 2009 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. The composition of the combustible fraction taken off the SIDEC waste and delivered to the MWI was analysed in 2009. This fraction having a higher C content than the average waste, was taken into account for the calculation at the MWI.

Recovered CH_4, as determined from monthly reports of the landfill operators (measured quantities) is subtracted from the estimated emissions.

8.2.2.3 Methodology

The spreadsheet implementing the Tier 1 methodolgy from the 2006 IPCC Guidelines for national greenhouse gas inventories has been used. Following the recommendations of the in-country review of 2008 and the centralized review of 2009[164], the calculation was made since 1950 and also taking into account the pre-treatment of waste before landfilling. In 2009, the Environment Agency conducted two studies : 1) Composition of the high caloric fraction from SIDEC and 2) Emissions of the waste deposited at the MSW landfills. In 2011 the study "Emissions of the waste deposited at the MSW landfills" was refined for the period 2004-2007, calculated for the years 2008 and 2009 and extrapolated for the years 2010 to 2030

8.2.2.4 Parameters

Table 8-5 gives an overview of the parameters used for the estimation of emissions from solid waste disposal on land. Only default values were used as no country specific values are available.

[164] ARR 2009, § 106.

Table 8-5– Parameters used for the calculation of emissions from CRF category 6A

	IPCC default value		Country-specific parameters	
			Value	Reference and remarks
Starting year		1950	1950	
DOC (Degradable organic carbon)	Waste by composition			
(weight fraction, wet basis)	**Range**	**Default**		
Food waste	0.08-0.20	0.15	0.15	
Garden	0.18-0.22	0.2	0.2	
Paper	0.36-0.45	0.4	0.4	
Wood and straw	0.39-0.46	0.43	0.43	
Textiles	0.20-0.40	0.24	0.24	
Disposable nappies	0.18-0.32	0.24	0.24	
Sewage sludge	0.04-0.05	0.05	0.05	
Industrial waste	0-0.54	0.15	0.15	
DOCf (fraction of DOC dissimilated)		0.5	0.5	
Methane generation rate constant (k)	Wet temperate			
(years^{-1})	**Range**	**Default**		
Food waste	0.1–0.2	0.185	0.185	
Garden	0.06–0.1	0.1	0.1	
Paper	0.05–0.07	0.06	0.06	
Wood and straw	0.02–0.04	0.03	0.03	
Textiles	0.05–0.07	0.06	0.06	
Disposable nappies	0.06–0.1	0.1	0.1	
Sewage sludge	0.1–0.2	0.185	0.185	
Industrial waste	0.08–0.1	0.09	0.09	
Delay time (months)		6	6	
Fraction of methane (F) in developed gas		0.5	0.5	
Conversion factor, C to CH_4		1.33	1.33	
Oxidation factor (OX)		0	0	
Parameters for carbon storage				
% paper in industrial waste		0%	0%	
% wood in industrial waste		0%	0%	

Note: if parameters shown in column "country specific values" are identical to the IPCC default values, this means that the IPCC default value was used.

8.2.2.5 Methane Correction Factor (MCF)

From 1950 to 1971 municipal waste was deposited to unmanaged local landfills. Due to a lack of information it was assumed that 50% were brought to unmanaged shallow and 50% to unmanaged deep landfills. In 1972 the controlled landfill of SIDEC was installed and more and more municipalities joined the SIDEC. In 1979 the controlled landfill of SIGRE was installed and more and more municipalities joined the SIGRE. These two landfills had an impact in time on the MCF. In 1993 SIGRE started with a cold pre-treatment of waste under aerobic conditions. Since 2007 the mechano-biological pre-treatment at SIDEC is fully operational. 100% of municipal and bulky waste is since then pre-treated before landfilling. Since then the MCF for uncategorised landfills is applicable. For an overview of the evolution, see Table 8-6.

Table 8-6– Methane correction factors and waste distribution by waste management type

	MSW					
	Un-managed, shallow	Un-managed, deep	Managed	Managed, semi-aerobic	Uncate-gorised	Distri-bution Check
	MCF	MCF	MCF	MCF	MCF	
IPCC default	0.4	0.8	1	0.5	0.6	
Country-specific value	0.4	0.8	1	0.5	0.1	
	Distribution of Waste by Waste Management Type					
"Fixed" Country-specifc value	25%	30%	25%	5%	15%	Total
Year	%	%	%	%	%	(100%)
1950	50%	50%	0%	0%	0%	100%
1951	50%	50%	0%	0%	0%	100%
1952	50%	50%	0%	0%	0%	100%
1953	50%	50%	0%	0%	0%	100%
1954	50%	50%	0%	0%	0%	100%
1955	50%	50%	0%	0%	0%	100%
1956	50%	50%	0%	0%	0%	100%
1957	50%	50%	0%	0%	0%	100%
1958	50%	50%	0%	0%	0%	100%
1959	50%	50%	0%	0%	0%	100%
1960	50%	50%	0%	0%	0%	100%
1961	50%	50%	0%	0%	0%	100%
1962	50%	50%	0%	0%	0%	100%
1963	50%	50%	0%	0%	0%	100%
1964	50%	50%	0%	0%	0%	100%
1965	50%	50%	0%	0%	0%	100%
1966	50%	50%	0%	0%	0%	100%
1967	50%	50%	0%	0%	0%	100%
1968	50%	50%	0%	0%	0%	100%
1969	50%	50%	0%	0%	0%	100%
1970	50%	50%	0%	0%	0%	100%
1971	50%	50%	0%	0%	0%	100%
1972	45%	45%	10%	0%	0%	100%
1973	40%	40%	20%	0%	0%	100%
1974	40%	40%	20%	0%	0%	100%
1975	40%	40%	20%	0%	0%	100%
1976	40%	40%	20%	0%	0%	100%
1977	40%	40%	20%	0%	0%	100%
1978	40%	40%	20%	0%	0%	100%
1979	10%	10%	80%	0%	0%	100%
1980	10%	10%	80%	0%	0%	100%
1981	10%	10%	80%	0%	0%	100%
1982	10%	10%	80%	0%	0%	100%
1983	10%	10%	80%	0%	0%	100%
1984	10%	10%	80%	0%	0%	100%
1985	10%	10%	80%	0%	0%	100%
1986	10%	10%	80%	0%	0%	100%
1987	10%	10%	80%	0%	0%	100%
1988	10%	10%	80%	0%	0%	100%
1989	10%	10%	80%	0%	0%	100%
1990	10%	10%	80%	0%	0%	100%
1991	10%	10%	80%	0%	0%	100%
1992	10%	10%	80%	0%	0%	100%
1993	0%	0%	79%	0%	21%	100%
1994	0%	0%	71%	0%	29%	100%
1995	0%	0%	69%	0%	31%	100%
1996	0%	0%	54%	0%	46%	100%
1997	0%	0%	55%	0%	45%	100%
1998	0%	0%	55%	0%	45%	100%
1999	0%	0%	60%	0%	40%	100%
2000	0%	0%	67%	0%	33%	100%
2001	0%	0%	66%	0%	34%	100%
2002	0%	0%	63%	0%	37%	100%
2003	0%	0%	62%	0%	38%	100%
2004	0%	0%	58%	0%	42%	100%
2005	0%	0%	56%	0%	44%	100%
2006	0%	0%	53%	0%	47%	100%
2007	0%	0%	39%	0%	61%	100%
2008	0%	0%	17%	0%	83%	100%
2009	0%	0%	15%	0%	85%	100%

Note: if parameters shown as "country specific values" are identical to the IPCC default values, this means that the IPCC default value was used.

8.2.2.6 Activity data

Activity data were calculated in accordance to the MSW produced per capita/year. Data on the population are from STATEC.

No national data on municipal waste production from 1950 to 1989 were available. Data from Germany for the years 1950 and 1975 were used. Data in-between were interpolated. Data for Luxembourg for the year 1990 were available (581 kg) which were nearly identical to the IPPC default values (560 kg). Data up to the year 2009 were from the Environment Agency taking into account the effect of aerobic decomposition at SIGRE since 1993 and at SIDEC since 2007.

Municipal waste was completely landfilled till 1975. In 1976 the incinerator of SIDOR opened and waste incinerated was subtracted in accordance of the population living in the SIDOR municipalities. Data from 1990 to 2009 were data from the Environment Protection Agency taking into account the effect of aerobic decomposition.

Waste composition is exactly known since 1992. The data from the national waste composition analyse 1992/94 were used till 2003. For the years 2004 to 2009 the data from the 2011 study were used taking into account the aerobic pre-treatment before landfilling. For the years before 1992 no data are available. Luxembourg oriented its values near the IPPC default values but some changes were made: 1950-1974 it is assumed that the fractions "food", "paper" and "wood" landfilled were lower. The difference was allocated to the fraction "plastics, other inert" waste.

1975-1991 adaptations for the fraction "food" were made in accordance to the IPPC default values. One-way nappies appeared in the 1970 and were allocated to the waste composition.

An overview of the waste composition trends is given in Table 8-7.

Table 8-7– Waste composition (1990-2009)

					Composition of waste going to solid waste disposal sites							
Year	Population	Waste per capita	Total MSW	% to SWDS	Food	Garden	Paper	Wood	Textile	Nappies	Plastics, other inert	Total
	millions	kg/cap/yr	Gg	%	%	%	%	%	%	%	%	(=100%)
1950	0.292	200	58.4000	100%	20%	0%	25%	5%	0%	0%	50%	100%
1951	0.294	205	60.2700	100%	20%	0%	25%	5%	0%	0%	50%	100%
1952	0.295	210	61.9500	100%	20%	0%	25%	5%	0%	0%	50%	100%
1953	0.297	220	65.3400	100%	20%	0%	25%	5%	0%	0%	50%	100%
1954	0.299	235	70.2650	100%	20%	0%	25%	5%	0%	0%	50%	100%
1955	0.301	250	75.2500	100%	20%	0%	25%	5%	0%	0%	50%	100%
1956	0.303	260	78.7800	100%	20%	0%	25%	5%	0%	0%	50%	100%
1957	0.305	270	82.3500	100%	20%	0%	25%	5%	0%	0%	50%	100%
1958	0.308	280	86.2400	100%	20%	0%	25%	5%	0%	0%	50%	100%
1959	0.310	290	89.9000	100%	20%	0%	25%	5%	0%	0%	50%	100%
1960	0.312	300	93.6000	100%	20%	0%	25%	5%	0%	0%	50%	100%
1961	0.315	305	96.0411	100%	20%	0%	25%	5%	0%	0%	50%	100%
1962	0.318	310	98.5800	100%	20%	0%	25%	5%	0%	0%	50%	100%
1963	0.321	315	101.1150	100%	20%	0%	25%	5%	0%	0%	50%	100%
1964	0.324	320	103.6800	100%	20%	0%	25%	5%	0%	0%	50%	100%
1965	0.327	330	107.9100	100%	20%	0%	25%	5%	0%	0%	50%	100%
1966	0.331	335	110.8850	100%	20%	0%	25%	5%	0%	0%	50%	100%
1967	0.335	340	113.8286	100%	20%	0%	25%	5%	0%	0%	50%	100%
1968	0.335	350	117.2500	100%	20%	0%	25%	5%	0%	0%	50%	100%
1969	0.336	355	119.2800	100%	20%	0%	25%	5%	0%	0%	50%	100%
1970	0.338	360	121.6800	100%	20%	0%	25%	5%	0%	0%	50%	100%
1971	0.340	365	124.0420	100%	20%	0%	25%	5%	0%	0%	50%	100%
1972	0.344	370	127.2800	100%	20%	0%	25%	5%	0%	0%	50%	100%
1973	0.346	375	129.7500	100%	20%	0%	25%	5%	0%	0%	50%	100%
1974	0.353	380	132.2400	100%	20%	0%	25%	5%	0%	0%	50%	100%
1975	0.357	385	134.3650	100%	24%	1%	25%	11%	1%	1%	37%	100%
1976	0.361	395	138.6450	40%	24%	1%	25%	11%	1%	1%	37%	100%
1977	0.361	405	143.3700	40%	24%	1%	25%	11%	1%	1%	37%	100%
1978	0.362	415	148.5700	40%	24%	1%	25%	11%	1%	1%	37%	100%
1979	0.362	420	151.6200	40%	24%	1%	25%	11%	1%	1%	37%	100%
1980	0.364	440	159.7200	40%	24%	1%	25%	11%	1%	1%	37%	100%
1981	0.365	460	167.4400	40%	24%	1%	24%	11%	1%	2%	37%	100%
1982	0.366	480	175.6800	40%	24%	1%	24%	11%	1%	2%	37%	100%
1983	0.365	495	182.1600	40%	24%	1%	24%	11%	1%	2%	37%	100%
1984	0.366	510	188.1900	40%	24%	1%	24%	11%	1%	2%	37%	100%
1985	0.366	520	192.9200	40%	29%	4%	20%	11%	1%	2%	33%	100%
1986	0.367	530	197.1600	40%	29%	4%	20%	11%	1%	2%	33%	100%
1987	0.369	550	205.1500	40%	29%	4%	20%	11%	1%	2%	33%	100%
1988	0.372	560	212.2400	40%	29%	4%	20%	11%	1%	2%	33%	100%
1989	0.376	570	218.3100	40%	29%	4%	20%	11%	1%	2%	33%	100%
1990	0.379	581	223.6850	39%	29%	4%	20%	11%	1%	2%	33%	100%
1991	0.384	562	216.9320	34%	29%	4%	20%	11%	1%	2%	33%	100%
1992	0.390	503	195.9688	27%	39%	8%	16%	1%	1%	5%	30%	100%
1993	0.395	451	178.0716	24%	39%	8%	16%	1%	1%	5%	30%	100%
1994	0.400	434	173.8257	24%	39%	8%	16%	1%	1%	5%	30%	100%
1995	0.406	420	170.3855	26%	39%	8%	16%	1%	1%	5%	30%	100%
1996	0.412	385	158.5226	39%	39%	8%	16%	1%	1%	5%	30%	100%
1997	0.417	397	165.6969	30%	39%	8%	16%	1%	1%	5%	30%	100%
1998	0.422	385	162.5595	30%	39%	8%	16%	1%	1%	5%	30%	100%
1999	0.427	406	173.4377	25%	39%	8%	16%	1%	1%	5%	30%	100%
2000	0.434	383	166.2248	24%	39%	8%	16%	1%	1%	5%	30%	100%
2001	0.439	379	166.3934	25%	39%	8%	16%	1%	1%	5%	30%	100%
2002	0.444	380	168.8846	25%	39%	8%	16%	1%	1%	5%	30%	100%
2003	0.448	374	167.5418	26%	39%	8%	16%	1%	1%	5%	30%	100%
2004	0.455	376	170.9444	22%	22%	6%	18%	17%	3%	2%	32%	100%
2005	0.461	366	168.8481	27%	22%	5%	18%	16%	3%	2%	34%	100%
2006	0.469	363	170.1495	24%	28%	6%	19%	8%	2%	2%	35%	100%
2007	0.476	346	164.9551	20%	24%	6%	16%	9%	2%	2%	41%	100%
2008	0.484	345	166.8374	19%	27%	6%	14%	9%	2%	2%	39%	100%
2009	0.494	336	165.8048	18%	32%	7%	13%	9%	2%	2%	35%	100%

Table 8-8 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 Chapter 2). They, of course, generate important quantities of waste that are then divided by the resident population when estimating per capita figures.

Table 8-8 - Solid waste disposed on land (1990 - 2009)

Waste treated on SWDS sites *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	74 540	*39 340*	*24 600*	*10 600*	*NO*	*389 600*	*191.32*
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	73 188	*40 941*	*32 247*	*NO*	*NO*	*469 100*	*156.02*
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*
2008	51 819	*25 095*	*26 724*	*NO*	*NO*	*493 500*	*105.00*
2009	48 105	*19 668*	*28 437*	*NO*	*NO*	*502 100*	*95.81*
Trend 1990-2009	*-45.11%*	*-66.23%*	*54.55%*	*NA*	*NA*	*30.62%*	*-57.97%*

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.[165] This strong relationship between waste incineration and SWDL is illustrated in Figure 8-3 below.

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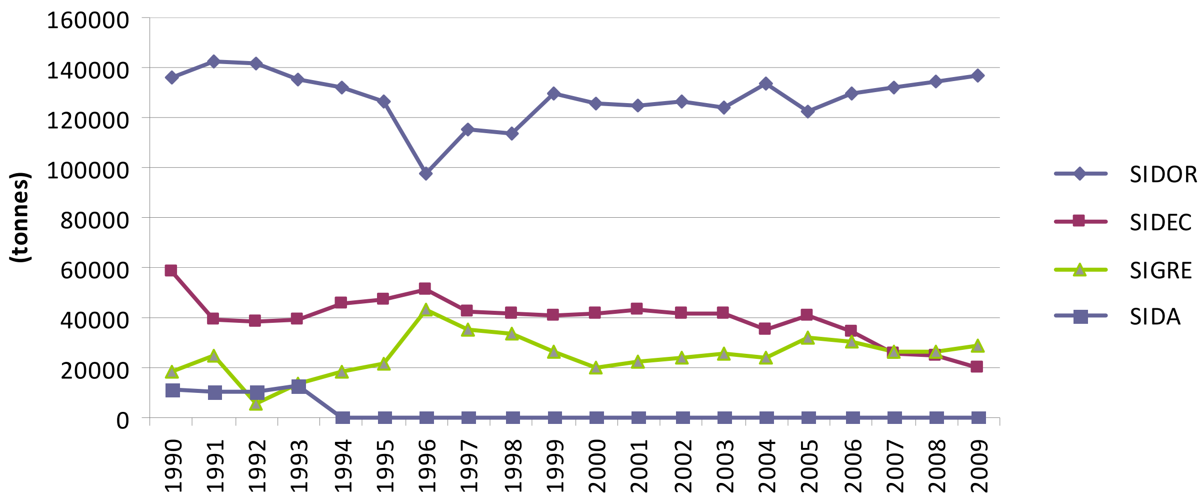
165 De Journal, N.200, p.7, "SIDOR: Feiern in der Zeit des Umbruchs"

Figure 8-3 - Relationship between waste incineration and waste disposal on land.



8.2.2.7 CH_4 Recovery

Recovery is only made since 2000. Data (from 2001 onwards) are from the annual reports from SIGRE and SIDEC being sent to the Environment Agency in accordance to their permits. For the year 2000, no data is available, so that the data from 2001 was used.

8.2.3 Uncertainties and time-series consistency

For uncertainties on activity data and emission factors, please refer to section 1.7.

8.2.4 Category-specific QA/QC and verification

No category specific QA/QC procedures have been completed.

8.2.5 Category-specific recalculations

Table 8-9 presents the main revisions and recalculations done relevant to CRF category 6A.

Table 8-9 - Changes in GHG inventory between submissions 2010v2.1 and 2011v1.3

GHG source & sink category	Revisions 2010v2.1 ➔ 2011v1.3	Type of revision
6A1	2004-2008: In 2010 a new MSW analysis was published, and thus the waste composition between 2004 and 2008 was recalculated via interpolation, the previous MSW analysis was done in 2004/2005. The pre-treatment as calculated in the 2011 study was also taken into account.	refinement
6A1 methane recovery	2000: methane recovery started in 2000, so the amount of methane emitted was revised. 2008: revised activity data	CH_4 revised

8.2.6 Category-specific planned improvements

No planned improvements are foreseen in this sector.

8.3 Wastewater Handling (6B)

8.3.1 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) waste water handling (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*). 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 in Chapter 6), thus, IPCC Category 6B = IPCC Sub-category 6B2, excluding sludge.

In 2009, this source category was responsible for 21% of the total GHG emissions from the waste sector – excluding waste incineration – and it represented 0.12% of the total GHG emissions in CO_2e (excluding LULUCF). For each of the two gases reported, in 2009:

- CH_4 from WWH represented 6.6% of waste treatment methane related emissions – excluding waste incineration – and 0.70% of the total methane emissions estimated for Luxembourg;
- N_2O from WWH represented 59% of waste treatment nitrous oxide related emissions – excluding waste incineration – and almost 2.5% of the total nitrous oxide emissions estimated for Luxembourg.

None of the source categories under WWH is a key category.

8.3.2 Methodological issues – methane emissions

Municipal wastewater treatment in Luxembourg uses mainly aerobic processes (see Table 8-10) such as 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.) the stabilisation is usually carried out aerobically, with oxygen and energy consumption, while for facilities with a treatment capacity larger than 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.

Table 8-10 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 8-10 – Municipal WWTP capacities and aerobic procedures: 1990-2009

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%
2008	1017.3	98%
2009	1066.3	98%
Trend 1990-2009	*80.24%*	*NA*

Source: Water Management Agency

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 have been taken into 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 decreases 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:

$$MCF = 2/3 * 0{,}35 + 1/3 * 0{,}1 = 0{,}27$$

<u>Calculation of the organic load:</u>

*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*

<u>Calculation of the methane emissions:</u>

$$CH_4\ sep\ [t/year] = BODsep * B0 * MCF / 1000 ;\ where : sep = septic\ tanks$$

$$CH_4\ mec\ [t/year] = BODmec * B0 * MCF / 1000$$

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 plant is based on the last national detailed population inventories, as these censuses take place every ten years, and the last one in 2001, the evaluation is based on these population numbers for the years 2005-2009. The new census took place at the beginning of 2011, so that for the submission 2012 or 2013 a recalculation can be done for this period, depending on the publication date of the newest census.

Total methane emission from wastewater handling:

$$CH_4\ tot = CH_4\ sep + CH_4\ mec\ [t/year)]$$

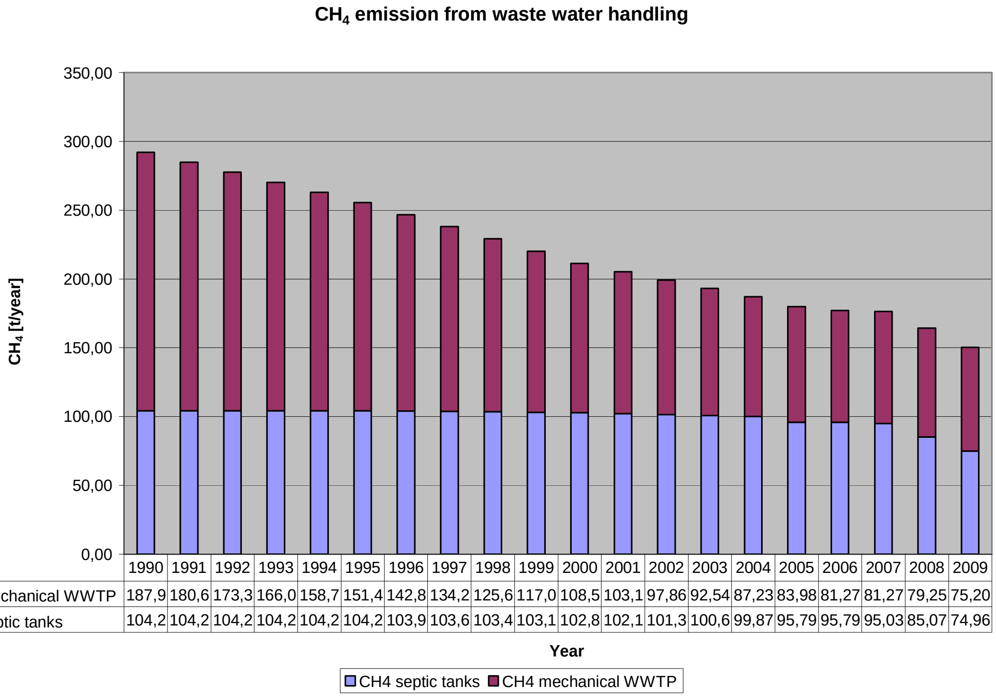
The estimated emissions obtained following the method described above are presented in Table 8-11 and Figure 8-4.

Table 8-11 – CH_4 emission trends for IPCC Sub-category 6B2 – Domestic & Commercial WWH: 1990-2009

CH4 emissions (tonnes) 6B2 - Domestic & Commercial WWH			
Year	Mechanical	Septic Tanks	Total
1990	187.94	104.20	292.14
1991	180.63	104.20	284.83
1992	173.33	104.20	277.53
1993	166.02	104.20	270.22
1994	158.72	104.20	262.92
1995	151.41	104.20	255.61
1996	142.83	103.94	246.77
1997	134.25	103.67	237.92
1998	125.66	103.41	229.08
1999	117.08	103.15	220.23
2000	108.50	102.88	211.38
2001	103.18	102.13	205.31
2002	97.86	101.38	199.24
2003	92.54	100.62	193.17
2004	87.23	99.87	187.10
2005	83.98	95.79	179.77
2006	81.27	95.79	177.06
2007	81.27	95.03	176.30
2008	79.25	85.07	164.32
2009	75.20	74.96	150.17
Trend 1990-2009	-59.99%	-28.06%	-48.60%

Source: Water Management Agency.

Figure 8-4 – CH_4 emission trends for IPCC Sub-category 6B2 – Domestic & Commercial WWH: 1990-2009



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CH4 mechanical WWTP	187,9	180,6	173,3	166,0	158,7	151,4	142,8	134,2	125,6	117,0	108,5	103,1	97,86	92,54	87,23	83,98	81,27	81,27	79,25	75,20
CH4 septic tanks	104,2	104,2	104,2	104,2	104,2	104,2	103,9	103,6	103,4	103,1	102,8	102,1	101,3	100,6	99,87	95,79	95,79	95,03	85,07	74,96

Source: Water Management 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.

8.3.3 Methodological issues – nitrous oxide

8.3.3.1 Nitrous oxide emissions from municipal wastewater

Pursuant to the 2006 IPCC Guidelines, nitrous oxide emissions from household wastewater can be evaluated by 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 populations:

1. not connected to a wastewater treatment plant (WWTP)
2. connected to a WWTP without denitrification
3. connected to a WWTP with denitrification

The N_2O emissions resulting from the population not connected to a WWTP were calculated according the 2006 IPCC default approach. For the nitrous oxide calculation daily commuters have also been taken into account, in addition to the residents of the country. As these commuters spend only their working hours in the country, their impact was calculated using only have half of their nitrous oxide load. The number of inhabitants and the commuters are provided by the STATEC.

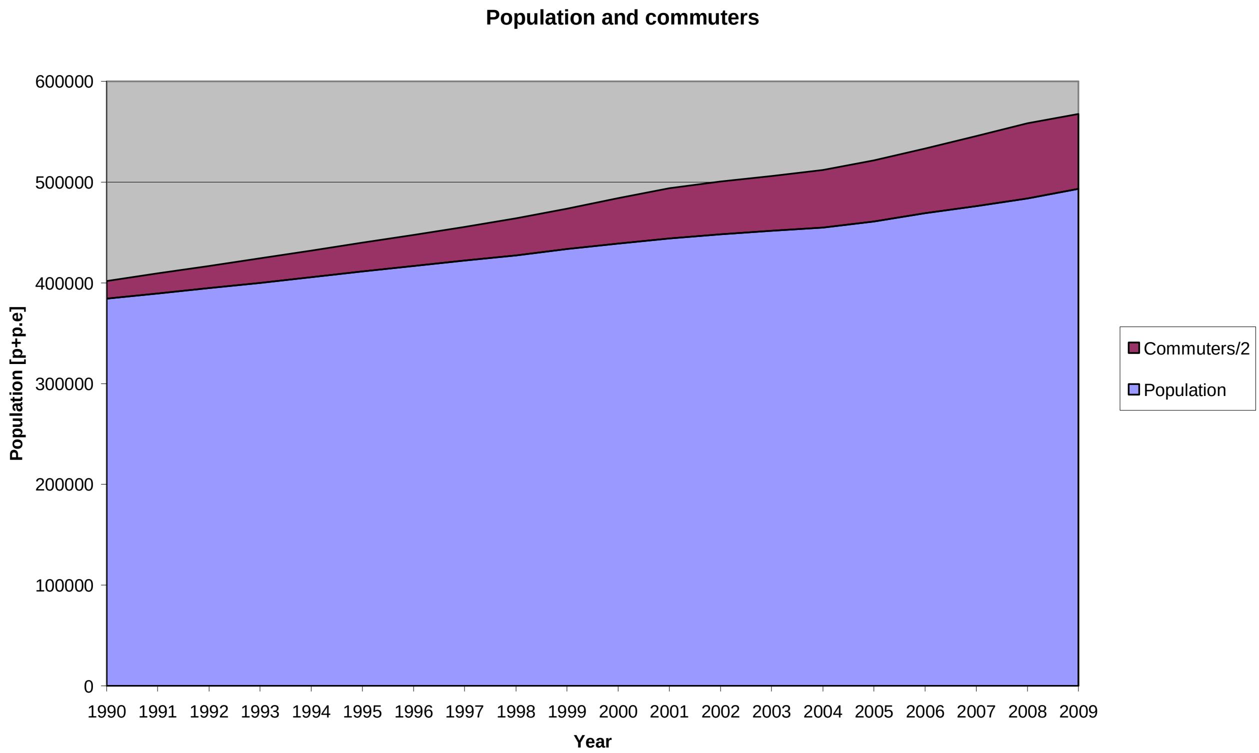
Figure 8-5 illustrates the population and cross-border commuters growth between 1990 and 2009. The latter is divided by 2 in the figure below (so that only a half load of nitrogen is counted for by commuting individual).

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.

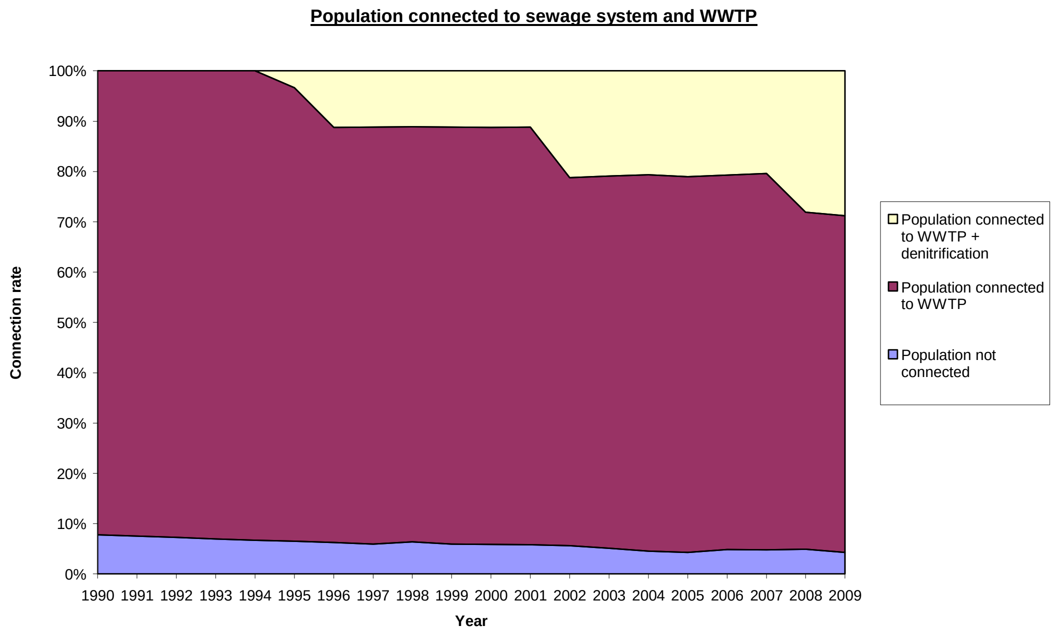
Figure 8-6 provides an overview of the population of Luxembourg connected to WWTPs (with or without denitrification) or not.

Figure 8-5 – Resident population and cross-border commuters: 1990-2009



Sources: Le Portail des Statistiques au Luxembourg, Statistical Yearbook
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=383&IF_Language=fra&MainTheme=2&FldrName=1&RFPath=68
http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=494&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92

Figure 8-6 – Population connected to sewage system and biological WWTP: 1990-2009



Source: Water Management 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

$$N_2O_{wwtp\text{-}de} = P * F_{ind\text{-}com} * EF_{plant} / 1.000.000 \qquad [t/year]$$

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

$$N_2O_{mun\ tot}\ [t/year] = N_2O \text{ not connected} + N_2O \text{ connected to WWTP without denitrification} + N_2O \text{ connected to WWTP with denitrification}$$

where:

mun = municipal wastewater

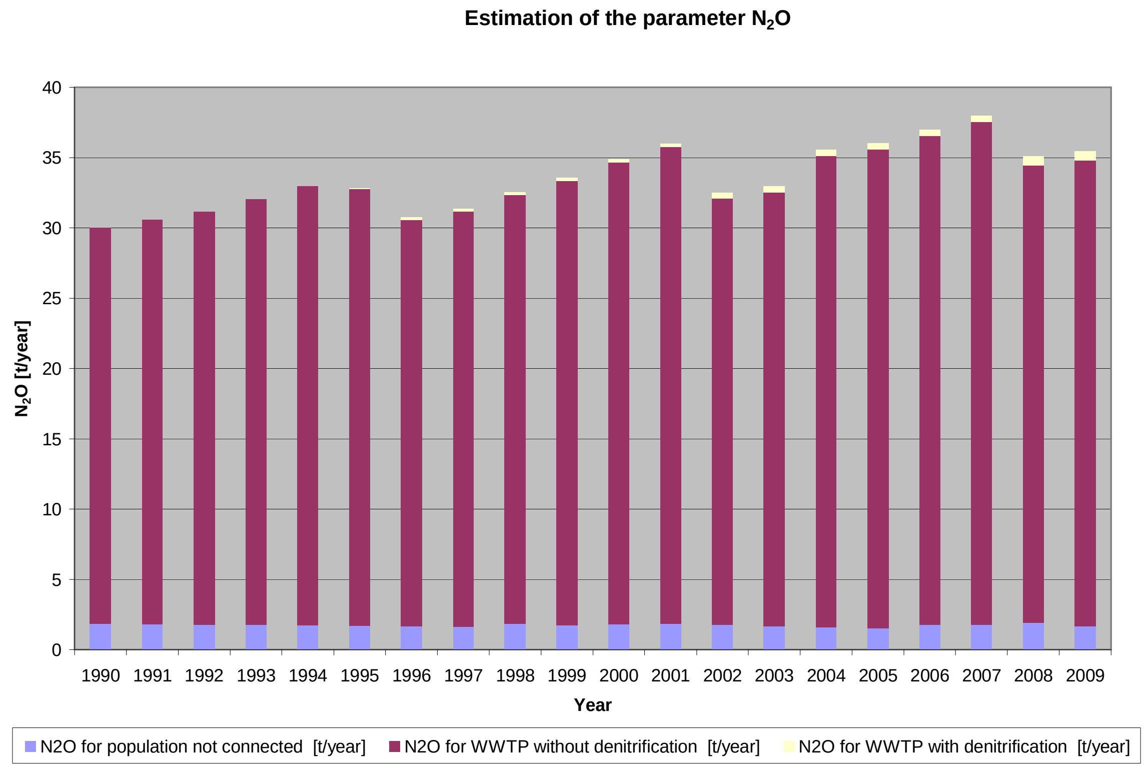
The estimated emissions obtained following the method described above are presented in Table 8-12 and Figure 8-7.

Table 8-12 – N_2O emission trends for IPCC Sub-category 6B2 – Domestic & Commercial WWH: 1990-2009

Year	N_2O emissions (tonnes) 6B2 - Domestic & Commercial WWH			
	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	31.14	0.43	33.24
2004	1.60	34.09	0.43	36.11
2005	1.55	34.76	0.45	36.75
2006	1.78	35.37	0.45	37.59
2007	1.79	36.40	0.45	38.64
2008	1.89	33.45	0.64	35.98
2009	1.66	33.92	0.66	36.24
Trend 1990-2009	-9.47%	20.43%	226%	20.81%

Source: Water Management Agency.

Figure 8-7 – N_2O emission trends for IPCC Sub-category 6B2 – Domestic & Commercial WWH: 1990-2009



Source: Water Management 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 wastewater treatment plant (WWTP) is equipped with a biological treatment with denitrification. N_2O emissions are based on the measured inflow data in the WWTP. The data available since the year 2002 are the flow as well as the mean annual 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)

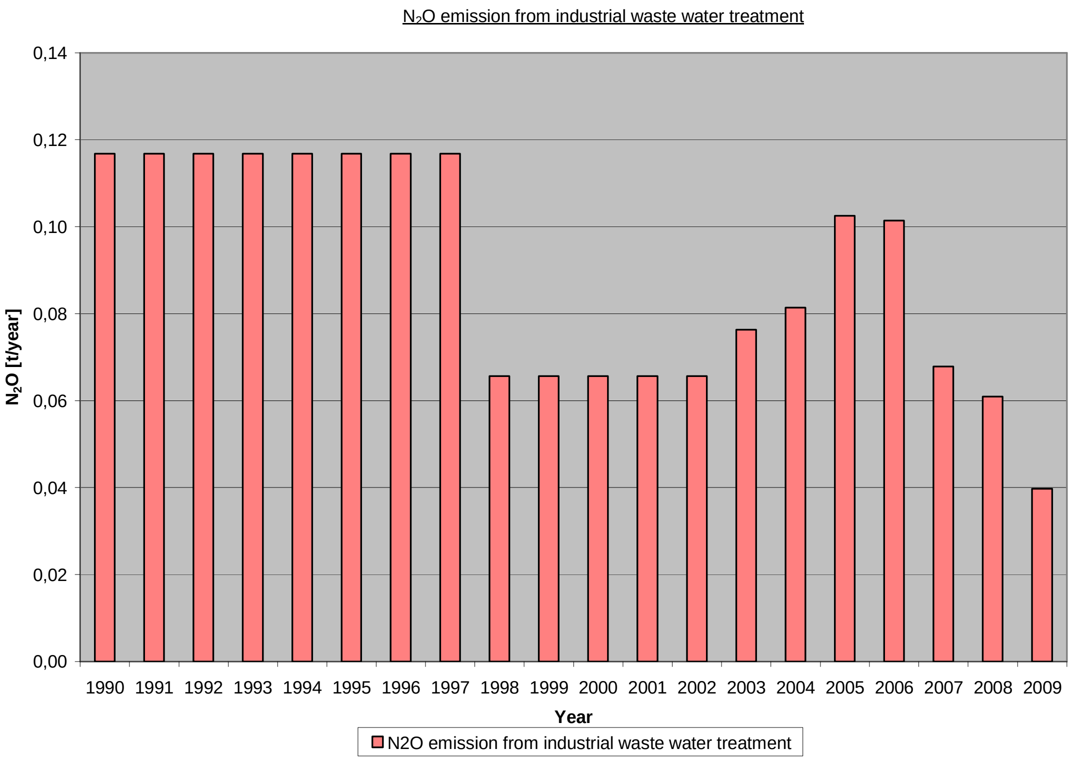
% FRAC denitri = 70% denitrification rate in % (% of wastewater which is denitrificated)

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 8-8.

Figure 8-8 – N_2O emission trends for IPCC Sub-category 6B1 – Industrial wastewater WWH: 1990-2009



Source: Water Management Agency.

Determination of N concentration:

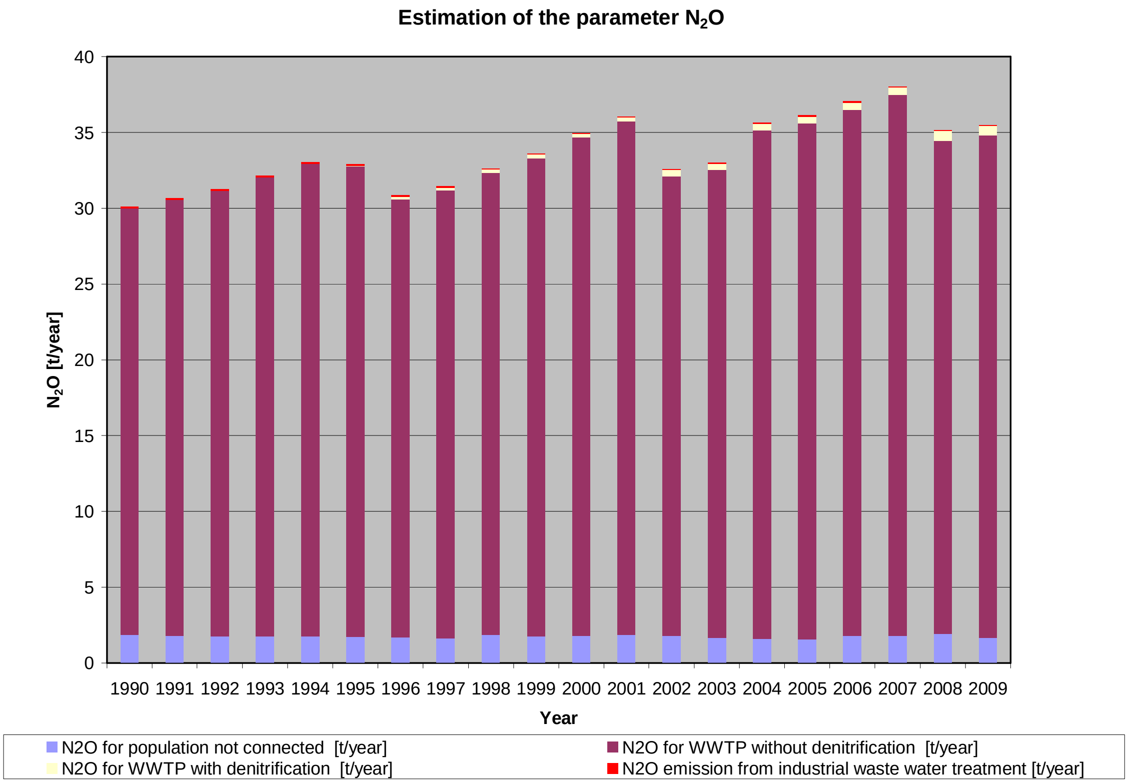
Year 1990 - 1997	Year 1998 - 2002	Year 2002 – 2009
N concentration extrapolated by expert judgment of the water management administration	N concentration extrapolated by expert judgment of the water management administration. In 1998 the WWTP has been upgraded allowing also denitrification	N concentration based on monitoring analyses

8.3.3.2 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 8-9 and Table 8-13.

Figure 8-9 - N_2O emission trends for IPCC Sub-category 6B1 and Sub-category 6B2 WWH: 1990-2009



Source: Water Management Agency.

Table 8-13 – N_2O emission trends for IPCC Sub-category 6B1 and Sub-category 6B2 WWH: 1990-2009

Year	N_2O emissions (tonnes) 6B1 and 6B2 - Domestic & Commercial and Industrial WWH				
	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	31.14	0.43	0.08	33.31
2004	1.60	34.09	0.43	0.08	36.19
2005	1.55	34.76	0.45	0.10	36.85
2006	1.78	35.37	0.45	0.10	37.70
2007	1.79	36.40	0.45	0.07	38.71
2008	1.89	33.45	0.64	0.06	36.04
2009	1.66	33.92	0.66	0.04	36.28
Trend 1990-2009	-9.47%	20.43%	NA	-66%	20.47%

Source: Water Management Agency.

8.3.4 Uncertainties and time-series consitency

- 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)

For further information on uncertainties, please refer to section 1.7.

8.3.5 Category-specific QA/QC and verification

Category-specific QA/QC procedures have been completed for the following parameters:

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).

8.3.6 Category-specific recalculations

No recalculations were undertaken.

8.3.7 Category-specific 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 8-14 will be explored.

Table 8-14 – 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	The new census took place at the beginning of 2011, so that for the submission 2012 or 2013 a recalculation can be done for this period, depending on the publication date of the newest census

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 3.2.6 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)

8.5.1 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.

In 2009, this source category was responsible for 23% of the total GHG emissions from the waste sector – excluding waste incineration – and it represented 0.13% of the total GHG emissions in CO_2e (excluding LULUCF). For each of the two gases reported, in 2009:

- CH_4 represented 15% of waste treatment methane related emissions – excluding waste incineration – and 1.7% of the total methane emissions estimated for Luxembourg;
- N_2O represented 41% of waste treatment nitrous oxide related emissions – excluding waste incineration – and 1.7% of the total nitrous oxide emissions estimated for Luxembourg.

Table 8-15 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 8-15 – CH_4 & N_2O emission trends for IPCC Category *6D – Other – Compost Production:* 1990-2009

Year	6D - Other - Compost Production *Emissions (Gg)* CO_2	CH_4	N_2O	Total in CO_2e
1990	*NO*	*NO*	*NO*	NO
1991	*NO*	*NO*	*NO*	NO
1992	*NO*	*NO*	*NO*	NO
1993	*NO*	*0.02*	*0.00*	1.03
1994	*NO*	*0.03*	*0.00*	1.19
1995	*NO*	*0.03*	*0.00*	1.49
1996	*NO*	*0.03*	*0.00*	1.30
1997	*NO*	*0.06*	*0.00*	2.85
1998	*NO*	*0.11*	*0.01*	4.72
1999	*NO*	*0.11*	*0.01*	4.91
2000	*NO*	*0.21*	*0.01*	9.11
2001	*NO*	*0.20*	*0.01*	8.50
2002	*NO*	*0.24*	*0.02*	10.32
2003	*NO*	*0.31*	*0.02*	13.19
2004	*NO*	*0.30*	*0.02*	12.88
2005	*NO*	*0.32*	*0.02*	13.75
2006	*NO*	*0.36*	*0.03*	15.44
2007	*NO*	*0.34*	*0.02*	14.68
2008	*NO*	*0.39*	*0.03*	16.38
2009	*NO*	*0.35*	*0.03*	15.20
Trend 1993-2009	*NA*	*1423.42%*	*1338.77%*	*1378.94%*

Source: Environment Agency.
Note: the added emissions (*italic*) from 2000 onwards are those of the pilot project Soil-Concept.

Compost production is not a key category.

8.5.2 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.

8.5.2.1 Data origin

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.

8.5.2.2 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 8-16.

Table 8-16 – Composting activities: 1995-2009

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
							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	59 628	63 866
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*	*125.2*	*125.9*	*129.4*
Minette-Kompost Mondercange *(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	30614	32 237
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*	*172.1*	*172.4*	*179.1*
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	5 185	5 117	5 288
kg/habitant	*170.1*	*133.5*	*158.7*	*115.6*	*135.2*	*176*	*170.1*	*167.5*	*164.5*	*172.2*	*181.8*	*170.4*	*174.6*	*164.9*	*168.7*
SIDEC Fridhaff *(3)*				6 169	3 451	8 120	5 416	5 920	6 116	6 564	6 510	6 238	6 092	5 678	5 989
SIDEC Angelsberg *(4)*							691	2 353	2 174	2 534	2 651	2 670	2 702	1 917	2 219
kg/habitant				*70.9*	*39.1*	*88.3*	*65.6*	*88.7*	*87.9*	*95.3*	*93.3*	*88.6*	*87.5*	*74.3*	*79*
Commune de Hespérange									611.4	742	786	743	786	830	743
kg/habitant									*50.4*	*59.2*	*59.9*	*54.9*	*58.1*	*59.3*	*51.1*
Ville de Luxembourg/ Reckenthal									15 297	9 439	8 083	11 108	9 733	11 921	12 187
kg/habitant									*181.5*	*113.2*	*97.5*	*122.8*	*107.6*	*128.4*	*125.1*
SIGRE Muertendall *(5)*											2 763	2679	3 525	3 551	5 203
kg/habitant											*51.4*	*48.5*	*63.8*	*63.3*	*91.1*
Pétange *(2)*	538														
							tonnes dry								
Soil-Concept *(6)*						6379.8	6238.9	8898.1	9488.5	9429.8	10228.1	13401.5	11050.7	14707.1	9827.4

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.

8.5.2.3 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 8-17.

Table 8-17 – 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
Composting excluding Soil-Concept project Soil-Concept project	*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.
	4	0.3	
	(0.03 - 8)	(0.06 - 0.6)	
	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][166]

8.5.3 Uncertainties and time-series consistency

For uncertainties on activity data and emission factors, please refer to section 1.7.

8.5.4 Category-specific QA/QC and verification

No category specific QA/QC procedures have been completed, only the tools embedded in CRF Reporter have been used.

8.5.5 Category-specific recalculations

No recalculations were done since submission 2010v2.1

166 So far, emission estimates for composting are not taking CH_4 recovery into account.

8.5.6 Category-specific 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 8-18 will be explored.

Table 8-18 – 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

9 Other

CRF sector 7 is not applicable to Luxembourg's inventory.

10 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 2010v2.1. Recalculations are quantified for total GHG emissions for all years and gas specific emissions for 1990 and 2008.

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.

10.1 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 2010v2.1 and 2011v1.3, in each recalculation sub-section of Chapters 3 to 8.

10.2 Implication on Emission Levels

The analysis is made by comparing our two last official submissions to the UNFCCC Secretariat, i.e. submissions 2010v2.1 and 2011v1.3. After the ICR that took place in October 2008, Luxembourg's inventory experienced dramatic improvements in some sectors and categories. These improvements were continued for this submission, and many recommendations of the ERT were taken into consideration. Hence, the total GHG estimates for the year 1990 in submission 2011v1.3 differ from those reported in submission 2010v2.1, 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).[167]

Table 10-1 presents the recalculation differences between submission 2010v2.1 and 2011v1.3 for each of the 6 GHG (a positive value indicates that submission 2011v1.3 estimate is higher).

Table 10-1 – Recalculation differences between submissions 2010v2.1 and 2011v1.3 (excl. LULUCF): 1990 and 2008

GHG	1990 (base year)	2008
	recalculation difference (%)	
CO_2	-2.30%	-1.67%
CH_4	-0.43%	-0.60%
N_2O	0.25%	-0.26%
HFCs	-4.67%	-33.7%
PFCs	NA	100%
SF_6	-61.2%	63.5%
Nat. Total (excl. LULUCF)	-2.22%	-1.87%

Source: Environment Agency

Differences for the GHGs – CO_2 and F-gases – are largely explained by the recalculations conducted in CRF Sectors 1 and 2.

For CO_2, significant changes happened in CRF Sector 1, due to the application of national densities and NCVs for all fuels (NCVs were streamlined with national statistics and other governmental administrations), which affected the entire time-series. Secondly, the revised energy balance perpared by national statistics mainly affected the years 2000-2009. Consequently, allocations between different categories were revised, and new categories appeared (1A2d). Finally, concerning natural gas, national consumption as reported in the previous submissions was based on the GCV. This

167 See http://unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php

was corrected in this submission, by multipling with a factor of 0.9 (conversion between GCV and NCV), with the consequence that natural gas generally decreased ower the entire timeseries.

For F-gases, the entire category *2F - Consumption of halocarbons and SF_6*, was revised based on the results of a new study. Previously, the consumption was based mostly on proxy data and projections. The revised data is based on national data, and where no such data was available on data from Belgium adapted to national cirumstances. Basing the data on belgian data makes sence, since Luxembourg and Belgium are economically closely linked[168], and most of the F-gases are imported from Belgium.

For additional and more detailed explanations, please refer to the relevant sections in each of the CRF Sectors Chapters 3 to 8).

Table 10-2 shows the recalculation effect for all years.

Table 10-2 – Recalculation differences between submissions 2010v2.1 and 2011v1.3 for total GHG emissions (excl. LULUCF): 1990-2008

Year	National Total GHG emissions, excluding LULUCF submission 2010v2.1 Gg CO_2 eq.	submission 2011v1.3 Gg CO_2 eq.	recalculation difference %
1990	13'118.41	12'827.46	-2.22
1991	13'603.36	13'367.18	-1.74
1992	13'372.21	13'150.85	-1.66
1993	13'472.33	13'264.08	-1.55
1994	12'605.23	12'430.92	-1.38
1995	10'363.99	10'103.70	-2.51
1996	10'427.80	10'164.79	-2.52
1997	9'796.67	9'457.88	-3.46
1998	8'965.68	8'573.72	-4.37
1999	9'375.78	8'991.63	-4.10
2000	9'901.80	9'766.38	-1.37
2001	10'206.89	10'275.20	0.67
2002	11'278.49	11'044.20	-2.08
2003	11'716.86	11'485.97	-1.97
2004	13'205.52	12'900.12	-2.31
2005	13'275.93	13'152.40	-0.93
2006	13'194.47	13'018.13	-1.34
2007	12'790.48	12'397.88	-3.07
2008	12'493.94	12'259.77	-1.87
Trend 1990-2008	-2.50%	-3.35%	*NA*

168 Belgium–Luxembourg Economic Union: http://en.wikipedia.org/wiki/Belgium%E2%80%93Luxembourg_Economic_Union ; followed by the BENELUX Union: http://en.wikipedia.org/wiki/Benelux

10.3 Implications for Emissions Trend

As shown in Table 10-2, the recalculation between the two submissions 2010v2.1 and 2011v1.3 led to a modification in the total GHG (excluding LULUCF) emissions trend from -2.50% to -3.35%. This is mainly due to the high contribution of liquid and gaseous fuels in Luxembourg's GHG inventory. Indeed, the recalculations enumerated above mostly affected these fuels. Densities and NCVs are generally slightly higher, whereas the consumption of natural gas is lower, as it is now based on NCV.

10.4 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 10-3. 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*".[169]

Table 10-3 – Main planned improvements

The list needs to be updated, for now please refer to the sector chapters for the correct planned improvements.

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[169] The text into bracket is an addition by Luxembourg.

Issue GHG source & sink category	Planned improvement
Cross-cutting improvements	
Uncertainties	A new study (Tier 1 and Tier 2) has been comissionned from an Austrian consultant, in order to update the Uncertainty study from 2007. This study will take into account all the impovements which have been done to the inventory, and also include LULUCF. First results can be expected in October 2011, and will be included in the next NIR.
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	
1A2 – Manufacturing Industries and Construction	Reallocate emissions from off-road vehicles and other machinery from the respective subcategories 1A2a – 1A2e to category 1A2f - Other
1A2b – Non-Ferrous Metals	Include other non-ferrous activities if relevant (copper processing and production from copper scrap) which are now included in 1A2f.
1A3b – Road Transportation	A detailed study has been commissioned to better estimate emissions from both the domestic fleet, and the emissions due to fuel export. A preliminary report is currently being prepared, but further work will be needed to refine the data before incorporation into the GHG inventory.
1A3b – Road Transportation	lubricants: 50% of carbon that is not stored will be allocated in this sub-category
1A4 – Other Sectors	collect information helping to refine the fuel consumption split between the commercial/institutional sector and the residential sector for the years 1990-1999.
1A5 – Other	further investigate whether the consumption data for the remaining years, reported by the national statistics, has been correctly understood, and correctly allocated.
1B2a5 - Distribution of refined oil products	Assess whether these emissions occur and, if appropriate, estimate and report fugitive emissions from the infrastructure supporting the transport, distribution, storage and sale of refined fuel oils. Investigate the German EFs in detail, since it is the only country reporting emissions from the distribution of oil products.
2A7 – Other – Glass Production	streamlining with the new 2006 IPCC Guidelines and the new 2007 ETS Guidelines.
2F – Consumption of Halocarbons & SF6	increase transparency of category 2F description, especially the methodologies and assumptions made.
3A, 3B, 3C, 3D5	Investigate the possibility of acquiring more country-specific data in order to establish the emission levels from solvent and other product use. Nevertheless the IEF for CO2 emission from Austria seemed to be more accurate and applicable than the default fossil carbon content fraction provided by the 2006 IPCC GL because the IEFCO2 is based on substance specific carbon dioxide factors for 15 substances. The amount of these substance used in Luxemburg (production/import/export) are taken into account in emission estimation.
4A – Enteric Fermentation	- analyze whether it would be possible to replace some default parameter values – such as GE – by national values; - implementing ERT's recommendations on including in the NIR additional information on the parameters, coefficients and activity data used.
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.
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	investigate whether it would be worth, straightforward and not time/resources consuming to include the missing farm animals (ostriches, "productive animals").
4B – Manure Management	implementing ERT's recommendations on including in the NIR additional information on the parameters, coefficients and activity data used.
4B – Manure Management - AWMS	analyzing whether it would be feasible to refine AWMS per livestock category and through the reporting years.

Issue GHG source & sink category	Planned improvement
Source categories improvements	
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 or, at least, use updated databases (notably for the OECD source).
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	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; - implementing ERT’s recommendations on including in the NIR additional information on the parameters, coefficients and activity data used.
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.
5E	investigate whether the level of sealing of settlement areas, which is now based on expert judgement, could be updated using data from the European Urban Atlas project.
5A-5F	perform T1 and T2 uncertainty analysis.
6B2 – Domestic & Commercial WWH – N2O	List of WWTPs which produce methane gas for energy reuse in combined heat/power generating systems
6B2 – Domestic & Commercial WWH	The new census took place at the beginning of 2011, so that for the submission 2012 or 2013 a recalculation can be done for this period, depending on the publication date of the newest census
6D – Other	Include aerobic pre-treatment of municipal waste before landfilling at SIDEC

Part II: Supplementary Information required under Article 7, paragraph 1

11 KP-LULUCF

11.1 General information

11.1.1 Definition of forest

The OBS89, OBS99 and OBS07 land use maps are the main data providers for the greenhouse gas reporting of IPCC category forestland. The National Forest Inventory (IFN) of Luxembourg is the main data provider for the development of carbon stock factors. Consequently and for reason of consistency, the applied forest definition for the reporting follows the definition used within the IFN and the OBS maps. The selected parameters are:

Land Use Class	Definition
Forest Land	All forest and wooded land according to the FAO TBRA2000 definition: • Minimum land area: 0.5 ha • Minimum crown cover: 10 % • Minimum height: 5 m. In the geodata set, Forest land has been sub-divided into the forest types as defined below.
Conifers:	Including all forest land with > 10 % crown cover and on which more than 75 percent of the tree crown cover consists of coniferous species.
Deciduous:	Including all forest land with > 10 % crown cover and on which more than 75 percent of the tree crown cover consists of broadleaved species
Mixed (coniferous and deciduous):	with > 10 % crown cover and less than 75 % crown cover of one class.

Permanently unstocked basal areas that are directly connected with forest in terms of space and forestry enterprise and contribute directly to its management (such as forestal hauling systems, wood storage places, forest glades, forest roads) also represent forests. Areas which are used in short rotation with a rotation period of up to thirty years as well as forest arboretums, forest seed orchards, Christmas tree plantations and plantations of woody plants for the purpose of obtaining fruits such as walnut or sweet chestnut do not account as forests but represent cropland. Rows of trees (except shelter belts for wind protection) and areas with woody plants in a park structure are not forest land.

11.1.2 Elected activities under Article 3.4

As reported in the Initial Report[170], Luxembourg has decided not to elect any of the activities under Article 3.4 of the Kyoto Protocol.

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170 http://unfccc.int/files/national_reports/initial_reports_under_the_kyoto_protocol/application/pdf/mev_initial_report_0612.pdf

Figure 11-1 – Activity coverage relating to activities under Art. 3.3 and 3.4 (CRF table NIR-1)

Activity		Change in carbon pool reported[1]					Greenhouse gas sources reported[2]						
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization[3]	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning[4]		
							N_2O	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O
Article 3.3 activities	Afforestation and Reforestation	R	IE	IE	NO	R	NO			NO	NO	NO	NO
	Deforestation	R	IE	IE	R	R			NO	NO	NO	NO	NO
Article 3.4 activities	Forest Management	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA	NA
	Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA
	Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA	NA
	Revegetation	NA	NA	NA	NA	NA				NA	NA	NA	NA

11.1.3 Description of how the definitions of each activity under Article 3.3 have been implemented and applied consistently over time

The area of forest land reported for Aforestation/Reforestation and Deforestation under the Kyoto Protocol has the same basis as the area reported for Land use changes from and to forests in the UNFCCC greenhouse gas inventory taking the different time frame (ARD areas starting with 1990) as well as the permanence of ARD areas into account. All LUC from and to forests are considered to be direct human induced ARD. AR activities are reported together.

11.2 Land-related information

The land related information for the years 1989 and 2009 to support the KP reporting in Luxembourg was generated in the framework of the ESA funded "GMES Service Element Forest Monitoring in Luxembourg" carried out by LuxSpace S.à.r.l. Data related to the year 1999 could be included due to an accompanying measure financed by the "Ministry of sustainable Development and Infrastructures" and implemented by LuxSpace.

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

The base data used for this reporting is the so-called OBS map data "Occupation Biophysiques du Sol" that is a detailed land use / land cover map in digital format covering the entire territory of Luxembourg. There exist three versions of the OBS map data set. The first OBS data set, the OBS89, was collected in the field for several years and published in 1989 by the Environment Ministry (now called the "Ministry of sustainable Development and Infrastructures"). The second data set for the OBS99 was collected based on aerial Colour Infra Red Ortho-photos and some field surveying for validation and completion. The third set, and currently the most recent, is the OBS07, which is an update of the OBS99 using Very High Resolution satellite images (1m pixel size) of the US commercial Earth observation satellite IKONOS.

The Minimum Mapping Unit (MMU) of the OBS89 is unknown. The Table 11-1 and Figure 11-2 provide information about the frequency distribution of polygon areas.

Table 11-1 - OBS89 data: Frequency of Polygons in size classes & cumulative percentages

Area (m^2) smaller than	Nr of Poly-gons	Cumulative %
100	73	0,15%
500	173	0,52%
1000	334	1,22%
1500	720	2,73%
2000	1063	4,96%
5000	8609	23,03%
10000	10005	44,02%
50000	18008	81,82%
100000	3846	89,89%
500000	3936	98,15%
1000000	575	99,35%
More	308	100,00%

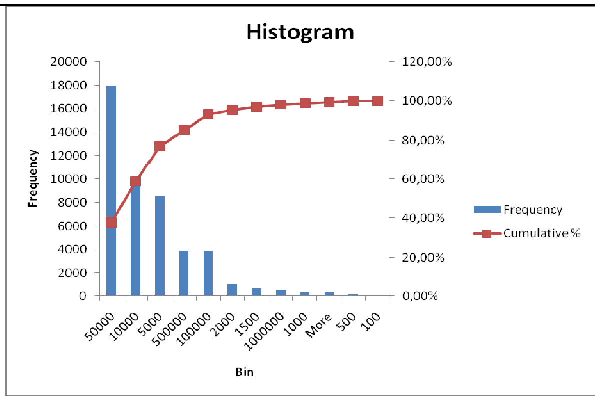


Figure 11-2 - Histogram of OBS89 data: Frequency of Polygons in size classes

The OBS99 MMU is in principle 2.500 m^2 (0.25 ha) but adapted for important but small areas, i.e. wetlands and little lakes/ponds to 1500 m^2 (0.15 ha). Linear structures and parts of it are mapped as areas if their width is larger than 20m, other parts (<20m) are taken from the BD-L-TC and presented as lines. Figure 11-3 and Table 11-2 provide information about the frequency distribution of polygon areas.

Area (m²) smaller than	Nr of Polygons	Cumulative %
100	116	0,10%
500	3609	3,18%
1000	7220	9,35%
1500	7522	15,78%
2000	6693	21,50%
5000	27358	44,88%
10000	21546	63,29%
50000	32140	90,76%
100000	5867	95,77%
500000	4653	99,75%
1000000	243	99,96%
More	48	100,00%

Table 11-2 - OBS99 data: Frequency of Polygons in size classes & cumulative percentages

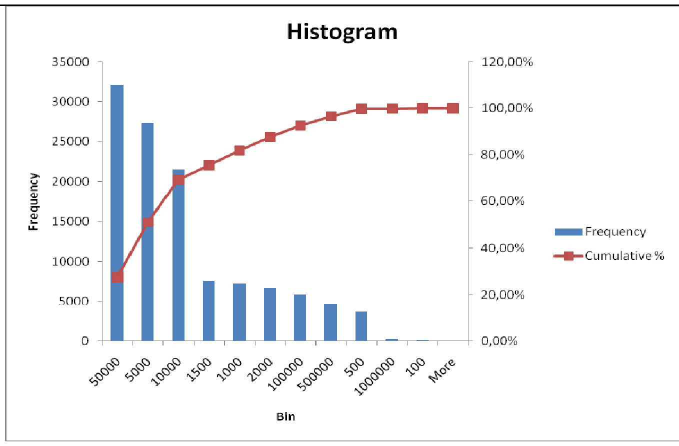


Figure 11-3 - Histogram of OBS99 data: Frequency of Polygons in size classes

The OBS07 MMUs correspond to those of the OBS99 with changes from OBS99 to OBS07 mapped with a MMU of 500m². Table 11-3 and Figure 11-4 provide information about the frequency distribution of polygon areas.

Area (m²) smaller than	Nr of Polygons	Cumulative %
100	56	0,04%
500	36	0,07%
1000	9049	7,27%
1500	9377	14,72%
2000	8256	21,29%
5000	31000	45,93%
10000	23388	64,52%
50000	33643	91,27%
100000	5993	96,04%
500000	4693	99,77%
1000000	247	99,96%
More	47	100,00%

Table 11-3 - OBS07 data: Frequency of Polygons in size classes & cumulative percentages

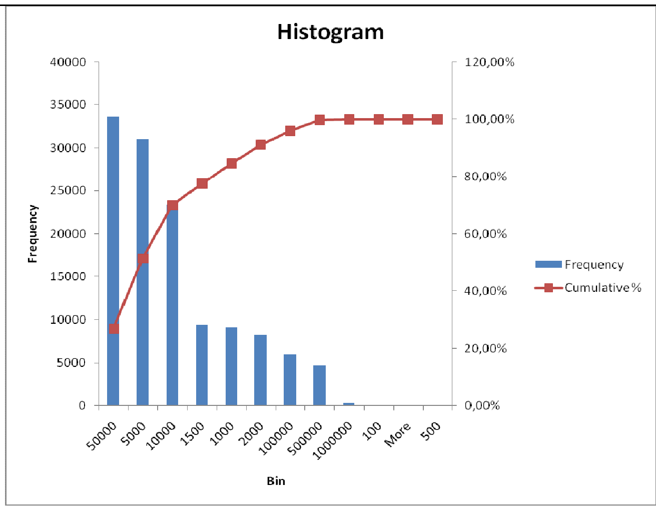


Figure 11-4 - Histogram of OBS07 data: Frequency of Polygons in size classes

11.2.2 Methodology used to develop the land transition matrix

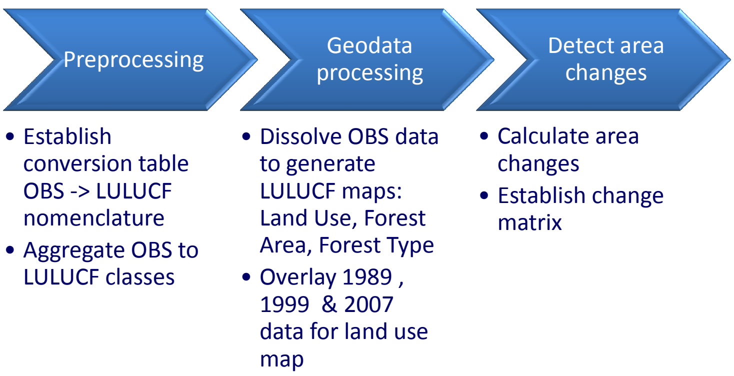
The generation of the LULUCF maps is based on the OBS data, i.e. data processing OBS89, OBS99 and OBS07 follows the same processing scheme.

The original OBS categories for the years 1989, 1999 and 2007 were assigned to the relevant classes of the LULUCF nomenclatures. The correspondence of OBS89 res OBS99/07 classification to the LULUCF nomenclature has been established in close collaboration of the relevant administrations and experts. The conversion tables from OBS89-99-07 to LULUCF are presented in chapter 7.2.3.

After aggregation of the class assignments according to the LULUCF nomenclature, the next step in geo data processing (using Geographic Information System software "ArcGIS") is to dissolve the polygons to the respective classes, i.e. all neighbouring polygons belonging to the same LU-LUFC class were aggregated to one single polygon. This process results in land use maps, i.e. LU89, LU99 and LU07.

In order to preserve the detail in the data for the generation of the area statistics, no generalisation was performed before the change detection. Change detection of Land Use / Forest types between the selected reference years 1989, 1999 and 2007 has been carried out by overlay (intersect) of the Land Use maps LU89, LU99 and the LU07 data sets. Figure 11-5 shows the processing steps.

Figure 11-5 – Processing chain for the creation of the land transition matrix



The resulting maps of the intersection show the differences in land use and the changes from which land use class to which other one. The total area as computed from the GIS data sets differs slightly from the official area of the Luxembourg territory. This is simply due to resolution /scale and data processing inaccuracies in the data sets. Therefore, the areas derived from the geodata have been put in relation to the official area of Luxembourg (258 600 ha). It means that all areas resulting from the geodata processing are proportional to the official territory of Luxembourg that is 2 586km^2. From this data the change statistics are derived and illustrated in the change matrix.

An exception to the use of OBS has been made for LUC areas between cropland and grassland. When using OBS figures, the LUC areas between cropland and grassland are too high because the areas with more than one land use change within 20 years are taken into account as LUC areas, whereas according to IPCC-GPG they should stay in their main category. In Luxemburg, and especially in the northern part of Luxemburg (Oesling), a crop rotation including temporary grass is largely used by the farmers. In this crop rotation, the changes temporary grass to annual crops are recorded as LUC grassland to cropland and the changes annual crops to temporary grass as LUC grassland to cropland when using OBS. An alternative way to estimate the LUC between cropland and grassland was found, using administrative data of the Ministry of Agriculture coming from the administration of the "aid scheme for the maintenance of the landscape and the natural environment and for encouraging an agriculture respecting the environment" an agri-environmental aid scheme administered by the Service d'Economie Rurale, an administration of the Ministry of Agriculture. As within this aid scheme a land use change from permanent grassland to cropland is not allowed, except in special circumstances and after a special authorization and as this aid scheme is largely taken up by the farmers, it was possible to estimate the annual LUC grassland to cropland (269 ha). As the part of permanent grassland in the utilized agricultural area is relatively stable, the annual LUC cropland to grassland is estimated to be of the same amount (269 ha). The LUC areas grassland to cropland respectively cropland to grassland going beyond 269 ha according to OBS are allocated to the category "grassland remaining grassland".

Table 11-4 shows the current land use transition matrix for the years 2008 to 2009.

Table 11-4 – Land transition matrix, area change between 2008 and 2009 year (in kha) (CRF table NIR-2)

To current inventory year / From previous inventory year		Article 3.3 activities		Article 3.4 activities				Other	Total area at the beginning of the current inventory year
		Afforestation and Reforestation	Deforestation	Forest Management (if elected)	Cropland Management (if elected)	Grazing Land Management (if elected)	Revegetation (if elected)		
		(kha)							
Article 3.3 activities	Afforestation and Reforestation	8.59	NO						8.59
	Deforestation		7.07						7.07
Article 3.4 activities	Forest Management (if elected)		NA	NA					NA
	Cropland Management (if elected)	NA	NA		NA	NA	NA		NA
	Grazing Land Management (if elected)	NA	NA		NA	NA	NA		NA
	Revegetation (if elected)	NA			NA	NA	NA		NA
Other		0.177	0.296	NA	NA	NA	NA	242.46	242.94
Total area at the end of the current inventory		8.77	7.37	0.00	0.00	0.00	0.00	242.46	258.60

11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

The data sets used for the KP reporting is spatially explicit map data from the so-called OBS map "Occupation Biophysiques du Sol" that is a detailed land use / land cover map in digital format covering the entire territory of Luxembourg.

Biophysical Land Cover Map 1989 at scale 1:10.000 - "Occupation Biophysique du Sol" OBS89

The first biophysical land cover map covering the entire Luxembourg territory consisted in a mapping and data collection in the field. Based on prepared aerial ortho photographs showing delineated areas, experts from the "Oeko Fonds and the association "Hellef fir d'Natur" mapped/classified the areas during field work according to a 6-level nomenclature with 5 main classes[171]:

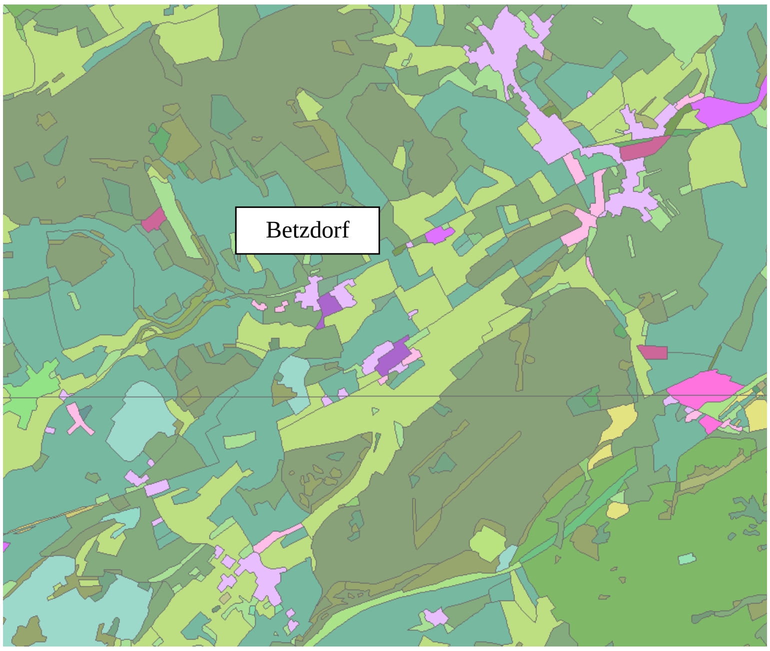
Table 11-5 – OBS89 Nomenclature at level1 and number of classes in levels 2-6

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Artificial areas	4	11	22	27	
Agricultural areas	3	4	9	10	3
Forest and semi-natural areas	3	9	27	37	
Wetlands	1	1	5	6	
Water surfaces	1	5	7	12	
Landscape elements	2	6	11		
Number of classes:	14	36	81	92	3

The OBS data has been provided by ANF as a shapefile. The Minimum Mapping unit corresponds in principle to a scale 1:10.000, but in the data set there are about 250 polygons smaller than 500m^2, 580 polygons smaller than 1000m^2 of a total of 47650 polygons. There is no further detailed description or information on accuracy of the OBS89 available. In addition to this base, a SPOT satellite image mosaic of 1989 was used to identify new clear cut areas that are forest land without forest cover, which was not mapped in the OBS89 data but identified by photo-interpretation of the satellite imagery.

171 Source: Ministère de l'environnement (1994): Cartographie de l'occupation biophysique du sol 1988 – Légende – Luxembourg

Figure 11-6 – Subset of the OBS89 with its 158 classes



The data has been used for LULUCF mapping for the year 1989.

<u>Biophysical Land Cover Map 1999 – "Occupation Biophysique du Sol" OBS99</u>

In 1999, the Ministry of sustainable Development and Infrastructure carried out an update of the OBS89 based on photo-interpretation of aerial Colour Infra-Red orthophotos covering the complete national territory in conjunction with the necessary field survey. The number of classes has been reduced to simplify the map and due to restrictions of the methodology (not all classes of OBS 89 could be photo interpreted). The aerial photographs were recorded in May (southern part of the country, optimal time for grassland and cropland before first cutting) and June 1999 (northern part, optimal time for forest areas during full developed vegetation period) at scale 1:15.000. The Minimum Mapping Unit is in principle 2 500 m² (0.25 ha) but adapted for important but small areas, i.e. wetlands and little lakes/ponds to 1500 m² (0.15 ha). Linear structures and parts of it are mapped as areas if their width is larger than 20m, other parts (<20m), they are taken from the BD-L-TC and presented as lines.

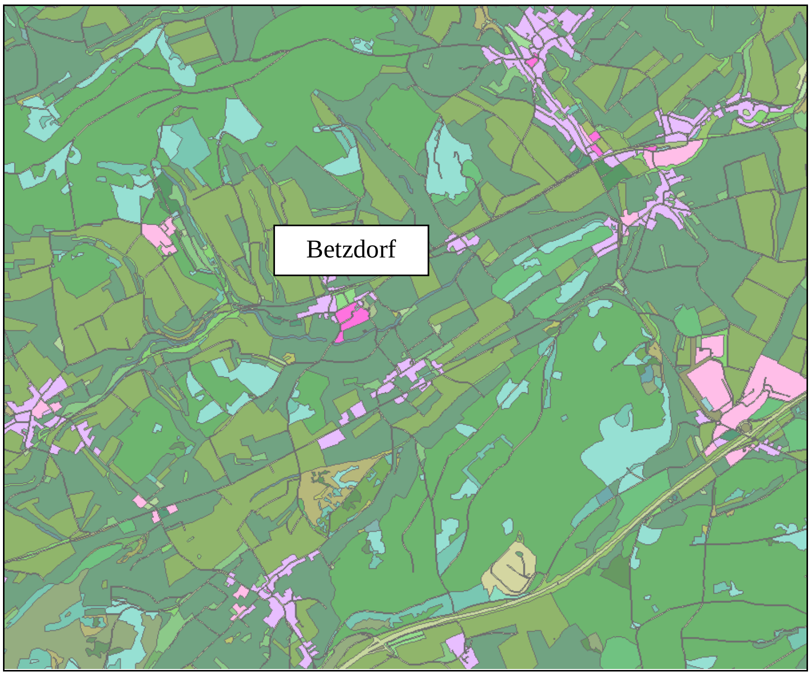
The map includes 4 landscape element categories (isolated tree, group of isolated trees, tree rows, hedges) and in total 77 land use/cover classes, divided in 5 broad categories:

Table 11-6 – OBS99 Nomenclature at level1 and number of classes in levels 2-5

Built-up and artificial areas (32 classes)	Agricultural areas (8 classes)
Forests and semi-natural areas (26 classes)	Wetlands (3 classes)
Water areas (18 classes)	

Concerning the nomenclature, the document describing the content of the OBS99 classes and showing examples of aerial photos has been made available by the Nature and Forestry Agency (ANF).

Figure 11-7 – Subset of the OBS99 with its 76 classes

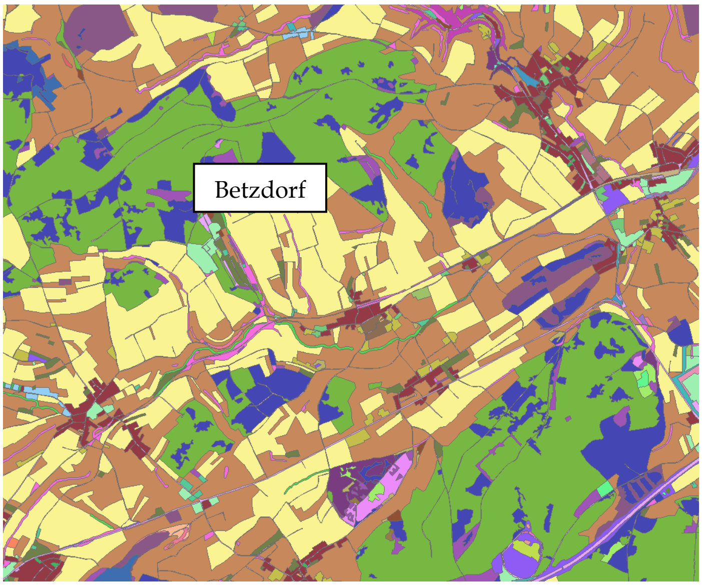


The data has been used for LULUCF mapping for the year 1999.

<u>Biophysical Land Cover Map 2007 – "Occupation Biophysique du Sol" OBS07</u>

In the framework of the ESA funded GSE-LUX-Land information service, this map has been generated by the service provider ESRI-BeLux, who is responsible for the quality of this data product. According to the accepted Integrated Approach for the "GSE extensions for Luxembourg", the detailed Biophysical Land Cover Map (OBS) of Luxembourg from 1999 was updated using the Very High Resolution IKONOS satellite image data acquired in July/August 2007. The Minimum Mapping Unit (MMU) corresponds to those of the OBS99 with changes from OBS99 to OBS07 mapped with a MMU of 500m^2. According to the GSE Land quality assurance and control procedures, the data has been validated by a third party, i.e. Geoville (Luxembourg), and accepted by the users, i.e. the Regional Planning Department of the Luxembourg Ministry of the Interior.

Figure 11-8 – Subset of OBS07 with its 76 classes



11.3 Activity-specific information

11.3.1 Methods for carbon stock changes and GHG emission and removal estimates

11.3.1.1 Description of the methodologies and the underlying assumptions used

The methodologies and assumptions used for the reporting under the Kyoto Protocol Art. 3.3. follow completely those for the areas of LUCs from and to forests (see chapter 7.4.2 Land Use Changes to Forest Land (5A2)).

The methods to derive the activity data were described before in chapter 11.2.

Table 11-7 gives an overview of the parameters used for biomass and soil in AR areas, and Table 11-8 gives similar information for D areas.

Table 11-7 – C stock change factors in AR areas

Aforestation/Reforestation	Biomass		Soil	
	C before LUC (t C/ha*y)	Growth (t C/ha*y)	C stock before LUC (t C/ha)	C stock after 20 years of LUC (t C/ha)
Annual Cropland converted to Forestland	5.00	1.65	77.00	85.00
Perennial Cropland converted to Forestland	63.00	1.65	43.00	85.00
Grassland converted to Forestland	6.80	1.65	92.00	85.00
Wetlands converted to Forestland	0.00	1.65	0.00	85.00
Settlements converted to Forestland	4.34	1.65	37.04	85.00
Other land converted to Forestland	0.00	1.65	0.00	85.00

Table 11-8 – C stock change factors in D areas

Deforestation	Biomass		Dead wood	Soil	
	C before LUC (t C/ha*y)	Growth (t C/ha*y)	C before LUC (t C/ha*y)	C stock before LUC (t C/ha)	C stock after 20 years of LUC (t C/ha)
Forestland converted to Annual Cropland	124.96	5.00	1.68	85.00	77.00
Forestland converted toPerennial Cropland	124.96	2.10	1.68	85.00	43.00
Forestland converted to Grassland	124.96	6.80	1.68	85.00	92.00
Forestland converted to Wetlands	124.96	0.00	1.68	85.00	0.00
Forestland converted to Settlements	124.96	1.29 / 0.15	1.68	85.00	37.04
Forestland converted to Other land	124.96	0.00	1.68	85.00	0.00

Note: Biomass growth values for Forestland converted to Settlements correspond to annual and perennial plants, respectively.

11.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3

No carbon pool is omitted.

Net carbon stock changes in litter are not reported separately. The used forest soil C stock includes the total humus layer (with the litter layer). So the estimates of the soil C stock changes account for the changes in the litter. Any further estimates for the litter layer would therefore lead to a double accounting of this carbon pool.

Deadwood is assumed not to occur on AR areas. Due to the young age of the forests at AR areas (since 1990) and the assumed lack of dead wood at areas of all other land uses it is assumed that a stock change of dead wood does not occur at AR areas. If there was any in the young forests of AR areas it would represent a C stock increase due to the lack of dead wood in the previous land uses. So, this assumption is conservative.

There is no practice of biomass burning at ARD areas in Luxembourg. Furthermore, forests are not fertilised in Luxembourg. So, fertilisation at AR areas and liming at ARD areas do not occur.

11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

Due to a lack of available methods in the IPCC GPG and elsewhere, indirect and natural GHG emissions/removals have not been factored out.

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

No recalculations were performed since the last submission.

11.3.1.5 Uncertainty estimates

An uncertainty assessment of emissions/removals of the ARD units is planned during 2011.

11.3.1.6 Information on other methodological issues

The methods used to estimate emissions/removals from ARD activities are of the same tier method as those used for the UNFCCC reporting.

11.3.1.7 The year of the onset of an activity, if after 2008.

In 2008, the following ARD activities were presumed: AR at 177 ha, D at 296 ha.

In 2009, the following ARD activities were presumed: AR at 177 ha, D at 296 ha.

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

The OBS89, OBS99 and OBS07 land use maps are the main data providers for the greenhouse gas reporting of IPCC category forestland. The OBS89, OBS99 and OBS07 maps represent the land use status in 1989, 1999 and 2007, respectively. Thus, the OBS99 allows to determine the differences in land use since the 1st of January 1990 and 1999, and the OBS07 between 1999 and 2007. For the period after 2007, the land use changes have to be extrapolated. A new land use map (OBS12) is expected to be available in 2013, covering land use data for the year 2012, so that after 2012 the land use changes, occurring during the commitment period (2008-2012) could be estimated by the same procedure as for the years 1989 to 2007.

Luxembourg considers all LUC from and to forest land since 1990 as detected by OBS as “direct human induced” ARD lands. In addition, it might be noteworthy to mention that the total forest land area of Luxembourg is to be considered as “managed forest”, so that the definition of forest management, as defined in the Marrakesh Accords, is applicable: “a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of forest in a sustainable manner”.

Information that demonstrates that activities under Article 3.3 are directly human-induced is derived from the National Nature Conservation Act (Loi du 19 janvier 2004 concernant la protection de la nature et des ressources naturelles (telle qu’elle a été modifiée)) downloadable in French). More specifically, chapter 4 of the act regulates the protection of fauna and flora, and in particular articles 13 and 17 state the following:

"*No change of use of forestland is permitted, except if the minister authorises it in the case of a general interest, or in view of a enhancement of agricultural structures. However, if such authorisation is given, compensating reforestation must be undertaken elsewhere (see note [a] at the end of this section).*"[172].

The total AR areas since 1990 are approximately as large as the D areas since 1990 which is the result of the Nature Conservation Act that leads to direct human induced "compensating reforestations" (AR in sense of Kyoto-Protocol) under this Act when deforestations are allowed.

A further possibility for deriving such data would be the use of Luxemboug's second national forest inventory (NFI), which is currently being compiled. The first forest inventory results are from 1999. The results for the second forest inventory will be available at the beginning of 2012. But the use of the second NFI would allow to estimate the changes in land use, as well from forestland to non-forestland as from non-forestland to forestland.

However, the OBS surveys (1) have an excellent fit with the time period under consideration for the Kyoto Protocol, (2) assessed the land use in the total area in Luxembourg and (3) detected rather balanced ARD areas in the observed time period which is in line with the legal situation in Luxembourg that requests "compensation reforestations" after deforestations. Therefore, Luxembourg considers all LUC from and to forest lands as observed by the OBS as "direct human induced" ARD lands.

Nevertheless, Luxembourg will continue to validate and, if needed, improve its reporting of ARD lands on the basis of all available statistics, data and administrative documents.

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

Art 13 of the National Nature Conservation Act states *that 3 years after a clear cut on forestland, the owner is pledged to reconstruct the forestland*.[173] This means that areas of forestland, where a clear-cut has occurred, has to be considered as forestland, as no other use of forestland after a clear-cut is permitted. In addition, after a period of three years, the owner is forced to take measures to restore

172 Please note that the cited text is a translation/interpretation from French to English of some text passages of the legal text from art. 13 and art. 17. The relevant French legal text is cited in section 11.4.4)

173 See section 1.4.4. for the original French text of article 13.

forestland, if it hasn't occurred already. So no deforestation can occur by law, except if permitted by a ministerial act. If this is the case, this is documented by the Ministry.

The OBS, which is the basis of the land use and land use change assessment in Luxembourg, takes these provisions into account and assesses clear-cut forest areas as forest land. Indeed, for the generation of the OBS, a specific photo-interpretation manual providing instructions for the OBS mapping (based on aerial orthophotographs and field surveys) including real world pictures was used. This manual was compiled by Hansaluftbild GmbH (Germany), the service provider who generated the OBS99 map (a pdf copy in German can be obtained upon request). In this mapping manual, two categories namely WSF (other forest areas (felled-area flora, wind throws), translated from German: "*sonstige Forstflächen (Schlagflur, Windbruch)*") and WAU (forest plantings (plantings, thickets, natural regenerations), translated from German: "*Forstliche Pflanzung (Aufforstung, Dickungen, Naturverjüngung)*") correspond to clear-cut areas. These areas are to be considered as forest land as they belong to the general category "forest". Opposed to these, are areas where no trees could be detected during the subsequent mapping exercise (in this case the OBS07 mapping), and where an other land use could be identified (for example sealed surfaces). These areas are were then obviously not counted to forest land but to their new land use category (for "sealed areas" this would be "settlements"). In other words, if for a given area, which was classified in "forest land" in OBS99, and in the following OBS07 has been classified to another land use, then this area is assigned to "deforestation". If the same forest area, meaning an area with trees, was identified at a later stage as an area with no trees, and no other land use could be detected, then this area was identified as WAU respectively WSF and classified to "forest land".

11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

With regards to clear cut areas (areas that lost forest cover but are not classified as "Deforested"), there are 2 distinct classes in the OB89 nomenclature:

- « *32414 végétation des coupes forestière* » and
- « *32415 recrus divers* ».

In addition to these polygons, so-called "new clear cut" areas were identified using Earth observation satellite data from the French SPOT1 satellite recorded in 1989.

With regards to clear cut areas (areas that lost forest cover but are not classified as "Deforested"), there is one distinct class in the OB99/07 nomenclature, i.e. "3134 Autres surfaces forestières (coupes rases, chablis)". The relevant areas were assigned to Forest Areas without trees.

Table 11-9 – Areas having lost forest cover but not classified as deforested (1989, 1999, 2007)

Class	Area in OBS89 (ha)	Area in OBS99 (ha)	Area in OBS07 (ha)
32414 Vegetation des coupes forestière	3912		
32415 Recrus divers	2699		
New Clear Cut areas (as identified from satellite images)	444		
3134 Autres surfaces forestierès (coupes rases, chablis)		1441	1307

11.4.4 Articles 13 and 17 of the National Nature Conservation Act

Loi du 19 janvier 2004 concernant la protection de la nature et des ressources naturelles (telle qu'elle a été modifiée):

Art. 13. *Tout changement d'affectation de fonds forestiers est interdit, à moins que le Ministre ne l'autorise, dans l'intérêt général ou en vue de l'amélioration des structures agricoles.*

Le Ministre imposera des boisements compensatoires quantitativement et qualitativement au moins égaux aux forêts supprimées et cela sur le territoire de la commune ou de la commune limitrophe. Il peut substituer la création d'un autre biotope ou habitat approprié au sens de l'article 17 au boisement compensatoire.

Le Ministre peut déroger à l'alinéa qui précède dans l'intérêt de la conservation des habitats de l'annexe 1.

Après toute coupe rase le propriétaire ou le possesseur du fonds est tenu de prendre, dans un délai de 3 ans à compter du début des travaux d'abattage, les mesures nécessaires à la reconstitution de peuplements forestiers équivalant, du point de vue production et écologie, au peuplement exploité.]

Art. 17. *Il est interdit de réduire, de détruire ou de changer les biotopes tels que mares, marécages, marais, sources, pelouses sèches, landes, tourbières, couvertures végétales constituées par des roseaux ou des joncs, haies, broussailles ou bosquets.*

Sont également interdites la destruction ou la détérioration des habitats de l'annexe 1 et des habitats d'espèces des annexes 2 et 3.

Sont interdits pendant la période du 1er mars au 30 septembre:

a) la taille des haies vives et des broussailles à l'exception de la taille des haies servant à l'agrément des maisons d'habitation ou des parcs, ainsi que de celle rendue nécessaire par des travaux effectués dans les peuplements forestiers;

b) l'essartement à feu courant et l'incinération de la couverture végétale des prairies, friches ou bords de champs, de prés, de terrains forestiers, de chemins et de routes.

Le Ministre peut exceptionnellement déroger à ces interdictions pour des motifs d'intérêt général.

Le Ministre imposera des mesures compensatoires comprenant, si possible, des restitutions de biotopes et d'habitats quantitativement et qualitativement au moins équivalentes aux biotopes et habitats supprimés ou endommagés.

11.4.5 Information on emissions and removals of greenhouse gases from lands harvested during the first commitment period following afforestation and refforestation on these units of land since 1990 consistent with the requirements under paragraph 4 of the annex to decision 16/CMP.1 (paragraph 8 (c) of the annex to 15/CMP.1)

The average age for these lands during the first commitment period is 10 years. No forest land in Luxembourg is clear-cut or even thinned by the age of 10 years. the first thinning is usually made after the age of 20 years.

11.5 Article 3.4

Luxembourg did not choose any article 3.4 activities.

11.6 Other information

11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

In Luxembourg, LULUCF activities under the Kyoto Protocol are not considered as key categories. For further explanations, please refer to chapter 1.5.2.

11.7 Information related to Article 6

There are no Article 6 activities concerning the LULUCF sector in Luxembourg.

12 Information on accounting of Kyoto units

12.1 Background information

Annex I Parties are required to report, from their national registry, the holding of Kyoto units and the transactions of Kyoto units in the previous calendar year, i.e. 2010, and inform about related issues. The following chapters serve this purpose.

12.2 Summary of information reported in the SEF tables

The standard electronic format (SEF) for providing information on ERU's, CERs, tCERs, lCERs, AAUs and RMUs for the year 2010 was submitted to the UNFCCC on April 15th, 2011 (SEF_LU_2011_1_10-5-35 6-1-2011.xls).

12.3 Discrepancies and notifications

Further information on KP units referring to the respective paragraphs of decision 15/CMP.1 is reported in the following list:

- **Paragraph 12:** No discrepant transactions occured in 2010.
- **Paragraph 13:** No CDM notification occurred in 2010.
- **Paragraph 14:** No CDM notification occurred in 2010.
- **Paragraph 15:** No non-replacements occured in 2010.
- **Paragraph 16:** No invalid units exist as at 31 December 2010.
- **Paragraph 17:** No actions were taken or changes made to address discrepancies for the period under review

12.4 Publicly accessible information

The public reports relating to Luxembourg's emissions trading registry can be directly consulted on the dedicated website: https://www.climateregistry.lu/crweb/report/public/publicReportList.do

Reports are provided according to Annex XVI of the Commission Regulation 2216/2004 amended by Regulation 916/2007, Regulation 994/2008 and Regulation 920/2010.

12.5 Calculation of the commitment period reserve (CPR)

Calculation of the Commitment Period Reserve (*CPR*) at 31/12/2010:

48.986.302 AAUs + 24.138 ERUs + 0 RMUs + 1.840.677 CERs + 0 tCERs + 0 lCERs = 50.851.117 units, which is 8.188.421 units above the threshold for CP 1 (2008-2012).

For Luxembourg, this CPR threshold is 42.662.696 units (90 per cent of the assigned amount).

The CPR can be calculated via the SEF: take the sum of all units in party holding, entity holding and retirement accounts in the table 4 of the SEF report of this year. This table contains all units at the end of the year and is therefore the CPR.

12.6 KP-LULUCF accounting

Luxembourg selected accounting of the KP-LULUCF activities at the end of the commitment period.

13 Information on changes in the national system

The national system is unchanged compared to the description given in the previous National Inventory Report.

14 Information on changes in the national registry

No significant changes occurred during 2010.

14.1 Information submitted in accordance with paragraph 32 of the annex to decision 15/CMP.1

The required information was provided in the UNFCCC Registry Readiness Questionnaire for LU (hereafter referred to as RQ) as confirmed in the IAR of the LU registry.

14.2 Registry Administrator

The name and contact information of the registry administrator designed by the Party to maintain the national registry.

No change in the name or contact information of the Registry Administrator occurred during the reported period.

The name of the registry administrator is: Ms. Martine Kemmer.

Name:	Administration de l'environnement
Adress:	16, rue Eugène Ruppert
City:	L-2453 Luxembourg
Tel:	+352 40 56 56 525
Fax:	+352 49 62 56
e-mail:	regadmin@aev.etat.lu or martine.kemmer@aev.etat.lu

14.3 Consolidated System with other Parties

The names of the other Parties with which the Party cooperates by maintaining their national registries in a consolidated system.

No change of cooperation arrangement occurred during the reported period.

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 14-1 below.

Table 14-1 – 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

14.4 Database structure and capacity

A description of the database structure of the national registry.

No change to the database or to the capacity of the national registry occurred during the reported period.

The database structure and capacity correspond to the requirements of the Data Exchange Standards (*DES*).[174]

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.

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174 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.

14.5 Conformity with Data Exchange Standards

A description of how the national registry conforms to the technical standards for data exchange between registry systems for he purpose of ensuring the accurate, transparent and efficient exchange of data between national registries, the clean development mechanism registry and the transaction log (decision 19/CP.7, paragraph 1).

No changes to the conformity with data exchange standards were performed in the reported period.

On the 30th of September 2009 the registry software was upgraded towards version 1.8.0 (as developed by Dr. Lippke & Dr. Wagner GmbH based on the CR software). This new version of the software was tested according to the ETS test plan on 24th of September 2009.

The European Commission confirmed on 29th of September 2009 that the new version of the registry software had passed all mandatory test cases and that it was ready to release; however the final test certificate has not yet been delivered.

14.6 Minimization of discrepancies

A description of the procedures employed in the national registry to minimize discrepancies in the issuance, transfer, acquisition, cancellation and retirement of ERUs, CERs, tCERs, lCERs, AAUs and/or RMUs, and replacement of tCERs and lCERs, and of the steps taken to terminate transactions where a discrepancy is notified and to correct problems in the event of a failure in termination the transactions.

No change of discrepancies occurred during the reported period.

14.7 Overview of security measures

An overview of security measures employed in the national registry to prevent unauthorized manipulations and to prevent operator error and of how these measures are kept up to date.

Since the end of November 2010, all users are blocked. This temporary security measure will be maintained until the introduction of the 2-factor authentication with SMS-tan.

14.8 Publicly accessible information

A list of the information publicly accessible by means of the user interface to the national registry.

No change of the list of publicly available information occurred during the reporting period.

Data related to operator holding accounts can be consulted and downloaded under: https://www.climateregistry.lu/crweb/report/public/accountOh.do

Information about all accounts, account holders and representatives can be consulted and downloaded under: https://www.climateregistry.lu/crweb/report/public/account.do

Due to the latest amendment of the Commission Regulation 2216/2004 (Commission Regulation 920/2010, Annex XVI, point 2(c)[175]), account holders have to request in writing to display all or some of the information of their account representatives.

14.9 The Internet address of the interface to its national registry

General registry website: http://www.environnement.public.lu/air_bruit/dossiers/CCregistre_national_quotas_GES/index.html

Secured direct access to the Registry: https://www.climateregistry.lu

No change of the registry Internet address occurred during the reporting period.

14.10 Disaster recovery

A description of measures taken to safeguard, maintain and recover data in order to ensure the integrity of data storage and the recovery of registry services in the event of a disaster.

No change of data integrity measures occurred during the reporting period.

A new Disaster Recovery exercise has been performed on the 4th and 5th June 2009.

The main goal of this exercise was to test the revised DR procedure with the actual situation (the first DR exercise dated from before the Go-Live with the ITL).

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.

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

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175 The following information for each account shall be displayed in the week after the account has been created in a registry, and shall be updated on a weekly basis: … (c) name, address, city, postcode, country, telephone number, facsimile number and email address of the primary and secondary authorized representatives of the account specified by the account holder for that account, provided that the account holder requested the registry administrator in writing to display all or some of this information.

14.11 Test procedures

The results of any test procedures that might be available or developed with the aim of testing the performance, procedures and security measures of the national registry undertaken pursuant to the provisions of decision 19/CP.7 relating to the technical standards for data exchange between registry systems.

No change of test results occurred during the reported period.

As stated under 14.5, the new registry software version passed successfully the ETS test plan (test scenarios version 1.1).

14.12 Previous annual review recommendations

§.1.5.1. One review recommendation is still remaining.

§.1.5.2. As there were no Joint Implementation projects (JI projects) so far, the page displaying the information on this project still shows an empty list ("No Entries"). A bug was filed to display an additional statement to clearly inform the users that "No Entries" corresponds with the fact that no Article 6 projects took place yet.

This bug has however not been implemented in production yet, due to delayed software upgrades (bug milestone is set to version 2.0 of the registry software).

§1.5.3. The calculation of the Commitment Period Reserve according to 15/CMP.1 annex I.E. paragraph 18 is reported.

15 Information on minimization of adverse impacts in accordance with Article 3, paragraph 14

23. Each Party in Annex I shall provide information relating to how it is striving, under Article 3, paragraph 14, of the Kyoto Protocol, to implement its commitments mentioned in Article 3, paragraph 1 of the Kyoto Protocol in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention.

The Kyoto Protocol is, in principle and in general, designed to minimize adverse effects on specific sectors, specific industries or specific trade partners of a Party, including the adverse effects of climate change, on international trade, and social, environmental and economic impacts on other parties. This is due to the fact that it does not limit action to a single gas or sector, that the use of its flexible mechanisms garantees that possible impacts are distributed on various fields of action, that the Clean Development Mechanism aims at both promoting sustainable development in countries with continuing development needs and at reducing greenhouse gas emissions, and that it requests action to support the least developed countries. By striving to implement all the features that the Protocol has integrated Luxembourg is naturally working to minimize not only adverse effects of climate change but also any adverse effects due to the reduction of greenhouse gases.

Luxembourg is strongly promoting long term sustainable development and will hence have scarcely direct or indirect negative effects. In cases where adverse effects could occur, the following measures are/were undertaken:

Adverse effects of climate change

Emission Trading could lead to carbon leakage and higher emissions in countries which do not have comparable environmental standards. To minimise that risk, according to EU Directive 2003/87/EC emission allowances are granted for free to companies with specific characteristics.

Social, environmental and economic impacts on developing countries

JI/CDM projects may in principle have negative side effects in the host countries. For example, projects for the production of biofuels might add to deforestation of forests and/or result in higher prices for food. Luxembourg's JI/CDM programme therefore has demanding social and environmental criteria to be eligible as a Luxembourgish JI/CDM project. The favoured project categories reflect the high priority that is given to technology transfer projects. http://ec.europa.eu/environment/climat/pdf/lux_nap_final.pdf/)

Ensuring that any consequences of economic affairs are addressed, Luxembourg is improving its policies to eliminate potential negative impacts.

24. Parties included in Annex II, and other Parties included in Annex I that are in the position to do so, shall incorporate information on how they give priority, in implementing their commitments under Article 3, paragraph 14, to the following actions, based on relevant methodologies referred to in paragraph 11 of decision 31/CMP.1

(a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities.

Market imperfections:

Luxembourg has reformed its energy markets to a large extent to reduce market imperfections and in order to comply to European legislation:

- Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92EC.
- Directive 2003/55/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in natural gas and repealing Directive 98/30EC.
- Council Directive 90/377/EEC of the 29 June 1990 concerning a Community procedure to improve the transparency of gas and electricity prices charged to industrial end-users.
- Regulation (EC) No 1228/2003 of the European Parliament and of the Council of 26 June 2003 on conditions of access to the network for cross-border exchanges in electricity.
- Directive 2004/17/EC of the European Parliament and of the Council of 31 March 2004 coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors.

Fiscal incentives:

Several fiscal incentives have been put in place, aiming at reducing the use of fossil fuels:

- vehicle tax reform (RGD 22 december 2006): the tax is based on CO2 emissions from road vehicles.
- raising excise duties on fuels for transport purposes: By the 1st of january 2007, the exise rate on gasoline was increased by 2ct€/litre. For diesel, the excise rate was increased in two stages: 1.25ct€/litre on 1.1.2007, and by a further 1.25 cte/litre on 1.1.2008. This autonomous addition to the existing excise rates is used to finance the Kyoto funf set up in Luxembourg to deal with the Kyoto "flexible mechanisms" and is labled "climate change contribution". Indeed, increasing excise rates on road fuels lead to an increase of fuel retail prices and thus, set an incentive for consumers to lower demand.

Subsidies:

Several subsidies have been put in place in the residential, commercial and institutional sectors, aiming at reducing the use of fossil fuels:

- promotion of energy efficiency and the use of renewable energy sources in the residential sector (solar heaters, heat pumps, photovoltaics, biomass boilers and wood stoves).
- program encouraging refurbishment of existing residential buildings to increase energy efficiency.
- program encouraging the construction of highly energy efficient residential buildings.
- establishment of an energy pass certifying the energy class of residential, commercial and institutional buildings.
- promoting low energy electrical appliances.

(b) Removing subsidies associated with the use of environmentally unsound and unsafe technologies.

So far, no subsidies for environmentally unsound technologies have been identified.

(c) Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end.

This technological field is not a high priority in Luxembourg's research policy.

(d) Cooperating in the development, diffusion and transfer of less-greenhouse-gasemitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort.

(e) Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities.

(f) Assisting developing county Parties which are highly dependent on the export andconsumption of fossil fuels in diversifying their economies.

For (d) to (e) please refer to Luxembourg's 5th national communication, p.236-240.

16 References

16.1 Chapter 3: Energy (CRF sector 1)

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.

16.2 Chapter 4: Industrial Processes (CRF sector 2)

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.

EMEP/CORINAIR Emission Inventory Guidebook, 3rd edition (2006). European Environment Agency (EEA), Copenhagen.

EMEP/CORINAIR Guidebook (1996): Atmospheric Emission Inventory Guidebook. Prepared by the EMEP Task Force on Emission Inventories. Edited by Stephen Richardson, Task Force Secretary.

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.

INTERMOSELLE (1990 – 2007): Statistics on production and fuel consumption. Rumelange, Luxembourg.

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

Luxguard (1990 – 2007): Operation permits for Luxguard I and II. Luxembourg.

Ministère de l'Economie et du Commerce Extérieur, Direction de l'Energie (1990 – 2007): Rapports d'Activité. Luxembourg.

Ministère de l'Environnement, L'Environnement en Chiffres 2002-2003 (2003).

STATEC 1990 – 2007. Annuaires statistiques. Luxembourg.

Schwarz, 2009, Oeko-Recherche: Emissionen fluorierter Treibhausgase in Deutschland 2006 und 2007

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.

16.3 Chapter 5: Solvent and Other Product Use (CRF sector 3)

BARNERT (1998): ÖSTERREICHISCHES LACKINSTITUT: MÖGLICHKEITEN UND GRENZEN UMWELTVERTRÄGLICHER BESCHICHTUNG (LACKE, KLEBSTOFFE, BAUTENSCHUTZMITTEL, HOLZSCHUTZMITTEL), WIEN. AUSTRIA

EUROSTAT (2008): Enterprises and employees in Luxembourg (Industry, NACE Rev.1 Level-4), 1995-2005. http://epp.eurostat.ec.europa.eu.

SCHMIDT A., VITOVEC W., PUXBAUM H. & KNIERIDER R. (1998): TU Wien, Gesellschaft Österreichischer Chemiker: Die ökologischen Auswirkungen der Lösungsmittelverordnung 1991 und 1995. September 1998, Wien. Austria.

WINIWARTER, W.; KÖTHER, T (2008): UNCERTAINTY RELATED TO LUXEMBOURG'S NATIONAL GREENHOUSE GAS INVENTORY. AUSTRIAN RESEARCH CENTERS GMBH (ARC) DIVISION SYSTEMS RESEARCH. VIENNA. AUSTRIA.

WINDSPERGER, S.; STEINLECHNER, S.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G., SCHÖNSTEIN, R. & SCHÖRNER, G. (2002a): Gegenüberstellung und Abgleich der Daten von Top-down zu Bottom-up für Lösungsmittel im Jahr 2000. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, S.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G., SCHÖNSTEIN, R. & SCHÖRNER, G. (2002b): Verbesserung von Emissionsdaten (Inventur und Projektion bis 2010 für den Bereich Lösungsmittel in Österreich. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Lebensministeriums und Bundesministeriums für Wirtschaft und Arbeit. Wien.

WINDSPERGER, S.; STEINLECHNER, S.; SCHMIDT-STEJSKAL, H.; DRAXLER, S.; FISTER, G., SCHÖNSTEIN, R. & SCHÖRNER, G. (2004): Studie zur Anpassung der Zeitreihe der Lösungsmittelemissionen der österreichischen Luftschadstoffinventur (OLI) 1980–2002. Institut für Industrielle Ökologie (IIÖ) und Forschungsinstitut für Energie und Umweltplanung, Wirtschaft- und Marktanalysen GmbH (FIEU). Studie im Auftrag des Umweltbundesamt. Wien.

WINDSPERGER, S.; STEINLECHNER, S. (2006) : Pooling and Analysis of Information on Materials with Complicated Pathways (WP 1) – Part: Survey on Solvents, Oils and Lubricants. Institute for Industrial Ecology (IIÖ), Continuation of the "International Network Non-energy use and CO_2 emissions (NEU-CO2), Phase III. St.Pölten Austria.

WINIWARTER, W. (2008): Quantifying Uncertainties of the Austrian Greenhouse Gas Inventory, (ARC-sys-0154), Austrian Research Centers GmbH, Vienna Austria.

16.4 Chapter 6: Agriculture (CRF Sector 4)

European Environment Agency, EMEP/*CORINAIR Emission Inventory Guidebook – 2007*, *Technical Report N°16/2007*, Copenhagen, December 2007
http://www.eea.europa.eu/publications/EMEPCORINAIR5

Federal Office fort he Enviroment, *Switzerland's Greenhouse Gas Inventory 1990–2009*, *National Inventory Report 2010*, Bern, April 2010
http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5270.php

STATEC, *Annuaire statistique du Luxembourg 2010*, Luxembourg, March 2011
http://www.statistiques.public.lu/fr/publications/series/annuaire-stat-lux/index.html

STATEC, *Bulletin du STATEC 03_2009*, *Les recencements agricoles en 2008*, Luxembourg, August 2009
http://www.statistiques.public.lu/fr/publications/series/bulletin-statec/2009/03-09-recensement-agricole/index.html

STATEC, *Luxembourg in figures 2010*, Luxembourg, September 2010
http://www.statistiques.public.lu/fr/publications/series/lux-chiffres-fr/index.html

Umweltbundesamt, *Austria's National Inventory Report 2009*, Vienna, May 2010
http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5270.php

16.5 Chapter 8: Waste (CRF Sector 6)

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.

17 Annexes to the National Inventory Report

17.1 Annex 1: Key Categories

Please refer to Chapter 1.5 p. 52-58 for a description of the methodology for identifying key kategories, including KP-LULUCF, information on the level of disaggregation, Tables 7A1 - /A3 of the good practice guidance. Table NIR-3, as contained in the annex to decision 6/CMP.3 remains empty as no key categories were identified (please refer to explanations on p.57).

17.2 Annex 2: Detailed discussion of methodology and data for estimating CO_2 emissions from fossil fuel combustion

Please refer to Chapters 1.3-Inventory preparation (p.46-49), 1.4-Methodologies and data sources used (p.50-51) for a general overview, and Chapter 3-Energy (p.141-220) for a detailed description of all the methodologies and data used.

17.3 Annex 3: Other detailed methodological descriptions for individual source or sink categories, including for KP-LULUCF activities.

Please refer to the relevant Chapters for this kind of information, where all details are given and specific issues are discussed.

17.4 Annex 4: CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance.

For the time being, please refer to Chapter 3-Energy for this kind of information. For the next submissions, it is planned to extend extend the descriptions required in this annex. This issue needs also to be discussed with the National Statistical Agency (STATEC), especially clarify confidentiality issues and to define to which extend the energy balance can be detailed.

17.5 Annex 5: Assesement of completeness and (potential) sources and sinks of GHG emissions and removals excluded for the annual inventory submission.

The assessment of completeness can be found in Chapter 1.8 (p84-86). No sources and sinks have been excluded for this submission.

17.6 Annex 6: Additional information to be considered as part of the annual inventory submission.

CRF, KP-LULUCF and SEF tables as submitted under submission 2011v1.3 and as described in this report, can be downloaded from the UNFCCC website:

http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php

17.7 Annex 7: Tables 6.1 and 6.2 of the IPCCC good practice guidance.

Please refer to Chapter 1.7 (p68-84) for a full description of the uncertainty evaluation, including the required tables.

17.8 Annex 8: Other annexes.

No other annexes aer given.