LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Environnement

# Luxembourg's National Inventory Report 1990-2004

Submission under the United Nations Framework Convention on Climate Change

*Luxembourg, 29 December 2006*

*Contents*

# Chapter 1: Introduction

The Guidelines for the preparation of National Communications by Parties included in Annex I of the United Nation Framework Convention on Climate Change (*UNFCCC*), published on 3rd September 2004, determine in paragraph 38 that 'Annex I Parties shall submit to the COP, through the Secretariat, a National Inventory Report (*NIR*) containing detailed and complete information on their inventories'.

In conformity with the law of 27 November 1980, which created an Environment Agency,[1] the compilation and the maintenance of the national greenhouse gases (*GHG*) inventories, as well as the drafting of the NIR, are performed by the Air/Noise department of this Agency. It is worth noticing that the Environment Agency is also responsible for preparing emission inventories under the Convention on Long Range Transboundary Air Pollution (*CLRTAP*) and the EU emission ceilings Directive.

Consequently, annual GHG inventories of Luxembourg have been developed by the Environment Agency, for all years from 1990 through 2004. The input data used as a basis for the inventories are taken, among other sources, mainly from information supplied by operators of industrial or other activities, from official statistics compiled by the national statistics office (STATEC) and from statistical information received from other ministries (for example Ministry of Economic Affairs and External Trade). When no specific statistical data are available for Luxembourg, such as emission factors e.g., data from other European countries or from the literature were taken as default data.

All the material, estimates and calculation sheets, as well as the documentation on scientific papers and the basic data needed for the inventories compilation, are stored and archived within the Agency; the Ministry keeping only copies of the inventories (CRF tables) and of the related reports (such as the NIR) in its archives.

The inventories are developed according to the CORINAIR/EMEP methodology by using tools which were developed under the European Environment Agency's responsibility. These tools are the CollectER and ReportER software tools. For road traffic emissions, a software called COPERT has been used. COPERT has also been developed for the European Environment Agency. However, mostly IPCC Tier 1 approaches have been used for estimating GHG emissions, except when COPERT was used (COPERT is referred in IPCC Guidelines as a Tier 3 method).

A quantitative key source analysis has not yet been performed and a QA/QC plan has not yet been established. Also, an uncertainty evaluation of air emission data of annual inventories has not yet been done so far.

Until today, confidentiality of data has not been a major problem in the making of air emissions inventories.

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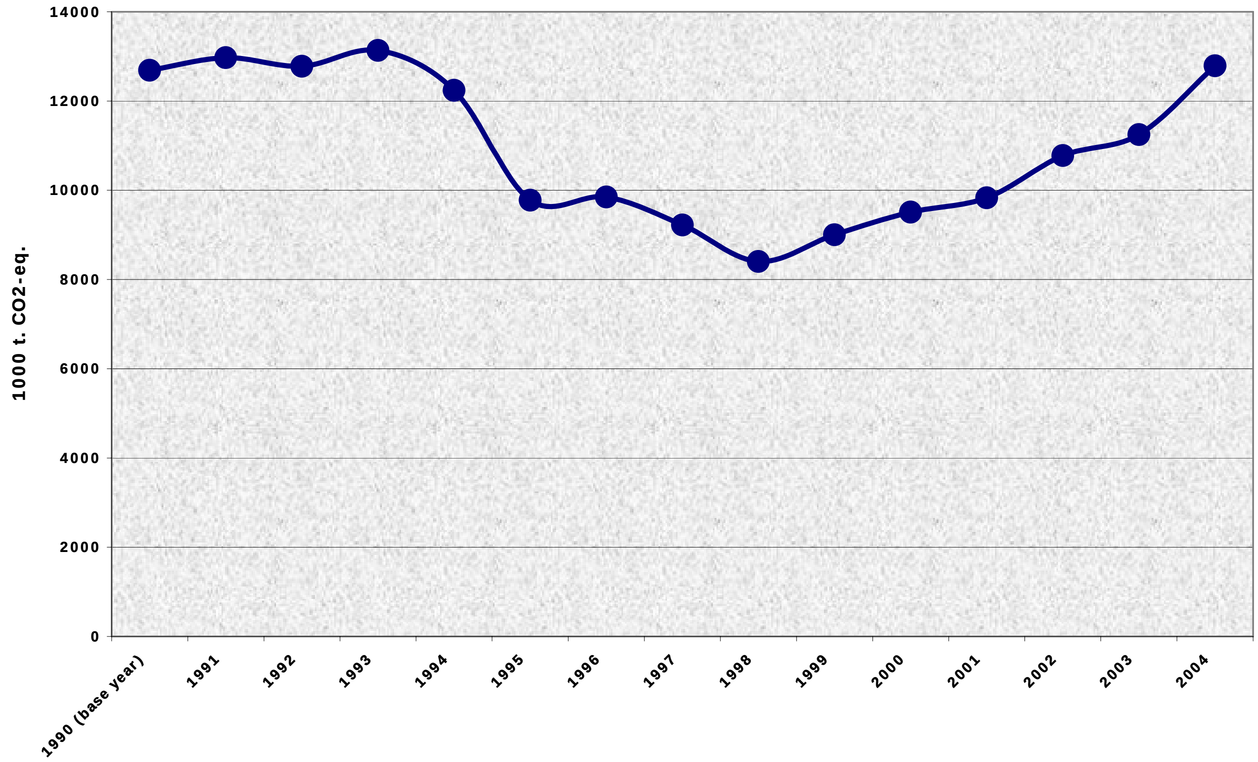
[1] The Environment Agency is directly linked to the Ministry of the Environment and works under its supervision.

# Chapter 2: Trends in GHG emissions

## 2.1. Description of emission trends for aggregated GHG emissions

Looking at the period between 1990 and 2004, GHG emissions of Luxembourg have been rather stable up to 1994. Between 1995 and 1998 they have decreased significantly. But since 1999, they have increased constantly from year to year, mainly because energy consumption and fuels sales in the transport sector have increased.

Graphic 1 -- Luxembourg's GHG emissions 1990-2004 without LUCF (1000 t $CO_2$-eq.)




The variations in those 15 years were essentially caused by changes of production techniques, changes of fuel types and changes of energy use. A major example for a production technique change happened in the iron and steel industry, where steel production process was changed – move from blast furnaces to electric arc furnaces – and, therefore, solid fuels (coke) were replaced to a very large extent by electricity. Due to that technological change, the total energy consumption in steel industry was significantly reduced (see also graphic 2 on page 5). Changes also occurred for the industrial and domestic sectors, where the consumption of liquid fuels (residual oil, gasoline) was reduced in favour of natural gas.

Finally, it is worth noticing that there are no known emission sources of PFCs in Luxembourg.

## Table 1 -- Luxembourg's GHG emissions and removals 1990-2004 (1000 t $CO_2$-eq.)

| Gg (1000 t.) $CO_2$ equivalent | 1990 (base year) | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ (without LUCF) | 12104.44 | 12382.86 | 12172.16 | 12518.85 | 11622.86 | 9157.55 | 9216.78 | 8569.30 | 7742.34 | 8316.24 | 8827.76 | 9096.11 | 10030.68 | 10486.28 | 11978.01 |
| fuel combustion | 10528.80 | 10856.30 | 10745.55 | 11024.54 | 10309.26 | 8194.41 | 8300.64 | 7728.03 | 7084.52 | 7626.17 | 8109.87 | 8434.71 | 9221.33 | 9739.23 | 11210.98 |
| industrial processes | 1556.59 | 1507.48 | 1407.50 | 1475.13 | 1294.38 | 943.86 | 896.78 | 821.87 | 638.36 | 670.58 | 698.54 | 642.24 | 790.14 | 727.84 | 747.81 |
| solvent and other product use | 9.05 | 9.08 | 9.11 | 9.18 | 9.22 | 9.28 | 9.36 | 9.40 | 9.46 | 9.49 | 9.35 | 9.16 | 9.21 | 9.21 | 9.22 |
| agriculture | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| LULUCF | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 | -294.93 |
| waste | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| other sources | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $CH_4$ (1) | 364.14 | 356.58 | 347.13 | 352.17 | 344.61 | 353.01 | 359.31 | 357.84 | 357.84 | 358.89 | 314.58 | 353.01 | 354.27 | 353.01 | 348.18 |
| $N_2O$ (2) | 201.50 | 213.90 | 244.90 | 244.90 | 254.20 | 248.00 | 257.30 | 275.90 | 288.30 | 310.00 | 319.30 | 334.80 | 347.20 | 362.70 | 415.40 |
| HFCs (3) | 13.62 | 13.62 | 13.62 | 13.62 | 13.62 | 13.62 | 13.62 | 13.62 | 13.62 | 13.62 | 43.07 | 43.07 | 43.07 | 43.07 | 43.07 |
| PFCs (4) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $SF_6$ (4) | 2.91 | 2.91 | 2.91 | 2.91 | 2.91 | 2.91 | 2.91 | 2.91 | 2.91 | 2.91 | 3.53 | 3.53 | 3.53 | 3.53 | 3.53 |
| Total GHG without LUCF | 12686.61 | 12969.87 | 12780.72 | 13132.45 | 12238.20 | 9775.09 | 9849.92 | 9219.57 | 8405.01 | 9001.66 | 9508.24 | 9830.52 | 10778.75 | 11248.59 | 12788.19 |
| LUCF (4) | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 | -316.63 |
| Total GHG with LUCF | 12369.98 | 12653.24 | 12464.09 | 12815.82 | 11921.57 | 9458.46 | 9533.29 | 8902.94 | 8088.38 | 8685.03 | 9191.61 | 9513.89 | 10462.12 | 10931.96 | 12471.56 |

Source: Environment Agency and Ministry

Notes

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

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

(3) the F-gases are those not covered by the Montreal Protocol, i.e. the HFCs, PFCs and SF6 expressed in $CO_2$ equivalents using the the global warming potential (GWP) values based on the effects of GHG over a 100-year time horizon.
These emissions are estimates based on different sources, amongst which a study conducted end 1999. This explains the break in the serie between 1999 and 2000.

(4) the land-use change and forestry emissions are based on constant estimates of 294.93 Gg of $CO_2$ for changes in forest and other woody biomass stocks (CRF 5A) and 0,07 Gg of $N_2O$ (i.e. 21,7 Gg $CO_2$ eq.) for other sinks (CRF 5E).

## 2.2. Description of emission trends by GHG (ref. Table 1, page 3)

### Carbon dioxide – $CO_2$

$CO_2$ is by far the biggest contributor to the total GHG emissions of Luxembourg. The main cause of $CO_2$ emissions is combustion of fossil fuels. 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 decarbonizing of mineral input in clinker and glass industry.

$CO_2$ emissions have decreased with the closing down of blast furnaces, whilst $CO_2$ emissions from liquid fuel and natural gas combustion have increased due to higher fuel consumption in the transport and in the electricity production sectors. Both trends have crossed in 1998, resulting in a minimum reached for national total GHG emissions.

### Methane – $CH_4$

Methane emissions are caused above all in the agricultural sector by enteric fermentation and by manure production and management. As agriculture in general, and life stock in particular, have been rather stable in the time period considered here, the corresponding methane emissions have not varied very much.

Another important source of methane emissions is waste treatment (solid waste, waste water). All major solid waste landfills in Luxembourg have a methane recovery system and respect the provisions of the EU Council Directive 1999/31/CE on the landfill of waste.

### Nitrous oxide – $N_2O$

A large part of nitrous oxide emissions are caused by agricultural soils. Another important source, which has generated increasing $N_2O$ emissions since 1990, is road transport, where incomplete $NO_X$ reduction in catalytic converters of gasoline motor vehicles leads to higher $N_2O$ emissions.

### Hydrofluorocarbons – HFCs

In a first study done end of 1999 by the Environment Agency of Luxembourg and Luxembourg's *Centre de Ressources des Technologies pour l'Environnement* (*CRTE*), the situation of fluorinated GHG emissions in Luxembourg was analyzed. Estimates of emissions of hydrofluorocarbons (*HFCs*), perfluorocarbons (*PFCs*) and sulphur hexafluoride (*$SF_6$*) were done. They indicated that there are some emissions of HFCs and of $SF_6$ in Luxembourg, but no emissions of PFCs however. The increase in HFCs emissions between 1990 and 2004 can be explained by more wide spread use of mobile and stationary cooling equipments.

In Luxembourg refrigerators are recycled systematically at the end of their life-cycle. Refrigerant fluids and gases of the thermal insulation foams are recovered. This happens currently for approximately 15 000 refrigerators every year, which represent 65% of all end of service refrigerators.

Sulphur hexafluoride – $SF_6$

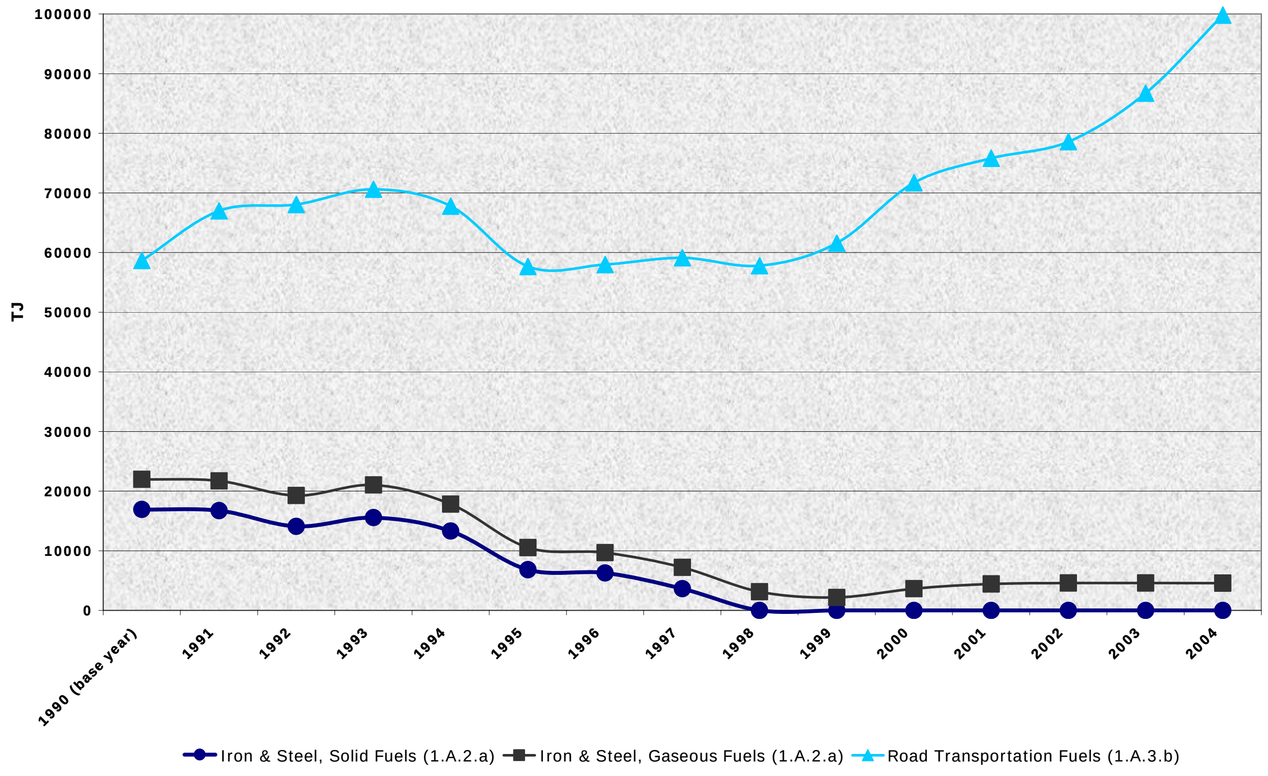
Emissions data of $SF_6$ were taken from the same analysis as those of HFCs. In that study, $SF_6$ emissions are expected to grow in the time period between 1995 and 2010 because of a higher use of high voltage electrical devices, and because a higher amount of $SF_6$ is expected to be emitted from noise reduction windows.

## 2.3. Description of emission trends by category (ref. Table 1, page 3)

### Energy

Due to their importance, the $CO_2$ emissions of the energy sector determine the trend of the overall annual national totals of Luxembourg. Moreover they reflect the fact that the iron and steel industry of Luxembourg has abandoned their blast furnaces between 1994 and 1998, and that fossil fuel consumption as well as road fuels sales have continued to increase after 1998. Many other emission trends are hidden by those two phenomena due to their importance in the national total GHG emissions.

Graphic 2 – Evolution of fuels consumption in the iron & steel and road transportation sectors (TJ)




### Industrial Processes

Carbon dioxide is the determining GHG in that category. Other GHG are HFCs and $SF_6$, however, they are of minor importance in the context of emissions of industrial process, and therefore they are not discussed here, but in the chapters of fluorinated gases.

For industrial processes; the major carbon dioxide emission sources are (emission values of 1990):

- Iron and steel industry (sintering of iron ore, basic oxygen furnace steel plants): 966 kt;
- Clinker/cement production: 551 kt;
- Glass production: 40 kt.

While the process emissions of iron and steel industry were reduced since 1990, with the move from blast furnaces to electric arc furnaces, the process emissions of the clinker/cement and of the glass production stayed rather stable.

### Solvent and Other Product Use

Emissions of VOCs have increased between 1990 and 1999 because of an increase in activities implying solvents use. After the introduction of paints with lower solvent concentrations, emissions have curbed and could be reduced compared to the maximum of 1999.

The estimation of VOC emissions of Luxembourg is partly based on data of 1994. However, in order to better reflect developments in solvent applications in the last years, an update of the estimations of VOC emissions must be done.

### Agriculture

Methane

The rather stable emission value is determined by the number of cattle. These numbers of cattle did not change dramatically during the period 1990-2004: from 217 451 heads to 186 725 for bovine animals and from 75 463 heads and 84 611 for pigs.

Nitrous oxide

As it is the case for methane, $N_2O$ emissions from agricultural soils were rather stable at a level of some 470 t of $N_2O$, due to the fact that the surface area of agricultural land, both the surface and the way of using it, did not change significantly between 1990 and 2004: total surface used in agriculture varied from 126 298 ha in 1990 to 128 073 ha in 2004.

### Land Use, Land Use Change and Forestry

A first estimation of the amounts of carbon captured by vegetation in Luxembourg has suggested a value of 294 930 t of $CO_2$ per year. This value has been included in all annual inventories since 1990.

### Waste

A value of 10 kt of $CO_2$ per year has been reported in all annual inventories since 1990 for the incineration of domestic waste. This figure corresponds to the emissions of carbon dioxide from the combustion of the non-biomass fraction of waste.

Waste disposal on land, waste water treatment and sludge spreading caused methane emissions of some 1.55 kt in 1990 and 1.14 kt in 2004. The impact on air emissions of the systematic recovery of refrigerant fluids and of the recycling of the various municipal waste fractions needs to be analysed in more detail to further improve the inventories.

## 2.4. Indirect GHG and $SO_2$

Indirect GHG are calculated in Luxembourg in the context of the Geneva Convention of 1979 on Long Range Transboundary Air Pollution (*CLRTAP*) using the CollectER software provided by the European Environment Agency. Air emissions of road transport calculated with the COPERT software are based on national vehicle fleet data and, in a second phase, are adjusted, using total fuel sales, to reflect the important share of fuel exports.[2] This correction is done only for the main GHG ($CO_2$, $CH_4$ and $N_2O$); hence 'not estimated' entries for the other gases (NOx, CO, NMVOC and $SO_2$) in CRF table 1. As a result, for Luxembourg, there are differences in the way GHG and indirect GHG data are calculated. For that reason the emissions of indirect GHG, and $SO_2$ in particular, are not analyzed here.

[2] In 1990, fuel combustion from the transport sector accounted for 21,5% of total GHG emissions (excluding LUCF). Then, with nearly 7 millions of tonnes of $CO_2$, this percentage reached 55% in 2004. $CO_2$ emissions due solely to 'fuel export' (i.e. fuel sold in Luxembourg but mostly consumed abroad) amounted to about 1.9 millions of tonnes in 1990 and reached almost 5.2 millions of tonnes in 2004, i.e. roughly a threefold increase (the same comparison shows only a twofold increase for road fuel consumed by the national vehicle fleet). In 2004, 'fuel export' represented 76.5% of $CO_2$ emissions due to the transport sector and more than 40% of total GHG emissions (excluding LUCF). For 1990, these percentages were, respectively, 71.5% and 14.5%.

# Chapter 3: Energy (CRF sector 1)

## 3.1. Overview of the energy sector

Between 1990 and 2004, the national total of carbon dioxide emissions has been strongly influenced by varying fuel consumption levels in industry, in particular in steel industry, as well as in road transport. There are several industrial sites which have relatively high levels of GHG emissions, and which, therefore, have had a large impact on the national total. In the transport sector, road fuel consumption, and even more so road fuel sales, has a very important weight in the national energy balance, and, consequently, has also a very important impact on the national total of $CO_2$ emissions.

The passage from blast furnaces to electric arc furnaces in the steel industry allowed to significantly reduce GHG emissions of that sector between 1994 and 1997. Due to the importance of iron and steel industry in Luxembourg, this evolution hided many other trends in $CO_2$ emissions between 1990 and 1998. After 1998, the increase of road fuel sales and, to a lesser extent, of electric energy production has lead to a rather steep increase of $CO_2$ emissions in these sectors and, by extension, of the national $CO_2$ total. Again, trends in other sectors have been mostly hidden by these two phenomena occurring in the transport and the electric energy production sectors.

The final energy consumption of Luxembourg has increased by almost 30% between 1990 and 2004. It has passed through a minimum between 1995 and 1998 (see table 2).

Table 2 – Final energy consumption 1990-2004 (ktoe)

| Year | Total | Solid fuels (coal, coke, wood, biomass) | Liquid fuels | Natural gas | Electricity | heat & cogeneration | blast furnaces' gas |
|---|---|---|---|---|---|---|---|
| 1970 | 3735.40 | 1285.40 | 1230.00 | 10.00 | 210.00 | 0.00 | 1000.00 |
| 1980 | 3422.37 | 1356.95 | 1048.95 | 360.15 | 310.17 | 0.00 | 346.15 |
| 1990 | 3399.79 | 834.32 | 1583.83 | 439.84 | 351.56 | 0.00 | 190.24 |
| 1991 | 3576.91 | 751.26 | 1838.66 | 450.74 | 363.45 | 0.00 | 172.80 |
| 1992 | 3583.32 | 718.86 | 1881.10 | 469.46 | 365.17 | 0.00 | 148.73 |
| 1993 | 3654.22 | 748.46 | 1883.51 | 488.19 | 378.47 | 0.00 | 155.59 |
| 1994 | 3607.77 | 666.69 | 1882.14 | 525.22 | 400.27 | 2.00 | 131.45 |
| 1995 | 3215.21 | 398.39 | 1734.00 | 574.45 | 430.85 | 12.27 | 65.25 |
| 1996 | 3298.54 | 389.69 | 1785.83 | 627.00 | 422.96 | 13.07 | 59.99 |
| 1997 | 3258.61 | 264.33 | 1864.12 | 648.60 | 435.92 | 13.46 | 32.18 |
| 1998 | 3237.95 | 132.02 | 1971.77 | 655.32 | 456.15 | 22.69 | 0.00 |
| 1999 | 3411.23 | 130.90 | 2103.82 | 679.18 | 473.77 | 23.56 | 0.00 |
| 2000 | 3582.85 | 144.20 | 2227.62 | 692.52 | 491.60 | 26.91 | 0.00 |
| 2001 | 3773.15 | 178.23 | 2368.94 | 708.62 | 484.31 | 33.05 | 0.00 |
| 2002 | 3763.27 | 109.50 | 2425.70 | 703.74 | 487.83 | 36.50 | 0.00 |
| 2003 | 3994.14 | 95.34 | 2622.03 | 712.99 | 517.26 | 46.52 | 0.00 |
| 2004 | 4400.00 | 110.00 | 2940.00 | 760.00 | 540.00 | 50.00 | 0.00 |

Source: STATEC, Ministry of Economic Affairs and External Trade

As table 2 shows, in 1990 big amounts of solid fuels were still used in the iron and steel industry. However, the passage from blast furnace technology to electric arc furnaces between 1994 and 1998 has lead to a drastic reduction of solid fuel use.

Blast furnace gas is a side product of iron production in blast furnaces that can be used as gaseous fuel. That was the case in Luxembourg until 1997 where blast furnace gas was used by the iron and steel industry for heating purposes and for electric energy production.

In CORINAIR, solid fuels, coke in particular, do not appear as fuel of blast furnaces for the iron and steel industry. However, blast furnace gas is seen as gaseous fuels in the CORINAIR methodology when it is used as such. 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 and instead of solid fuels, blast furnace gas appears in this balance. This has to be taken into account when comparing energy balances with those resulting from the emission inventories.

In 2004, the most important fuel type group are the liquid fuels, with gasoline being the first liquid fuel in terms of volumes sold. The liquid fuel consumption in Luxembourg is much lower than the level of fuels sales, because large amounts of road fuels are bought by foreign drivers passing through Luxembourg and using most of that fuel abroad ('fuel exports'). It has been estimated that more than 50% of road fuels sold in Luxembourg are burned abroad by vehicles registered abroad.

The importance of natural gas has increased constantly and significantly since 1990. In 2004, natural gas consumption ranked second after the consumption of liquid fuels.

Table 3 – Emission factors used for various fuels

| Fuel type | Emission factor (kg $CO_2$/GJ) |
|---|---|
| Hard coal | 98 |
| Coke | 93 |
| Lignite (brown coal) | 108 |
| Gasolines | * |
| Diesel | * |
| Gasoline | 70 |
| Residual oil | 75 |
| Natural gas | 55 |
| LPG | 62 |
| Blast furnace gas | 258 |

* see COPERT default values

## 3.2. Road traffic

Road traffic emissions have been calculated using COPERT. The input data were based on car fleet statistics of the vehicles registered in Luxembourg. Thus the annual fuel consumption of the Luxembourg vehicle fleet could be estimated. That fuel consumption is lower than the road fuels sales in Luxembourg; because many foreign drivers passing through Luxemburg refuel their vehicle in Luxembourg ('fuel exports') since fuel prices are lower in Luxembourg than in the neighbouring countries.

Air emissions of road traffic calculated with COPERT reflect Luxembourg's vehicle fleet. $CO_2$, $CH_4$ and $N_2O$ emissions of road traffic have been adjusted to reflect 'fuel exports' by taking total Luxembourg's road fuels sales as a basis. The inventory values of the other air pollutants in the CRF tables could not be updated that way, hence being marked as 'not estimated'.

## 3.3. International bunker fuels

### Aviation

In Luxembourg, there is only one airport for commercial aviation. Therefore all flights, coming to Luxembourg or going out from Luxembourg, are international flights. For that reason, emissions of bunker fuel consumption related to aviation are not included in the national total of Luxembourg, but are rather added as memo item under international bunkers.

### Shipping activities

As Luxembourg has no direct access to the sea, there are no maritime activities taking place. Similarly, Luxembourg has no domestic shipping activities, but only some shipping activities on the Moselle River, a border river with Germany. These can also be seen as international movements. Nevertheless, the related emissions are of minor importance.

## 3.4. Industry

### Iron and steel industry

During the period under review (1990 to 2004), the iron and steel industry has been the most important industrial activity in Luxembourg, both in terms of energy consumption and in terms of value added. As indicated above, it has undergone a restructuring process during the f1990s, which led to big changes in its air emissions. Today, its specific energy consumption is much lower than it was in 1990, but the steel industry has still relatively high energy consumption.

Table 4 – Iron and steel industry: steel production and final energy consumption

| Year | Steel production (kt) | Energy consumption (1000 toe*) |
|---|---|---|
| 1990 | 3560 | 1488 |
| 1991 | 3379 | 1359 |
| 1992 | 3068 | 1188 |
| 1993 | 3293 | 1331 |
| 1994 | 3073 | 1278 |
| 1995 | 2613 | 1037 |
| 1996 | 2501 | 976 |
| 1997 | 2580 | 823 |
| 1998 | 2477 | 333 |
| 1999 | 2600 | 342 |
| 2000 | 2571 | 351 |
| 2001 | 2725 | ** |
| 2002 | 2736 | ** |
| 2003 | 2675 | ** |
| 2004 | 2684 | ** |

Source: STATEC, Ministry of Economic Affairs and External Trade

* 1 toe = 41,8 GJ

** no official data available from iron and steel industry so far

### Glass industry

Since 1990 there are mainly two float glass plants in Luxembourg which major fuel input is natural gas. Their production has been rather stable since 1990 and is estimated at 400 kt per year. Natural gas consumption increased from 2,7 PJ in 1990 to a bit more than 3 PJ in 2004. That increase in energy consumption, in parallel with a rather constant production level, is caused by a gradual reduction in the energy efficiency of the production line due to aging, according to the operators.

### Clinker/cement industry

Between 1990 and 2004, one clinker/cement production plant operated in Luxembourg for which the major fuel input is hard coal. Its production has decreased from 1048 kt clinker in 1990 to 770 kt in 2003. Hard coal consumption has dropped from 3,6 PJ in 1990 to 2,1 PJ in 2002.

### Electrical energy production

In 1990, more than 90% of the electricity consumed in Luxembourg was imported. That same wear, basically one medium size power plant of some 70 MW was operating. This plant was owned by the iron and steel company ARBED and used mainly blast furnace gas as input. It 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. A few industrial companies installed gas turbines to produce electrical energy and heat in parallel (for example Good Year and Dupont de Nemours). In 2000, a power plant with a gas-vapour turbine of 350 MW started to be built in Esch-sur-Alzette. It started its operations in mid-2002. Almost all these plants are running with natural gas. Gasoline remains, however, the emergency fuel in case of natural gas supply interruptions.

Table 5 – Electric energy production (in MWh)

| Year | Total | Thermic (1) | Renewables (2) | Cogeneration |
|---|---|---|---|---|
| 1970 | 1347.50 | 1260.98 | 86.52 | 0.00 |
| 1980 | 914.55 | 828.31 | 86.24 | 0.00 |
| 1990 | 626.24 | 558.72 | 67.52 | 0.00 |
| 1991 | 676.37 | 622.11 | 54.26 | 0.00 |
| 1992 | 662.49 | 594.14 | 68.35 | 0.00 |
| 1993 | 669.79 | 607.83 | 61.96 | 0.00 |
| 1994 | 592.07 | 505.96 | 86.11 | 0.00 |
| 1995 | 527.68 | 346.53 | 81.33 | 99.82 |
| 1996 | 466.07 | 306.24 | 53.46 | 106.36 |
| 1997 | 415.66 | 213.96 | 92.14 | 109.56 |
| 1998 | 396.14 | 104.76 | 107.11 | 184.27 |
| 1999 | 375.28 | 51.62 | 133.12 | 190.54 |
| 2000 | 438.10 | 51.50 | 170.12 | 216.48 |
| 2001 | 864.40 | 374.14 | 146.34 | 343.93 |
| 2002 | 2822.82 | 2327.85 | 131.56 | 363.42 |
| 2003 | 2784.39 | 2285.48 | 116.63 | 382.28 |
| 2004 | 3373.52 | 2787.37 | 164.58 | 421.57 |

Source: STATEC, Ministry of Economic Affairs and External Trade

(1) including the gas-vapour turbine of 350 MW since, so far, heat is not yet used (hence, classified as a thermic power plant)

(2) small hydro-electric power plant, wind turbines, solar (photovoltaic cells), biogas

Small industrial plants or sub-sectors are not considered individually. Their $CO_2$ emissions as a whole were estimated on the basis of the fuel consumption or of the production data of the respective sub-sectors.

# Chapter 4: Industrial Processes (CRF sector 2)

## 4.1. Clinker/cement

Clinker production process implies that mineral carbonates are transformed into oxides under elimination of $CO_2$. That decarbonization process leads to high amounts of $CO_2$ emissions. The process emission of this production plant is estimated at 525 kg $CO_2$ per t of clinker.

## 4.2. Glass

Some of the mineral input materials used in float glass production contains carbonates. They also release $CO_2$ during the melting process of the glass. While annual glass production is 400 kt, process emissions of $CO_2$ are estimated at 40 kt annually.

## 4.3. Iron and steel

### Decarbonizing of iron ore during sintering

The compounds used to produce the sinter product taken as input material for the blast furnaces contain carbonates which release $CO_2$ during the sintering process.

### Basic oxygen furnace steel production

The carbon used for steel production is added to the iron as a chemical agent. Carbon is transformed into CO and $CO_2$ during the process. Therefore $CO_2$ emissions of this kind of process are considered to be process emissions.

### Electric arc furnace steel production

Steel production using electric arc furnaces uses carbon electrodes, and carbon (coal) as reacting agent in the production process. The oxidation of carbon results in $CO_2$ emissions. Emission factors of 50 to 100 kg of $CO_2$ per t of steel can result, and corresponding emissions are included into the emission inventory as process emissions.

## 4.4. Greenhouse gases containing fluorine (F)

A first estimation of the emissions of fluorinated GHG types (HFCs, PFCs and $SF_6$) was done end of 1999 by the Environment Agency of Luxembourg and Luxembourg's *Centre de Ressources des Technologies pour l'Environnement* (*CRTE*). The emissions' estimates in table 6 below are part of the results of that work.

It has been assumed that the estimates of 1995 in table 6 can be used for the emission inventories of the years 1990 through 1999, and the estimates of 2000 can be used for the inventories from 2000 through 2004.

Neither PFCs applications nor PFCs emission sources were found in Luxembourg.

Table 6 – Emissions of fluorinated greenhouse gases (in t $CO_2$-eq.)

| Application | 1995 | 2000 | 2005 |
|---|---|---|---|
| Stationary cooling installations | 2088 | 12670 | 33720 |
| Mobile cooling installations | 4160 | 21388 | 39006 |
| High voltage electrical equipments | 576 | 956 | 956 |
| Vaporizers (medical applications) | 4 | 2737 | 3650 |
| Filling of car tires | 0 | 0 | 0 |
| Noise reduction windows | 2332 | 2565 | 2822 |
| Foam blowing | 7366 | 6266 | 6266 |
| Sum | 16526 | 46582 | 86420 |

The data above should be seen as first estimates. In order to get more reliable emissions data, these results should be analyzed in more details.

## *Chapter 5: Solvent and other product use (CRF sector 3)*

The total amount of VOC emissions from solvents and other product use has been taken as a basis to calculate resulting $CO_2$ emissions. The VOC emissions' estimates from this source category were done for the year 1990.

Table 7 – Emission sources and emissions of VOC in 1990

| Emission source category (SNAP format) | Emission (t of VOC) |
|---|---|
| Paint application | 1354.00 |
| Degreasing, dry cleaning and electronics | 270.00 |
| Chemical products manufacturing or processing | 852.75 |
| Other use of solvents and related activities | 1280.00 |
| Sum | 3756.75 |

Part of these data is based on estimations of various solvent application activities in Luxembourg as they were at the beginning of the 1990s. In some sub-sectors, no statistical data on consumption of solvent containing products were available. Therefore part of the estimations is based on typical consumption estimates of products containing solvents for the neighbouring countries of Luxembourg and/or for Europe. An update of these estimations of VOC emissions from solvents could lead to an improvement of the emission data.

## *Chapter 6: Agriculture (CRF sector 4)*

In Luxembourg, agriculture is the sector emitting the highest amounts of methane and nitrous oxide. The emission estimates in the inventories are based on animal stock, on agricultural surfaces and on the amounts of fertilizers used. While the data on animal stock and on agricultural surfaces are taken from official data sources regularly published by the STATEC, only few data on fertilizer use are officially available.

Table 8 – SNAP format data and corresponding CRF format data for the agriculture, 1990

| SNAP code | SNAP category | Emission (t/a) | CRF code | CRF category |
|---|---|---|---|---|
| 1001 | Cultures with fertilizers | 474.8 t N2O | 4D | Agricultural soils |
| 1004 | Enteric fermentation | 16488.0 t CH4 | 4A | Enteric fermentation |
| 1005 | Manure management | 1134.0 t CH4 | 4B | Manure management |

Emission factors (but not implied emission factors) were kept unchanged since the beginning of the 1990s, partly in order to keep the time series of the inventories consistent.

Table 9 – Emission factors (in kg/capita, or as indicated) of the relevant source types for $CH_4$ and $N_2O$

| Source category (SNAP) | CH4 | N2O |
|---|---|---|
| 1001 Cultures w. fertilizer | | |
| 100102 Arable land crops | 0 | 86,04 g/kg fertilizer |
| 100104 Market gardening | 0 | 83,3 g/kg fertilizer |
| 100105 Grassland | 0 | 86,05g7kg fertilizer |
| 1002 Cultures wo. fertilizers | | |
| 100206 Grassland | 0 | 2900 g/ha |
| 1004 Enteric fermentation | | |
| 100401 Dairy cows | 100 | 0 |
| 100402 Other cattle | 60 | 0 |
| 100403 Ovines | 8 | 0 |
| 100404 Fattening pigs | 1,5 | 0 |
| 100405 Horses | 18 | 0 |
| 1005 Manure management | | |
| 100501 Dairy cows | 8,5 | 0 |
| 100502Other cattle | 2,8 | 0 |
| 100503 Fattening pigs | 1,0 | 0 |
| 100504 Sows | 1,0 | 0 |
| 100505 Ovines | 0,5 | 0 |

| | | |
|---|---|---|
| 100506 Horses | 3,2 | 0 |
| 100507 Laying hens | 0,1 | 0 |
| 100511 Goats | 0,5 | 0 |
| 100512 Mules and asses | 3,2 | 0 |

The on-going update of the estimation of emissions from agriculture, which should be based on recent developments and findings in this field, may help to improve the inventory's chapter on agriculture.

## Chapter 7: LULUCF (CRF sector 5)

A first estimation of carbon absorption by vegetation has been done by the *Administration des Eaux et Forêts*. It indicates that annually 294 930 t of carbon dioxide are absorbed by vegetation in Luxembourg. Forests cover an approximate surface of 88 000 ha. This $CO_2$ absorption value has been included in the emission inventories for all years.

Emissions of $N_2O$ from forests in Luxembourg have been estimated at the beginning of the 1990s with help from the French CITEPA. Those values have been included in all emission inventories since 1990.

Table 10 – Emissions and absorption of LULUCF in Luxembourg, 1990 -2004 (SNAP categories and corresponding CRF categories)

| SNAP code | SNAP category | N2O (t) | CO2 (kt) | CRF Tables |
|---|---|---|---|---|
| 111104 | Broadleaf forests | 17.9 | 0.0 | 5E |
| 111110 | Broadleaf forests | 26.1 | 0.0 | 5E |
| 111204 | Coniferous forests | 26.0 | 0.0 | 5E |
| 112102 | Temperate forests | 0.0 | -294.93 | 5A2 |
| | Sum | 68.0 | -294.93 | |

## *Chapter 8: Waste (CRF sector 6)*

Emissions calculations from waste should be seen as a first estimation, based on the limited information currently available for this sector.

The single existing incinerator of municipal waste is a major $CO_2$ emission source in that sector. $CO_2$ emissions were estimated at 125 kt in 1990, however a big part of those emissions result from biomass combustion. It is estimated that 10 kt of $CO_2$ (non-biomass combustion) should be included into the national total.

Table 11 – 1990 GHG emissions from waste in SNAP format, and corresponding allocation in CRF format

| SNAP code | SNAP category | $CO_2$ (kt) | $CH_4$ (t) | $N_2O$ (t) | CRF Table 6 |
|---|---|---|---|---|---|
| 090201 | Waste incineration | 10.00 (CRF)<br>135.97(SNAP) | NE | NE | C |
| 090401 | Waste disposal | NE | 1055.00 | 0.00 | A1 |
| 091001 | Waste water industrial | 0.00 | NE | NE | B1 |
| 091002 | Waste water domestic | 0.00 | NE | NE | B2 |
| 091003 | Sludge spreading | 0.00 | 0.00 | 0.00 | D |
| 091005 | Compost production | 0.00 | 0.00 | 0.00 | D |
| | Sum | 10.00 | 1055.00 | 0.00 | |

The transfer from SNAP to CRF format is done automatically for part of the SNAP categories. Due to the small emission amounts, the corresponding digits are small as well, and the automatic rounding of values causes significant errors in some cases.

A more detailed analysis of GHG emissions of the waste sector should allow to further clarifying the emission situation. In particular in the context of incineration of municipal waste, a more detailed analysis should allow to decide which emission data should be included in the annual totals of GHG emissions.

## *Chapter 9: Other (CRF sector 7)*

No emissions are reported in this chapter so far.

## *Chapter 10: Recalculations and improvements*

This is the second NIR prepared for Luxembourg under the United Nations Framework Convention on Climate Change, but it is only an update of the first NIR prepared in January 2006. The emission inventory data series from 1990 through 2004 is only the second entire data series of GHG prepared for Luxembourg. As this document is still a first one of its kind for Luxembourg, it seems that there are few possibilities to include information on recalculations.