Final report

Update of the national emission inventory of ozone depleting substances and fluorinated greenhouse gases (1995-2020)

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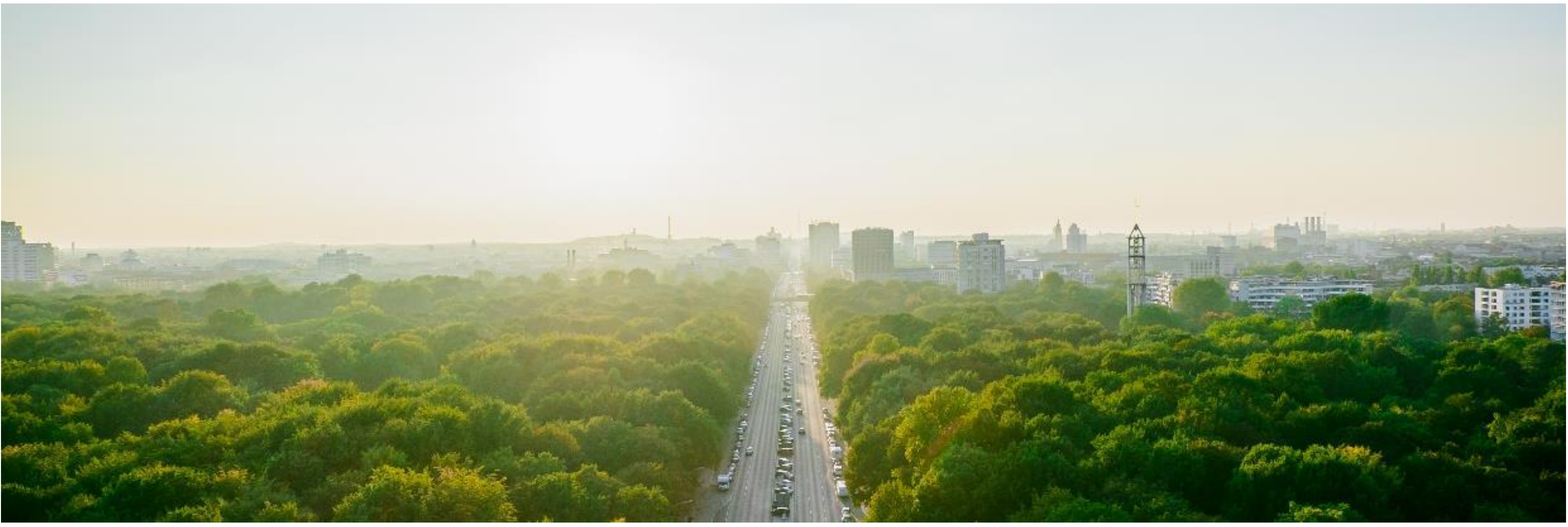

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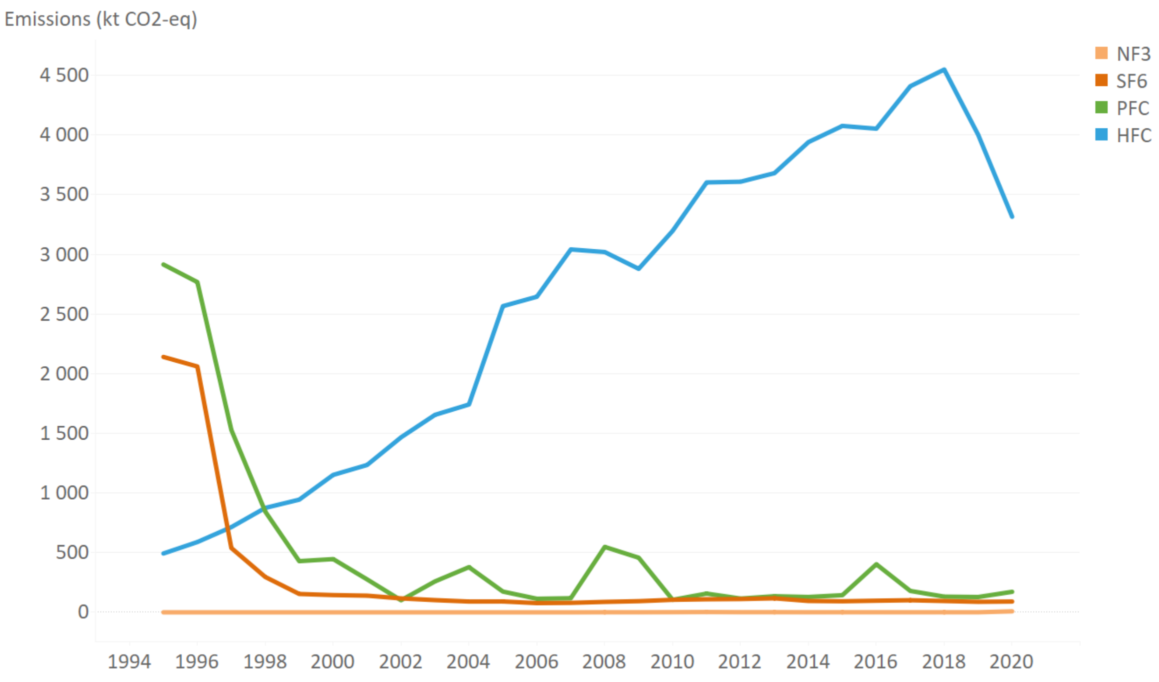
EXECUTIVE SUMMARY

In the present study the Belgian emission inventory of ozone depleting substances and fluorinated greenhouse gases (F-gases) covered by both the Montreal Protocol and the Kyoto protocol were updated for the years 1995-2020.

For each year, the emissions have been evaluated by region, by emission source, by type of emission (manufacturing emissions, operating losses, disposal emissions) and by individual substance. In total, emissions from 10 IPCC categories (2.B.9., 2.E.1, 2.E.4., 2.F.1., 2.F.2., 2.F.3., 2.F.4., 2.F.5., 2.G.1., and 2.G.2.) have been quantified, in combination with categories only relevant for ozone-depleting substances. In total 76 different substances are considered, of which 12 substances had no emissions in the period 1995-2020.

The emissions of the four F-gases under the Kyoto protocol, HFC, PFC, SF6 and NF3, expressed in kt CO_2-eq, are shown on Figure S-1 by gas and on Table S-1 by source category. Emissions of fluorinated greenhouse gas emissions have decreased in 2020 compared to 2019 with 632 kt CO_2-eq.

Figure S-1. Evolution of the CRF F-gas emissions per gas category in Belgium (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

Table S-1. Evolution of the CRF F-gas emissions by source (in kt CO_2-eq)

	Sector	2005	2010	2015	2019	2020
2 B 9	Fluorochemical production	900	684	1251	1407	968
2 E 1	Integrated circuit or semiconductor	18	13	14	19	20
2 F 1 a	Commercial refrigeration	1 221	1 753	1 941	1 711	1 539
2 F 1 b	Domestic refrigeration	23	19	24	16	16
2 F 1 d	Transport refrigeration	27	41	37	21	22
2 F 1 e	Mobile air conditioning	246	413	471	421	371
2 F 1 f	Stationary air conditioning	85	168	313	437	461
2 F 2 a	Closed cell foam	122	119	71	42	45
2 F 3	Fire protection	12	14	13	12	10
2 F 4 a	Metered dose inhalers	40	46	49	48	48
2 F 4 b	Other aerosols (technical aerosols)	50	35	42	2	2
2 G 1	Electrical equipment	11	16	11	9	11
2 G 2 c	Soundproof windows	70	86	79	73	72
2 G 2 d	Adiabatic properties: shoes and tyres	8	0	0	0	0
2 G 2 e	SF6 and PFCs from other product use	0	1	0	0	0
Total		**2 830**	**3 407**	**4 313**	**4 218**	**3 585**

Source: VITO, Econotec (own calculations, 2021)

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ABBREVIATIONS

AR4	Fourth Assessment Report of the IPCC (IPCC, 2007)
AR5	Fifth Assessment Report of the IPCC (IPCC, 2013)
CFC	Chlorofluorocarbon
CRF	Common Reporting Format of the UNFCCC
CRF-gas	compulsory gas for the UNFCCC reporting (same as ‘Kyoto-gas’)
FGR	F-gas regulation
HCFC	Hydrochlorofluorocarbon
HCFO	Hydrochlorofluoroolefin
HFC	Hydrofluorocarbon
HFE	Hydrofluoroether
HFO	Hydrofluoroolefin
IPCC	Intergovernmental Panel on Climate Change
Kyoto-gases	see CRF-gases
MDI	Metered Dose Inhaler
NF3	Nitrogen trifluoride
NIR	National Inventory Report for UNFCCC
ODS	Ozone-depleting substance
ORC	Organic Rankine Cycle
PFC	Perfluorocarbon
PFPMIE	Perfluoropolymethylisopropyl ether
PU	Polyurethane
XPS	Extruded Polystyrene
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER 1 INTRODUCTION

The present study consisted in updating for the years 1995-2020 the Belgian emission inventory of ozone depleting substances and fluorinated greenhouse gases. The emissions have been quantified by region[1], by emission source, by type of emission (manufacturing emissions, operating losses, disposal emissions) and by individual substance.

This report describes the methodology to assess emissions for each category, the improvements and updates that were made, the results and the outcome of the uncertainty analysis.

The inventory has been established according to the latest UNFCCC guidelines, which are applicable since the 2015 submission of the national inventory (Decision 24/CP.19). These guidelines implement the 2006 IPCC Guidelines[2].

In May 2019, the IPCC approved the “2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories”[3]. It will not replace the 2006 IPCC Guidelines. It is meant to be used in conjunction with the 2006 IPCC Guidelines. For most sectors, such as solvents, aerosol and fire protection, there is no refinement proposed. Where it is relevant, the refinement has been considered.

International trade in F-gases

Results internation trade

Statistics on international trade in F-gases, gathered from Eurostat, are presented in Annex 4. Since 2016, Eurostat data have become available for the main individual HFCs or HFC mixtures. These F-gas statistics are only given for information. They have not directly been used for setting up the emission inventory, because of their limitations (see Annex 4).

Illegal trade

The entry into force of the HFC phasedown of EU regulation 517/2014 has given rise to illegal HFC import in Europe[4]. According to an analysis by the EU Commission[5], imports of HFCs declared at customs seem to be correctly reported under the FGR, and therefore most illegal trade appears to be in the form of an evasion of customs (cross-border smuggling). Up to now it

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1 Please note that unless otherwise mentioned all tables and figures are given for Belgium as a whole.

2 IPCC, “Guidelines for National Greenhouse Gas Inventories. Volume 3 Industrial Processes and Product Use,” 2006. [Online]. Available: https://www.ipcc-nggip.iges.or.jp/public/2006gl/

3 IPCC, “2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories,” 2019. [Online]. Available: https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

4 Environmental Investigation Agency (EIA) (2021) Europe’s Most Chilling Crime: The illegal trade in HFC refrigerant gases. https://eia-international.org/report/europes-most-chilling-crime/

5 European Commission (2019) Indications of illegal HFC trade based on an analysis of data reported under the F-gas Regulation, Eurostat dataset and Chinese export data.

does not appear possible to quantify this customs evasion, even at EU level. However, it has been estimated that the amount of illegal imports could be as high as 34 million tonnes CO_2-eq, or 33% of the legal EU HFC market (https://stopillegalcooling.eu). The main amounts of illegal HFCs were seized in eastern European countries (Rumania, Bulgaria, Poland, Greece, as well as in Spain, Italy and the Netherlands (https://stopillegalcooling.eu), but non-refillable containers (prohibited by the FGR and a possible sign of illegal trade) have also been observed in Belgium.

It is therefore likely that HFC supply data obtained through our data collection and used for the emission inventory underestimate the actual supply. Unfortunately, we do not know to what extent. As the impact of this oversupply on the current emissions is probably limited for the time being (for the quantities concerned are mostly stored in equipment), we have decided to neglect it. In the meantime, action against illegal trade is being undertaken by the EU Commission, Member States and EFCTC[6], notably by encouraging the report of illicit F-gas products and imports. Should better information on the amount of illegal trade become available in the future, it could be used to adapt the inventory.

[6] EFCTC (2019) Illegal trade of HFCs. www.fluorocarbons.org/illegal-trade-of-hfcs.

Included sectors

Table 1-1. Categories included in this report.

	Sector
2.B.	Chemical industry
2.B.9.	Fluorochemical production (4.1)
2.E.	Electronics industry
2.E.1.	Integrated Circuit or Semiconductor (4.2)
2.E.4.	Heat Transfer Fluid (4.3)
2.F.	Product uses as substitutes for ODS
2.F.1.	Refrigeration and Air Conditioning Equipment
2.F.1.a.	Commercial refrigeration (4.4.1)
2.F.1.b.	Household refrigeration (4.4.2)
2.F.1.c.	Industrial refrigeration (4.4.3)
2.F.1.d.	Transport refrigeration (4.4.4)
2.F.1.e.	Mobile air conditioning systems (4.4.5)
2.F.1.f.	Stationary air conditioning systems (4.4.6)
2.F.2.	Foam Blowing Agents
2.F.2.a.	Closed cell foam (4.5.1)
2.F.2.b.	Open cell foam (4.5.2)
2.F.3.	Fire Extinguishers (4.6)
2.F.4.	Aerosols
2.F.4.a.	Metered-dose inhalers (4.7.1)
2.F.4.b.	Other aerosols (4.7.2)
2.F.5.	Solvents (4.8)
2.G.	Other product manufacture and use
2.G.1.	Electrical Equipment (4.9)
2.G.2.	SF6 and PFCs from Other Product Use
2.G.2.b.	Particle accelerators (4.10.1)
2.G.2.c.	Soundproof windows (4.10.2)
2.G.2.d.	Adiabatic properties: shoes (4.10.3)
2.G.2.e.	SF6 and PFCs from other product use (4.10.4)

Source: VITO, Econotec

Included gases

The updated inventory will take into account 50 gases:

- the 30 compulsory gases of the new UNFCCC reporting (19 HFCs, 9 PFCs, SF6 and NF3), of which quantitative data for 21 gases are provided;
- 12 ODS gases;
- 3 other PFCs, PFPMIE, CF3SF5 and 3 HFOs.
- as well as 28 substances emitted by the chemical industry.

Out of these 76 substances, 64 have non-zero emission values.

Global Warming Potential values (GWP)

In accordance with Decision 24/CP.19 of the Conference of the Parties to the UNFCCC, the GWP values used for the CRF-gases are those listed in Annex III of this decision, which are those contained in the errata of contribution of WG1 to the Fourth Assessment Report of the IPCC. For the remaining substances, the best available data have been used, among which those of the Fifth Assessment Report of the IPCC.

Box 1. Units and conversions

Emissions of fluorinated greenhouse gases presented in this report are normally given in either tonnes (t) or kilotonnes CO_2-equivalent (kt CO_2-eq).

Conversion of tonnes of greenhouse gas emitted into tonnes CO_2-equivalent:

tonnes of GHG * GWP / 1000 = kilotonnes of GHG in CO_2-equivalent.

The GWP is the Global Warming Potential of the greenhouse gas. The GWPs of fluorinated greenhouse gases used in this report are given in Annex 2.

Conversion of tonnes of ozone-depleting substance emitted into tonnes CFC-11-equivalent:

tonnes of ODS * ODP = tonnes of ODS in CFC-11-equivalent

The ODP is the Ozone Depleting Potential of the ODS. The ODPs of gases used in this report are given in Annex 2.

Regionalisation of emissions

Depending on the emission source, the national emissions are divided among the three regions using one of two alternative approaches:

- When the emissions are estimated at the level of sources located in individual regions, they are attributed to these regions. This is the case of the manufacturing emissions of ‘chemical industry’, ‘Car airco’, ‘Trucks airco’, ‘Foams’, ‘Aerosols’, ‘SF6 in glass sector’) and of the process emissions of ‘Methyl bromide’.
- The remaining emissions are regionalised using one of several (yearly) distribution keys: population, electricity consumption, number of private cars, greenhouse surface area.

Tasks

The inventory has been set up in a manner consistent with those of the previous years, according to the methodology first developed by ECONOTEC in 1999[7] and later improved and enhanced in collaboration with VITO in the course of the annual updates.

The same methodology was applied for all years from 1995 to 2020. Where improvements have been made to the methodology or to emission factors, or a new source has been added, recalculations have been made.

7 ECONOTEC & ECOLAS (1999) Opstellen van een globale methodologie voor het verzamelen van gegevens voor ozonafbrekende stoffen en broeikasgassen HFK’s, PFK’s en SF6. Study carried out for the Federal Services for Environmental Affairs and the Vlaamse Milieumaatschappij.

The following tasks have been carried out:

1. Data collection, among which:
   - enquiry among the refrigerant suppliers
   - enquiry among manufacturers of products containing F-gases (automobiles, air conditioning appliances, air dryers, foam, technical aerosols…)
   - enquiry among the fire extinction contractors and the semiconductor industry
   - collection of data on recovery and destruction of F-gases from the individual companies
   - collection of statistical data (cars, buses & coaches, external trade, registration of new refrigerated trucks and trailers, population…)
   - emissions of the chemical industry
2. Calculation of emissions:
   - Improvements of calculations methods
   - Calculation of actual emissions at national and regional level, for the year 2020
   - Update and optimisation of the emission estimates for the period 1995-2019
3. Compilation of emissions
   - Compilation of the detailed data for the sectoral calculations of emissions for all the relevant gases
   - Compilation of the relevant emission tables for the CRF Reporter
4. Uncertainty analysis for the year 2020, as well as update of the uncertainty analyses for 1995 and 2019
5. Reporting:
   - Drafting of the initial report, the interim report, and the final report
   - Presentations in the steering group meetings
   - Drafting of the contribution on F-gases for the National Inventory Report (methodology, information sources, recalculations made, uncertainty analysis, trend analysis)
6. Support for the In-Country Review of the Belgian emission inventory by the UNFCCC Expert Review Team in 2021.

In this chapter, results are shown on charts. Detailed data tables are provided in Annex 1.

The substances are grouped by type (CFCs, HCFCs, Halons, HFCs, PFCs, SF6, NF3, HFOs and Other), and further aggregated into three categories:

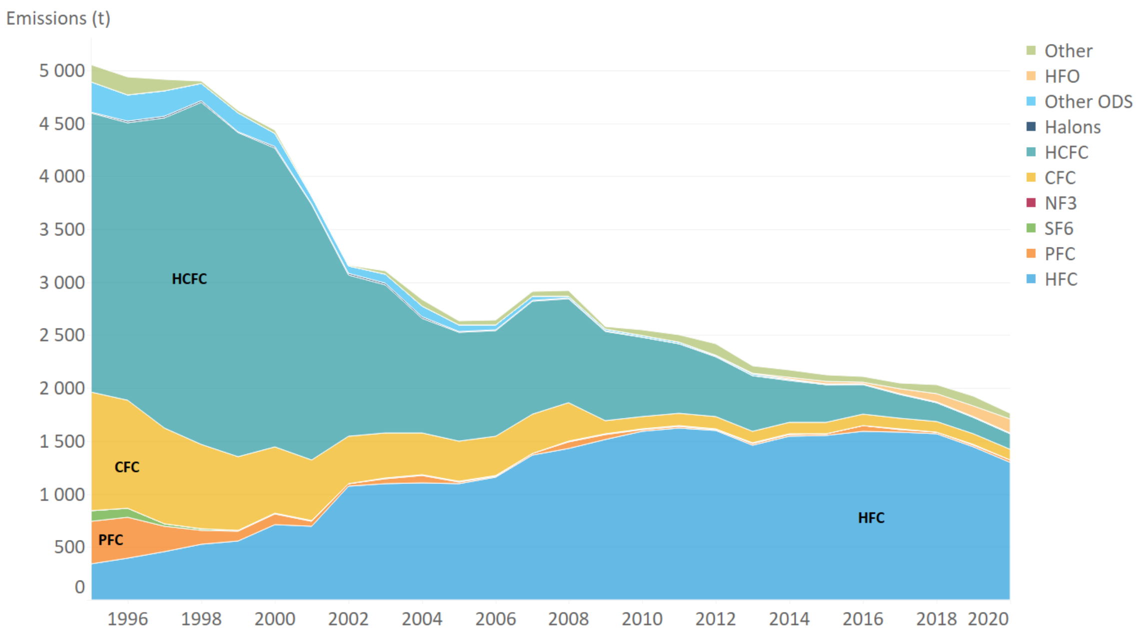
- ODS (ozone depleting substances),
- CRF (substances for which there is a reporting obligation in the CRF format),
- Other.

2.1. Evolution of emissions by gas

Figure 2-1 shows the evolution of emissions in tonnes, in Belgium, by category of gas. The chart clearly shows the replacements of CFCs by HCFCs and later by HFCs.

The downward trend is continuing, more pronounced in the last two years.

Figure 2-1. Emissions by type of gas in Belgium (t)

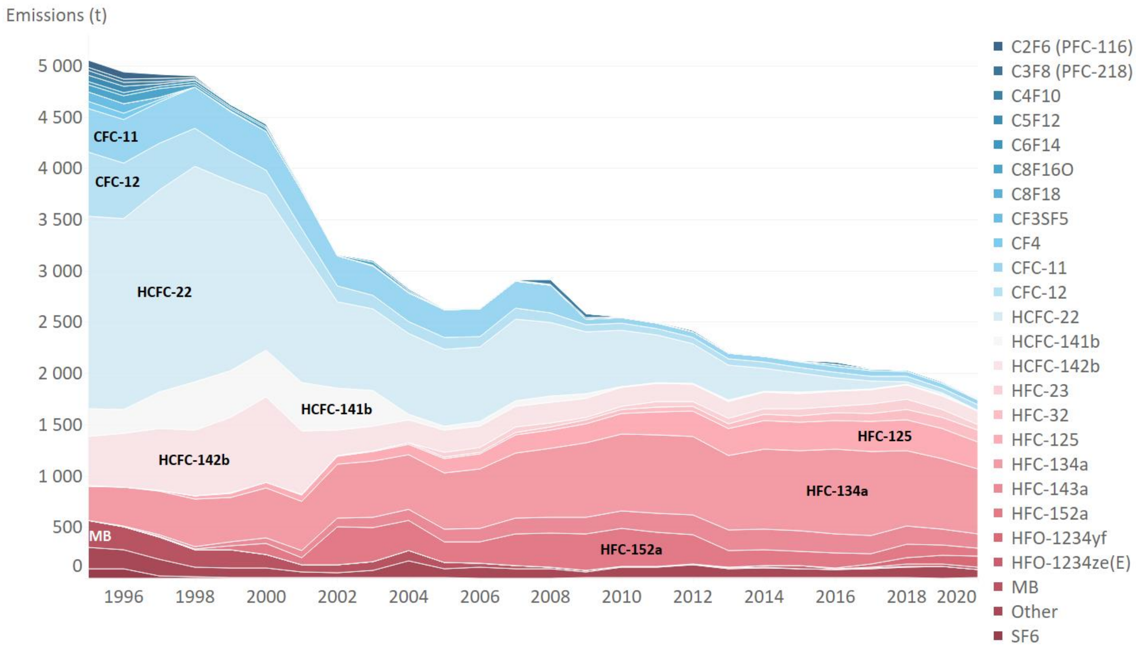


Source: VITO, Econotec (own calculations, 2021)

In 2020, the total emissions in tonnes have diminished by 8,3%. For the CRF-gases, the corresponding decrease is 9,6%.

Figure 2-2 shows that while up to 2008 the main substance in tonnes used to be HCFC-22, it later became HFC-134a, with a growing share of HFC-125.

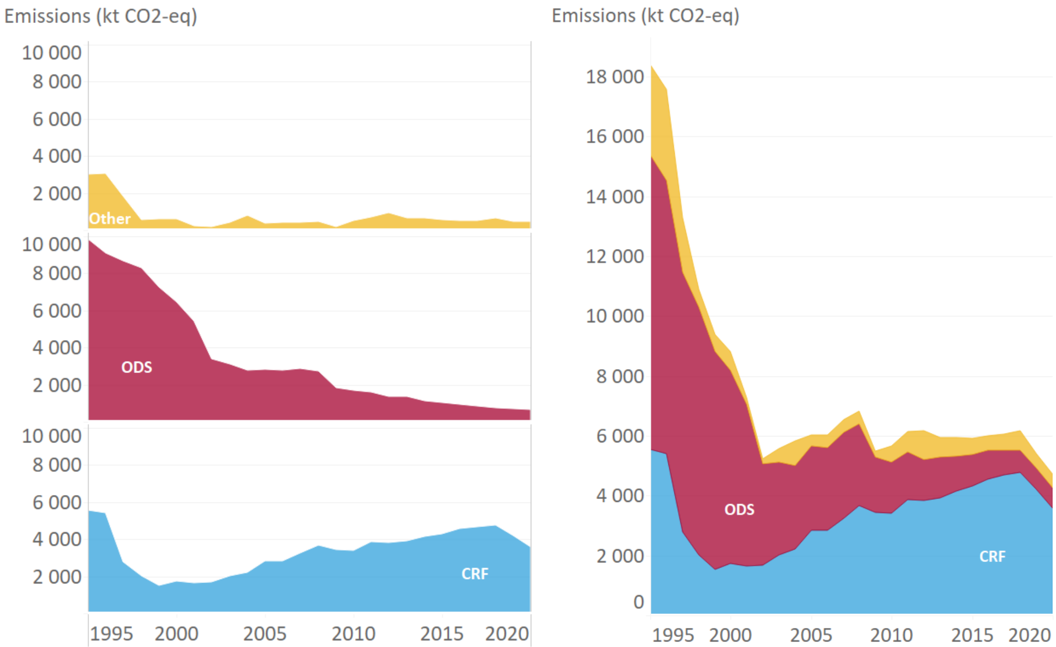
Figure 2-2. Evolution of the F-gas emissions by substance in Belgium (in t)



Source: VITO, Econotec (own calculations, 2021)

In terms of CO_2-equivalent, the emissions of ODS gases, which used to be the largest emission source, have strongly declined, as a result of the Montreal Protocol. The emissions of 'CRF-gases', which partly replaced them, peaked in 2018 and continued to diminish in 2020 (Figure 2-3).

Figure 2-3. Evolution of the F-gas emissions per gas category in Belgium (in kt CO_2-eq)

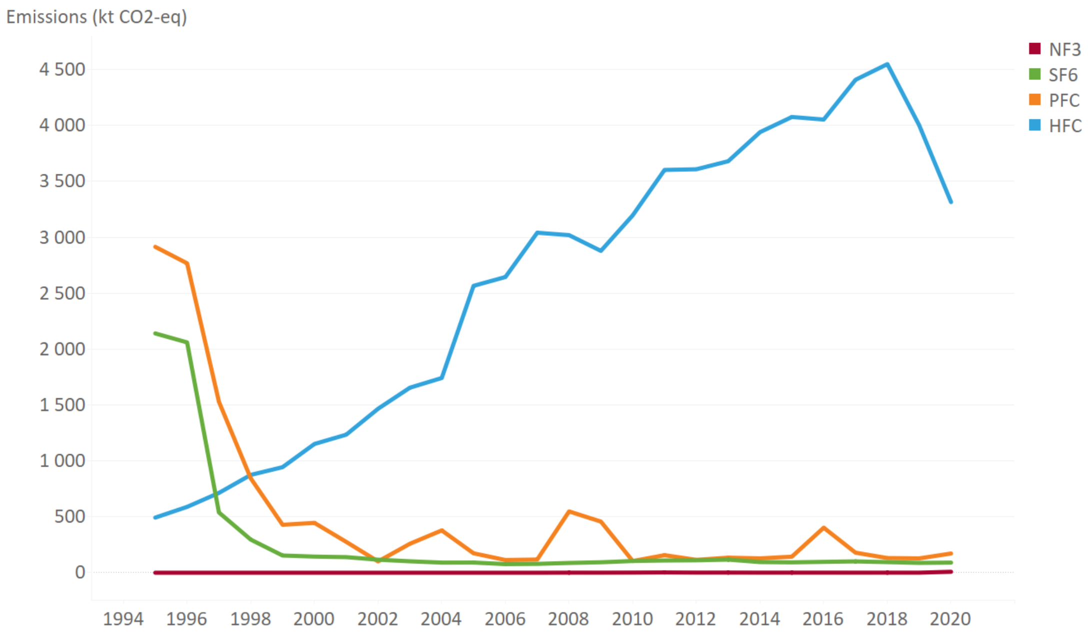


Source: VITO, Econotec (own calculations, 2021)

In 2020, total emissions decreased by 679 kt CO_2-eq (12,5%). 62% of this decrease (419 kt CO_2-eq) is due to HFC-23 (from the chemical industry).

As shown on Figure 2-4, the bulk of CRF-gas emissions is from HFCs.

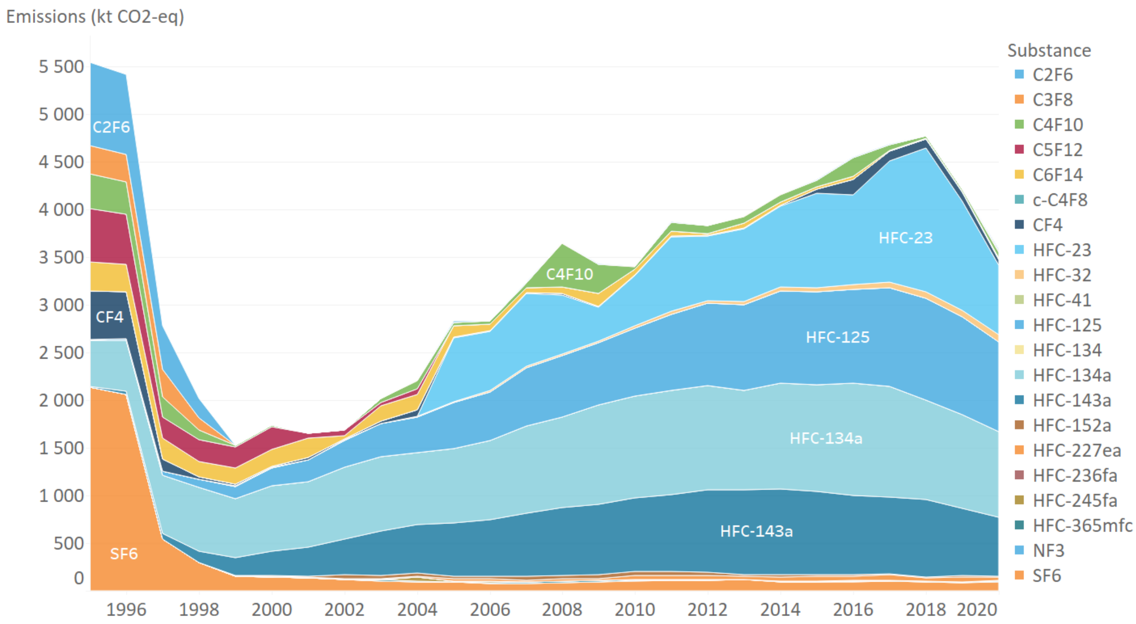
Figure 2-4. Evolution of the CRF F-gas emissions per gas category in Belgium (kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

On Figure 2-5, notable is the predominance of four gases in the last decade: HFC-23, HFC-143a, HFC-134a and HFC-125. The decrease since 2018 is mainly due to HFC-23, from the chemical industry.

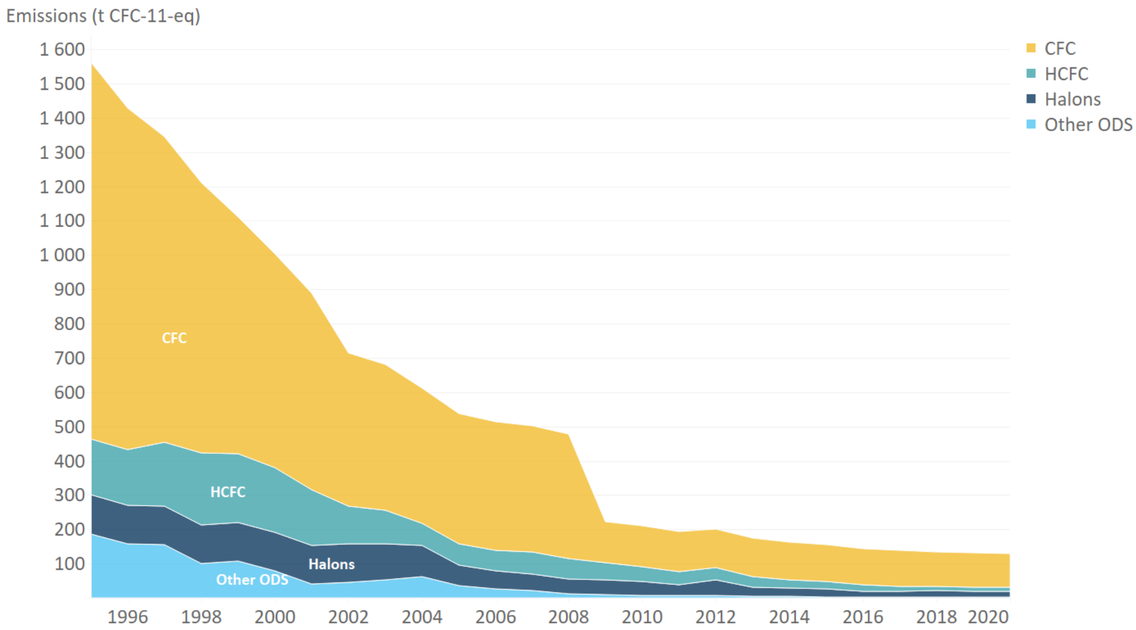
Figure 2-5. Evolution of the CRF F-gas emissions per substance in Belgium (kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

The evolution of emissions of ozone depleting substances, expressed in tonnes CFC-11 equivalent, is shown Figure 2-6 (by gas category) and Figure 2-7 (by substance).

Figure 2-6. Evolution of ozone depleting substances, by gas category, in Belgium (t CFC-11-eq)

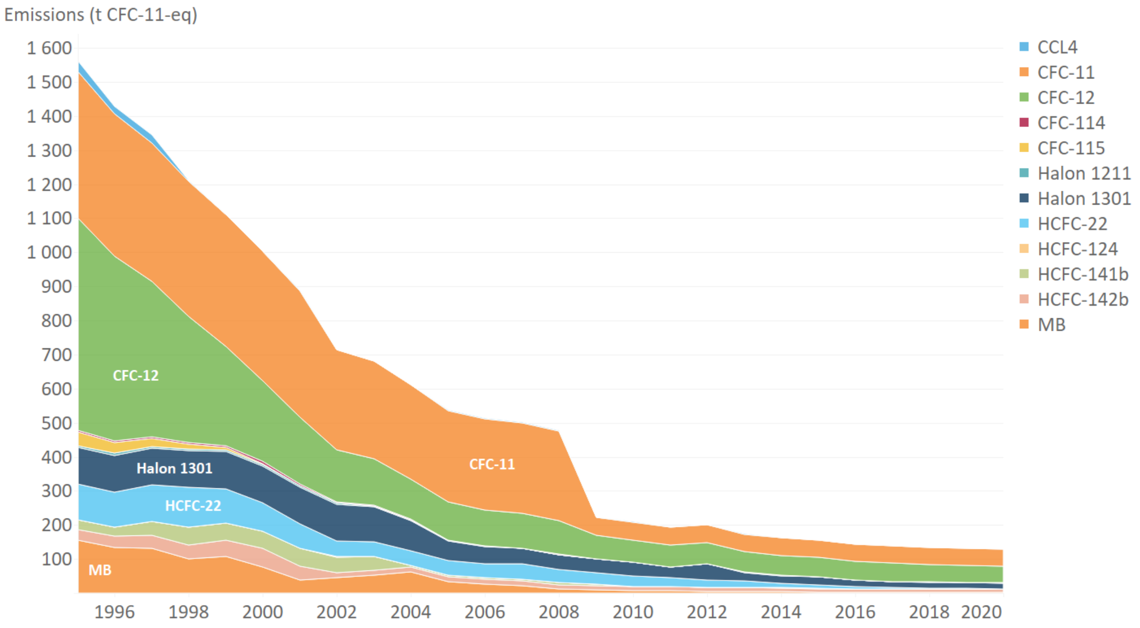


Source: VITO, Econotec (own calculations, 2021)

It can be remembered that the drop in CFC-11 emissions between 2008 and 2009 is due to the disappearance of the stock of CFC-11 in household refrigerators and freezers, as modelled assuming an equipment lifetime of 15 years.

The major part of these emissions are CFC emissions, essentially emissions of CFC-11 and CFC-12 (see Figure 2-7).

Figure 2-7. Evolution of ozone depleting substances, by substance, in Belgium (t CFC-11-eq).

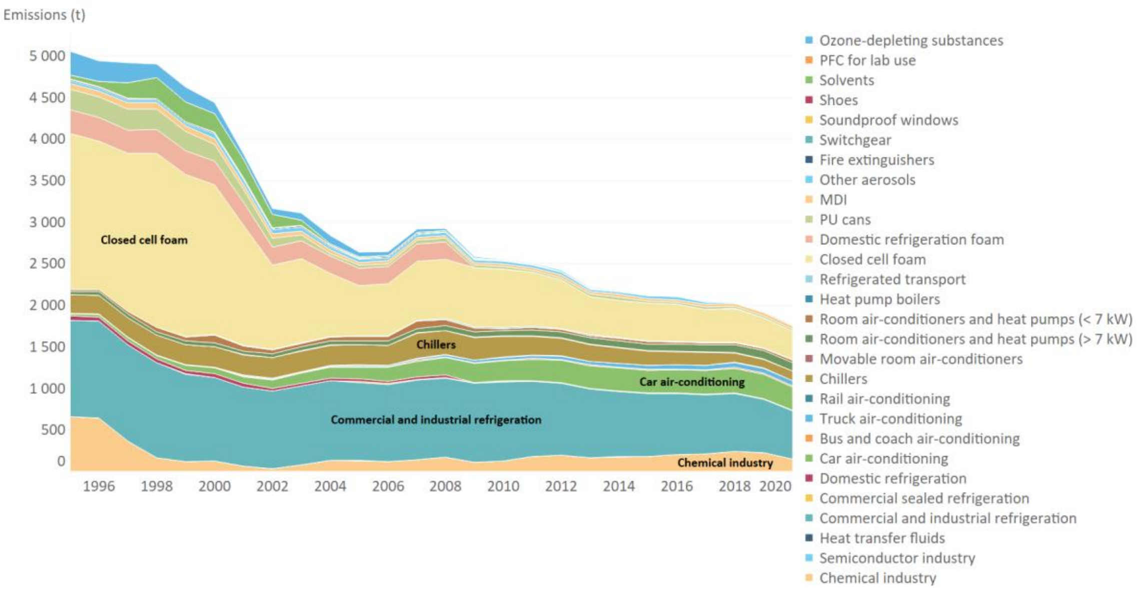


Source: VITO, Econotec (own calculations, 2021)

2.2. Evolution of emissions by source

When considering all gases and quantities in tonnes (Figure 2-8), stationary and mobile refrigeration and air conditioning are the main emission sources, together with closed cell foams.

Figure 2-8. Evolution of emissions by source in Belgium (in tonnes)

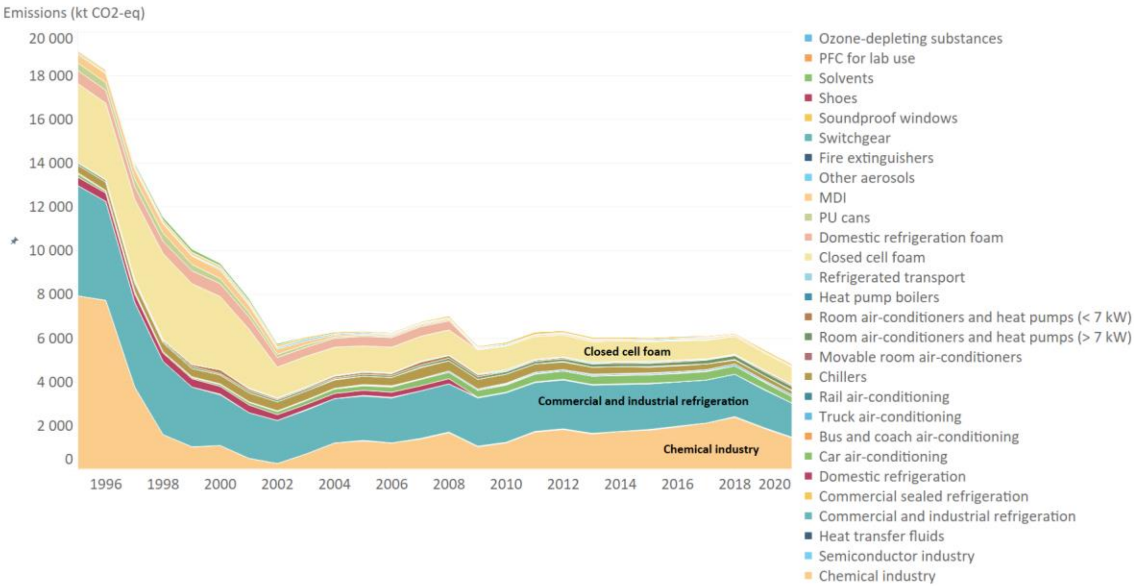


Source: VITO, Econotec (own calculations, 2021)

The total emission is declining by 160 t (8,3%) in 2020. This decline essentially happens in Commercial and industrial refrigeration (60 t), Chemical industry (76 t) and Closed cell foam (20 t).

In kt CO_2-eq (Figure 2-9), Chemical industry takes a significantly larger share (30% instead of 8%, in 2020).

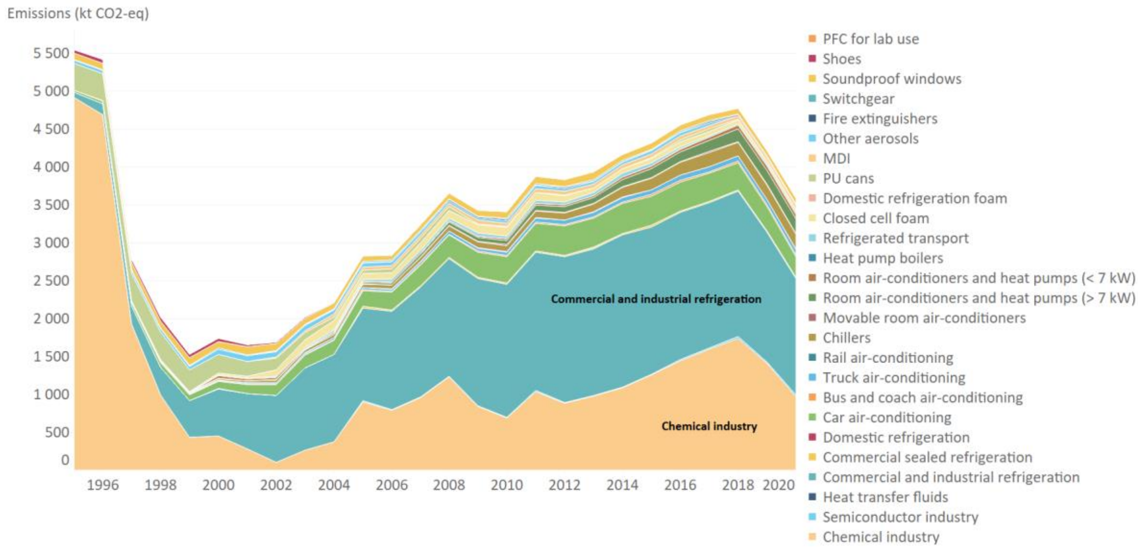
Figure 2-9. Evolution of emissions per source in Belgium (kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

When looking at CRF-gases emissions in CO_2-eq (Figure 2-10), there is a large increase up to 2018, followed by a strong decline (25%). The main sources are commercial and industrial refrigeration and chemical industry.

Figure 2-10. Evolution of CRF F-gas emissions per source in Belgium (kt CO_2-eq)

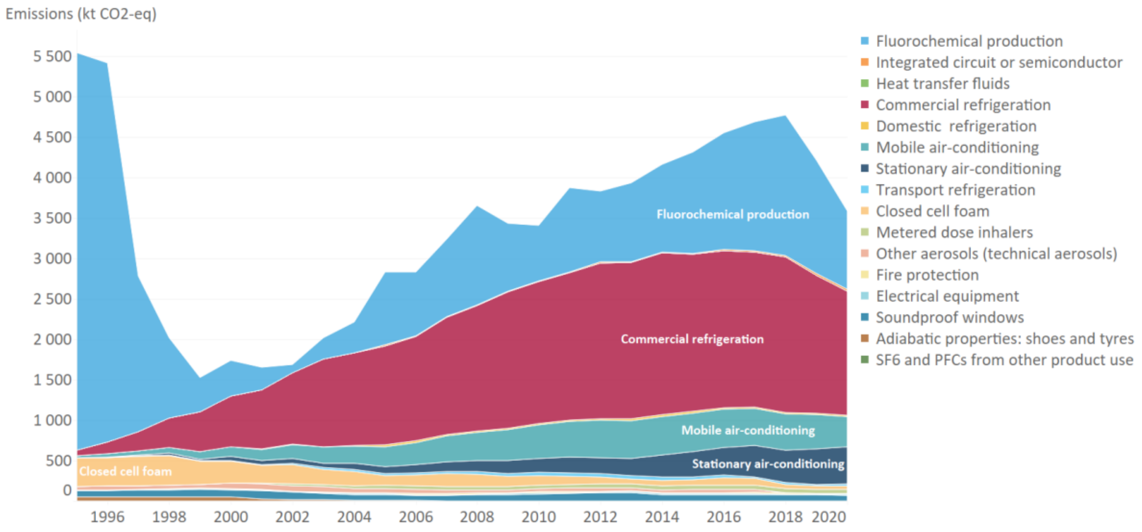


Source: VITO, Econotec (own calculations, 2021)

In 2020, the decline is 632 kt CO_2-eq (15%), which is mainly due to Chemical industry (439 kt CO_2-eq) and commercial and industrial refrigeration (171 kt CO_2-eq).

Figure 2-11 presents the emissions of the gases in the CRF reporting format of the UNFCCC, in terms of CO_2-equivalent. The largest emission source here is 'Commercial refrigeration', which includes industrial refrigeration. Striking is the irregular pattern for Fluorochemical production.

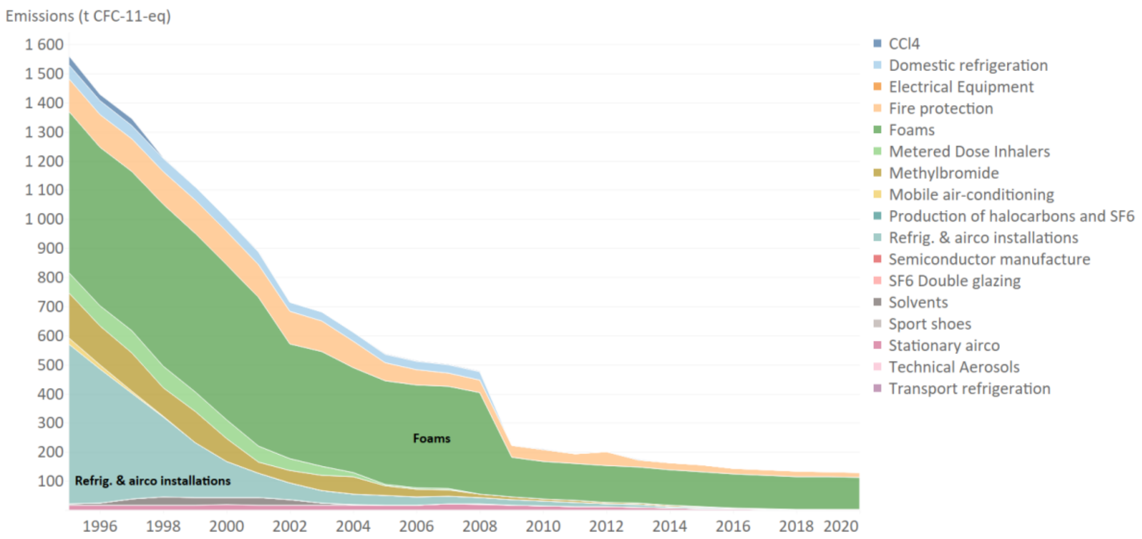
Figure 2-11. Evolution of CRF F-gas emissions by source in Belgium (kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

The ODS gas emissions, which fall under the Montreal protocol and are expressed in tonnes CFC-11-eq, have strongly declined (Figure 2-12), the main remaining share being that of Closed cell foam (CFC-11 in polyurethane foams and CFC-12 in polystyrene foams).

Figure 2-12. Evolution of ODS gas emissions by source in Belgium (t CFC-11-eq)



Source: VITO, Econotec (own calculations, 2021)

3.1. Improvements

The following improvement efforts have been made:

- Restructuring of the report according to the CRF nomenclature.
- Adjustments to the sectoral calculations sheet to improve extraction of more information into a format that could be used for pivot tables/interactive visualisations.
- Extension of the annexes of the results with split per refrigerant in addition to split per gas.
- On technical level: more extensive follow-up of trends and evolutions in use of refrigerants in stationary airconditioning.
- Emphasis on sectors specifically relevant for policy, such as refrigeration (Green Deal F-gases).
- Taking into account of new substances or refrigerants where relevant.

Assumptions, methods, etc. were scrutinized by desk research and consultation with stakeholders and companies.

3.2. Recalculations for 1995-2019

The recalculations that have occurred compared with the 2021 submission of the inventory to UNFCCC are listed in the table below. There are more recalculations due to corrections and adjustments in the methodology of calculating the emissions and of new information on the split in the sector stationary air conditioning.

Table 3-1. Overview of recalculations in period 1995-2019

CRF code	CRF source category	Period	Nature of the recalculation	Impact for CRF gases in 2019 (kt CO_2-eq)
2.F.1.a.	Commercial refrigeration	1995-2019	Change resulting from a reallocation of refrigerant consumptions between Commercial refrigeration and Stationary air conditioning.	+58,5
2 F 1 b	Domestic refrigeration	2019	Calculation bank adjusted affecting emissions.	-2,73
2 F 1 d	Transport refrigeration	2019	Small adjustment stocks of equipment in 2019.	0,51
2 F 1 e	Mobile air conditioning	2009-2019	Adjustment disposal emissions from buses.	-0,49
2.F.1.f.	Stationary air conditioning	1995-2019	Recalculation of time series based on updated information on split between different equipment types. Emissions calculated based on bank at the start of the year.	+52,18
2.F.4.b.	Other aerosols (technical aerosols)	2018-2019	Emissions from use are estimated based on per capita emissions from Germany. Data for 2019 was now updated based on latest information.	-0,48
2 G 1	Electrical equipment	2017-2019	Small adjustment on stock in 2017-2019, affecting emissions.	-0,05
Total				**107,44**

4.1. Fluorochemical production (2.B.9.)

Introduction

The emissions of this source are those of an electrochemical synthesis (electro-fluorination) plant, which emits PFCs and HFCs, as well as fluorinated greenhouse gases not covered in the CRF reporting. This plant produces a broad range of fluorochemical products, which are used as basic chemicals as well as end products, mainly in the electronics industry.

The processes used in this electro-fluorinated plant are unique within Europe (there are however some similar plants in the US). This means that there are no established guidelines for monitoring and reporting.

49 processes are considered, of which a minority are continuous processes and the remaining are batch ones. The emissions are partly ducted (those of the continuous processes and of most batch processes) and diverted to a thermal oxidizer, and partly non-ducted (the latter all from batch processes). The gas incinerator (thermal oxidizer) eliminates almost all the ducted emissions of the plant, but some CF_4-emissions nevertheless still occur. These are determined through measurements.

Methodology

For the non-ducted emissions, estimates are calculated by means of detailed material balances. For each process (all 49 processes for the greenhouse gas emissions) and for each component, an emission factor is established on an empirical basis. The emission factors are combined with detailed specific production data.

A full time series is given for all CRF greenhouse gases. The electrochemical plant has also provided emission data for non-CRF-gases, from 2005 onwards by substance, in t and kt CO_2-eq.

In 2015, the company reported that in 2014 it performed laboratory simulations of some specific production processes to better understand air emissions. These tests showed that HFC emissions could have been underestimated. This was already mentioned in previous inventory reports. To confirm the insights, local measurements on the related production processes were performed. These measurements confirmed the adjustments.

As part of the evaluation of these laboratory results, and in order to guarantee full transparency and reliability on the monitoring methodology of all processes and emissions, the company was requested to establish a monitoring plan that describes and evaluates in detail the calculation methods used for all F-gas emissions.

The drafting of the monitoring plan was performed in 2019. During that process, the company was assisted by an independent verification office (VBBV), appointed for that specific purpose by the Flemish Government because of its experience in monitoring EU ETS emissions. Its assessments resulted *inter alia* in the acceptance of updates of some of the emissions factors used until then. The monitoring plan was finalized early 2020.

The Flemish government also requested the company to recalculate the historic emissions, taking into account the new insights and in accordance with the established monitoring plan. The company recalculated its emissions for the period 2005-2018, arguing that before 2005, multiple production processes at the chemical plant were run significantly different and therefore the updated emission factors would not be accurate for this period.

The recalculated emissions for 2005 and the period 2016-2018 were verified by the independent verification office (VBBV), while also a review of the recalculated 2006-2015 emissions was performed. These recalculated emissions are considered to be more valid and accurate than those reported in the past.

The recalculation exercise results in a substantial increase of emissions expressed in CO_2-eq compared to the previous inventory, especially for the CRF-gases, because the new and more correct method results in higher emissions of CRF greenhouse gases and lower emissions of non-CRF greenhouse gases. It also changed the emission pattern. The revised emissions are shown by type of gas on Figure 4-1 and Figure 4-2.

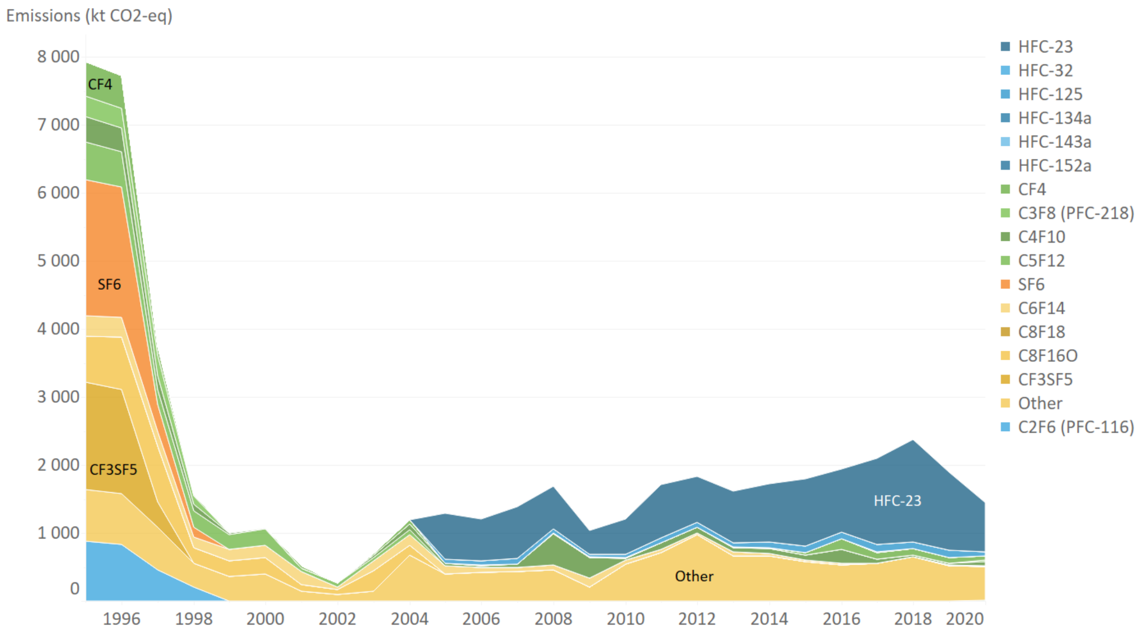
The company is taking further measures to monitor emissions more intensively and is planning and implementing mitigation measures to substantially reduce emissions in the short term (2020-2021). Emissions in 2019 were already below emissions in 2018 and continue to decrease. This stops the increasing trend observed since 2012 of CRF greenhouse gas emissions.

Results

The total and CRF emissions show three different periods: high emissions in 1995 declining rapidly until 2002; slowly increasing emissions between 2002 and 2018; reducing emissions from 2018. From 2005 the emissions of HFC-23, a gas with a high GWP value, makes up a large share of total emissions of fluorinated greenhouse gases.

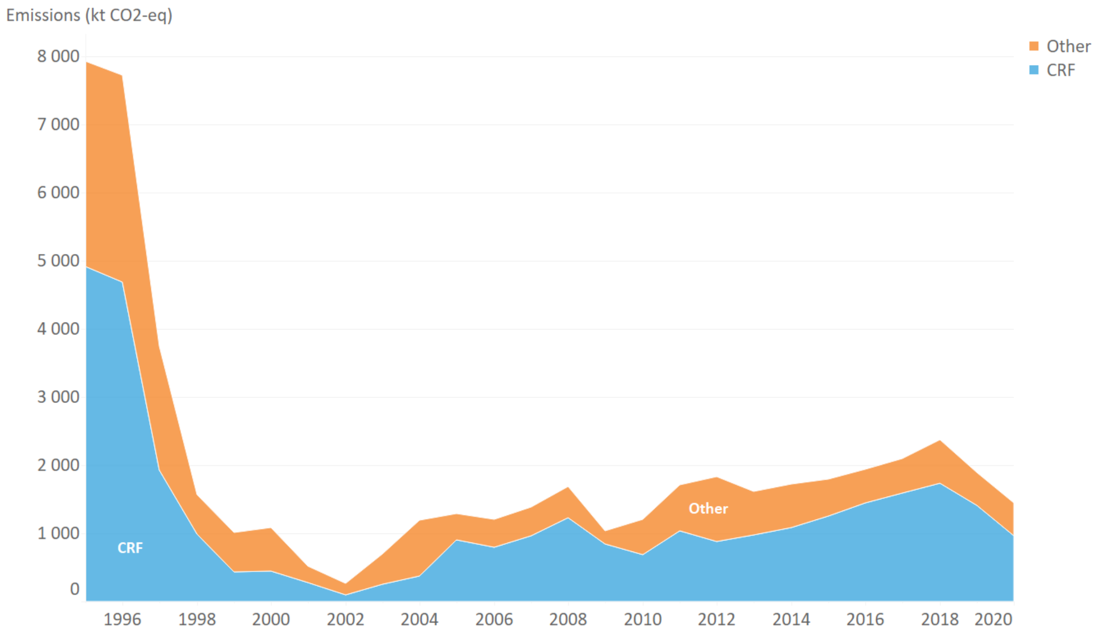
The emissions also include fluorinated greenhouse gases that are not covered by legislation or that have to be reported to the EU or to the UNFCCC. In 2020, 33% of total emissions were from these non-CRF greenhouse gases, mostly perfluorotributylamine (PTBA), perfluorotripropylamine (PTPA), perfluoromethyl morpholine (PMM) and LBA.

Figure 4-1.   Total F-gas emissions from fluorochemical production (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

Figure 4-2.   Total CRF (blue) and all F-gas (orange) emissions from fluorochemical production (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.2. Integrated Circuit or Semiconductor (2.E.1.)

Introduction

The semiconductor industry currently emits PFCs (CF4, PFC-116, PFC-218, c-C4F8), HFC (HFC-23, HFC-32, HFC-41, HFC-125), nitrogen trifluoride (NF3) and sulphur hexafluoride (SF6) from production processes. These gases are used for etching structures on thin layers and for cleaning reaction chambers following chemical vapour deposition (CVD). In the production process, some of the PFCs fed into plasma chambers are converted partly into CF4.

The semiconductor industry's emissions depend partly on the degree to which the industry uses waste-gas-scrubbing equipment. They also depend directly on semiconductor-production levels (in the present case, annual levels). As a result of these dependencies, emissions tend to fluctuate from year to year.

In printed circuit board (PCB) production, drilled holes are cleaning with systems that use CF4. As a repeat survey carried out in 2019 found, this area of application undergoes few changes.

PFCs are used as heat transfer fluids (HTFs) in commercial and consumer electronic applications. The various applications of PFC as HTFs use much smaller volumes of liquid PFCs than electronics manufacturing. Some examples of consumer applications include cooling kits for desktop computers and commercial applications include cooling supercomputers, telecommunication, and radar systems, as well as drive units on high-speed trains.

Methodology

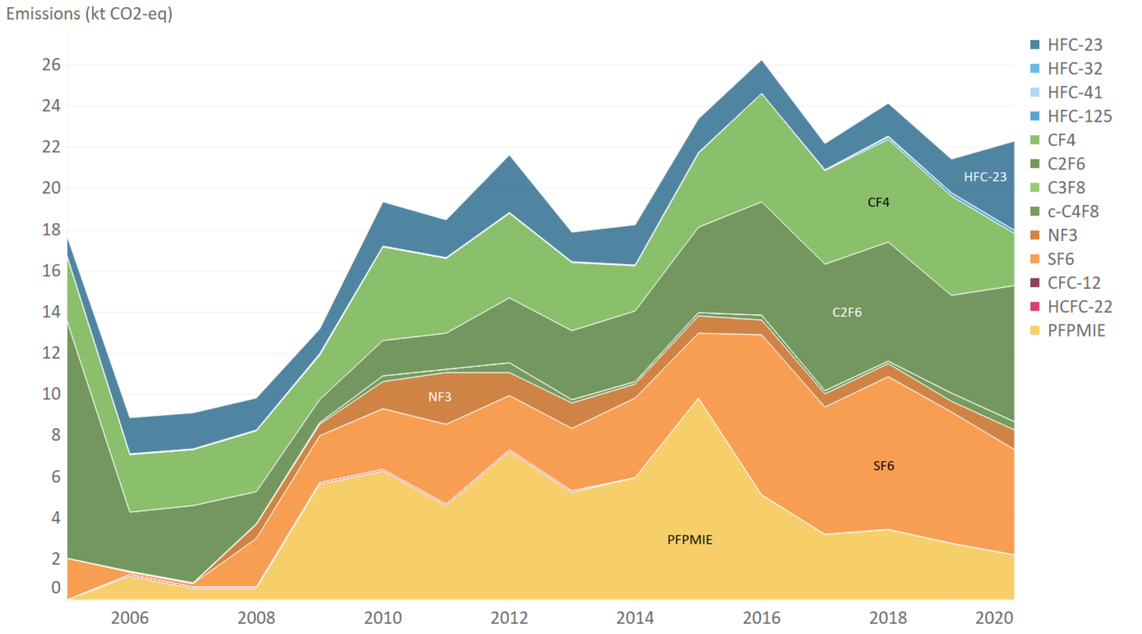
Photovoltech reported in previous years that no F-gases were used in their production process. Semiconductor manufacturers also reported the quantities of F-gases used, including NF3. We also requested information specifically on heat transfer fluids.

As an activity variable, the number of photomoves could be considered. One company provided this information, which corresponded well with the emissions. Although this activity variable is not useful to characterise the activities of research centres rather than production sites, there is a good correlation between the total emissions by this sector and the number of photomoves.

Results

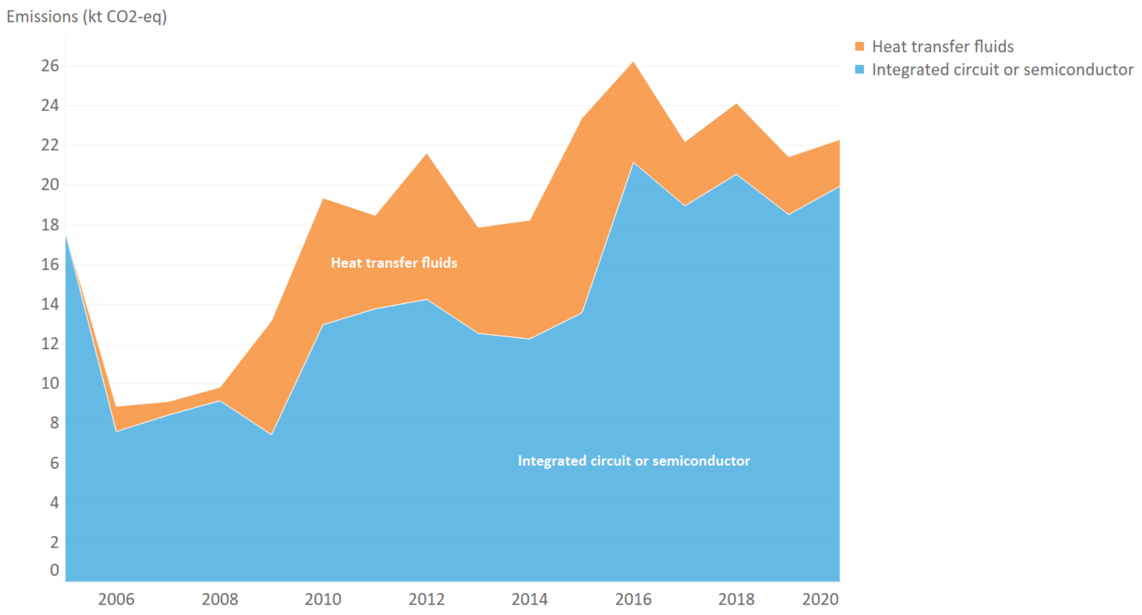
SF6, CF4, C2F6, and PFPMIE emissions are the most important for this sector. In 2020 emissions of HFC-23 are relatively high compared to previous years. The emissions are relatively stable over years, especially since 2015, fluctuating between 9 kt CO_2-eq in 2006 and 26 kt CO_2-eq in 2016. CRF emissions in 2020 were 20 kt CO_2-eq., including heat transfer fluids.

Figure 4-3. Total emissions from semiconductor industry in Belgium, including heat transfer fluids (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

Figure 4-4. Total emissions from semiconductor industry in Belgium, split between the IPCC sectors heat transfer fluids and integrated circuit or semiconductor (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.3. Heat transfer fluid (2.E.4.)

See section 2.E.1.

4.4. Refrigeration and air conditioning equipment (2.F.1.)

HFCs have been introduced and widely used as replacement for CFC and HCFC refrigerants in commercial, industrial and domestic refrigeration and in stationary and mobily air conditioning.

Emissions can occur at different stages of the lifecycle of refrigeration/air conditioning equipment:

- During the refrigeration equipment manufacturing process (for hermetically-sealed equipment);
- During the on-site installation and filling of equipment;
- Over the operational lifetime due to regular and accidental releases; and
- At disposal of the refrigeration or air conditioning unit on site or at diposal facility.

For the refrigeration sector, emissions have been estimated separately for the following source categories:

- industrial and commercial refrigeration installations,
- household and commercial hermetic refrigerators,
- chillers, room air conditioners and heat pumps,
- air conditioning of private cars,
- air conditioning of buses and coaches,
- trucks air conditioning,
- passenger rail transport air conditioning,
- refrigerated transport.

In accordance with the IPCC guidelines, the assembly emissions, the operation emissions and the disposal emissions are being determined separately. For each substance, the assembly emissions are calculated as a function of the estimated amount charged into new systems and the percentage assembly losses, the operation emissions as a function of the amount stocked in existing systems and assumptions on annual leakage rates, and the disposal emissions in function of the amount in systems at time of disposal and the estimated recovered fraction.

4.4.1. Commercial refrigeration (2.F.1.a.)

Introduction

As industrial refrigeration installations could not be evaluated separately from commercial refrigeration, under the source category Commercial refrigeration (2.F.1.a.) are reported all on-site assembled systems for industrial as well as commercial refrigeration.

Methodology

The stock and the emissions of refrigerants are modelled using a mass-balance approach, based on the annual supply of refrigerants. The latter is obtained from an annual inquiry among refrigerant suppliers on their national supply of each refrigerant mixture. The estimated supply for refilling vehicles' aircos (cars, buses and coaches, trucks, passenger rail transport), refrigerated transport and stationary air conditioning devices is subtracted. Assumptions are made on the average loss rates. The reason why no distinction is made between industrial refrigeration and commercial refrigeration installations is that it is not possible to disaggregate the refrigerant consumption data between these sub-sectors, because of the presence of intermediary wholesalers, and the fact that no inventory of installations is available.

The annual operation and servicing emissions are estimated as the amount of refrigerant banked in existing systems at the end of the previous year, times an annual leakage rate (see below). Where for each refrigerant the bank at the end of each year is calculated by a mass balance from the bank at the end of the previous year. The mass balance ensures that the overall emissions are consistent with the amounts of refrigerants sold on the market.

The disposal emissions are calculated, using equation 7.14, page 7.51 of the 2006 IPCC Guidelines, as the amount initially charged into new systems times the percentage residual charge, times one minus the recovery efficiency at disposal.

Equation: Emissions at end of life

$$E_{end\ of\ life,t} = M_{t-d} \times \frac{p}{100} \times \left(1 - \frac{\eta_{rec.d}}{100}\right)$$

$E_{end\ of\ life,t}$ = amount of HFC emitted at time of disposal in year t, kg

M_{t-d} = amount of HFC initially charged into new systems installed in year (t − d), kg

d = lifetime

p = residual charge of HFC in equipment being disposed of expressed in percentage of full charge, %

$\eta_{rec,d}$ = recovery efficiency at disposal, which is the ratio of recovered HFC to the HFC contained in the system, %

The percentage residual charge p is assumed to be 70%, and the lifetime 15 years (which is an average).

For the time being, we have kept for the recovery efficiency of disposal a fixed value of 25% (except for the disposal from retrofitting, for which the recovery rate has been assumed to be 50%, as it is more likely to be carried out by certified technicians). This figure is justified as follows. Figures on recovery of fluorinated gases are available from surveys among the companies authorized to collect such gases, carried out annually by ECONOTEC-VITO in the framework of the updating of the F-gas emission inventory.

The main reason why these figures have not been used directly for calculating disposal loss factors (ratios “disposal emissions”/”amount in systems at time of disposal”) is that the “amount in systems at time of disposal” is only estimated by modelling, based on simplified assumptions (such as a common lifetime of installations, equal to the average lifetime). If the annual data of recovered fluorinated gases were used, the calculation could sometimes lead to unrealistic values (e.g., larger than 100%) of disposal loss factor for individual years.

An order of magnitude of disposal loss factor can be obtained by comparing the sum over time of the recovery figures with the sum over time of the “amount in system at time of disposal”. However, this quantity remains quite uncertain, depends on the refrigerant, and varies with time. The 25% recovery factor may be considered as a conservative value, tending to overestimate the emissions rather than underestimate them. In 2019 no increase has been observed in the amounts of recovered refrigerant, nor in the average recovery rate (the average recovery rate of HFCs – including the ‘Stationary airco’ sector and estimated as described – over the period 1998-2018 is 28%). Recovery figures for 2020 are still incomplete.

Survey on the supply of refrigerants

As for the previous updates of the emission inventory, a survey of the supply of refrigerants in Belgium[8] was carried out among the 7 importers/wholesalers. All the companies have responded. The results up to 2020 are shown in Table 4-1, and in graphical form on Figure 4-5 and Figure 4-6. The composition of the refrigerants is given in Annex 3.

8 Excluding the supply to Original Equipment Manufacturers (OEM), which are covered separately).

Table 4-1. Total supply of fluorinated refrigerants in Belgium

(tonnes)	2003	2005	2010	2013	2014	2015	2016	2017	2018	2019	2020
HCFC	**712,1**	**545,3**	**113,5**	**40,0**	**20,0**	**0,0**	**0,0**	**0,0**			
R22	655,2	506,6	113,5	40,0	20,0	0,0	0,0	0,0			
R123 (*)	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0			
R124 (*)	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0			
R409A	56,9	38,3	0,0	0,0	0,0	0,0	0,0	0,0			
HCFC-HFC	**32,6**	**23,5**	**0,0**	**0,1**	**0,0**	**0,0**	**0,0**	**0,0**			
R401A	7,3	3,6	0,0	0,0	0,0	0,0	0,0	0,0			
R402A	2,4	2,0	0,0	0,0	0,0	0,0	0,0	0,0			
R403B	1,3	1,7	0,0	0,0	0,0	0,0	0,0	0,0			
R408A	21,6	16,1	0,0	0,1	0,0	0,0	0,0	0,0			
HFC	**709,7**	**831,4**	**1.090,3**	**1.031,4**	**1.103,0**	**1.042,3**	**996,4**	**907,3**	**582,7**	**502,7**	**473,3**
R23 (*)	4,2	4,1	0,6	4,6	0,7	2,5	1,5	2,1	0,7	0,6	1,2
R32	0,0	0,0	0,0	0,0	0,0	0,0	2,5	6,3	14,6	18,2	21,7
R134a	296,6	335,3	413,2	399,3	467,2	413,4	430,5	389,7	265,5	238,1	226,6
R404A	261,0	308,5	322,2	300,0	281,1	240,0	216,9	197,5	62,8	69,1	52,6
R407A	0,0	0,0	0,0	1,0	2,9	0,8	1,8	1,1	0,5	0,9	0,1
R407C	79,0	80,2	96,9	75,3	76,1	79,6	69,1	67,6	47,8	45,4	57,7
R407F	0,0	0,0	0,0	9,1	28,8	40,1	38,4	27,4	15,3	11,2	12,6
R410A	9,2	22,1	88,2	88,3	85,4	126,4	121,2	125,7	139,6	100,2	85,2
R417A	0,0	3,9	11,1	13,4	7,8	5,9	3,4	3,5	1,6	0,9	0,9
R422A	0,0	0,0	0,0	3,1	0,6	3,1	1,7	0,8	0,4	0,4	0,4
R422D	0,0	0,0	16,8	18,7	27,9	28,2	23,7	14,2	6,1	7,4	3,7
R427A	0,0	0,0	7,5	6,7	6,9	7,1	4,0	4,3	3,4	0,9	2,0
R434A	0,0	0,0	0,0	0,0	3,0	4,0	0,0	1,3	1,8	0,1	0,0
R437A	0,0	0,0	0,0	0,0	0,0	0,0	0,5	0,1	0,1	0,0	0,0
R438A							0,3	0,4	0,4	0,1	0,0
R507A	59,7	77,2	133,7	112,1	114,7	91,2	81,0	65,1	22,4	9,3	8,6
HFC-PFC	**12,3**	**6,4**	**0,9**	**0,3**	**6,1**	**0,0**	**0,1**	**0,0**	**0,2**	**0,1**	**0,0**
R413A	12,3	6,4	0,9	0,3	6,1	0,0	0,1	0,0	0,2	0,1	0,0
R508B	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
HFC-HFO	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**16,0**	**44,4**	**103,0**	**179,1**	**179,7**	**155,0**
R448A	0,0	0,0	0,0	0,0	0,0	2,0	6,0	24,7	42,1	48,1	32,8
R449A	0,0	0,0	0,0	0,0	0,0	13,0	37,6	70,9	110,2	97,0	85,3
R450A	0,0	0,0	0,0	0,0	0,0	1,0	0,0	0,5	2,1	1,1	1,1
R452A	0,0	0,0	0,0	0,0	0,0	0,0	0,9	6,1	22,0	24,0	24,1
R454A	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0
R454B									0,0	0,1	1,0
R454C	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	1,0
R455A	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,2
R513A	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,8	2,6	9,4	8,4
HFO	**0,0**	**0,0**	**0,0**	**2,0**	**2,2**	**2,4**	**8,4**	**5,5**	**9,8**	**8,6**	**12,8**
R1234yf	0,0	0,0	0,0	2,0	2,2	2,4	6,9	4,5	8,9	7,3	11,2
R1336mzz(Z)										0,1	
R1234ze(E)	0,0	0,0	0,0	0,0	0,0	0,0	1,5	1,1	0,9	1,1	1,6
Total	**1.466,7**	**1.406,5**	**1.204,8**	**1.073,8**	**1.131,3**	**1.060,8**	**1.049,2**	**1.015,8**	**771,9**	**691,1**	**641,1**

Excluding supply to original equipment manufacturers (OEM)

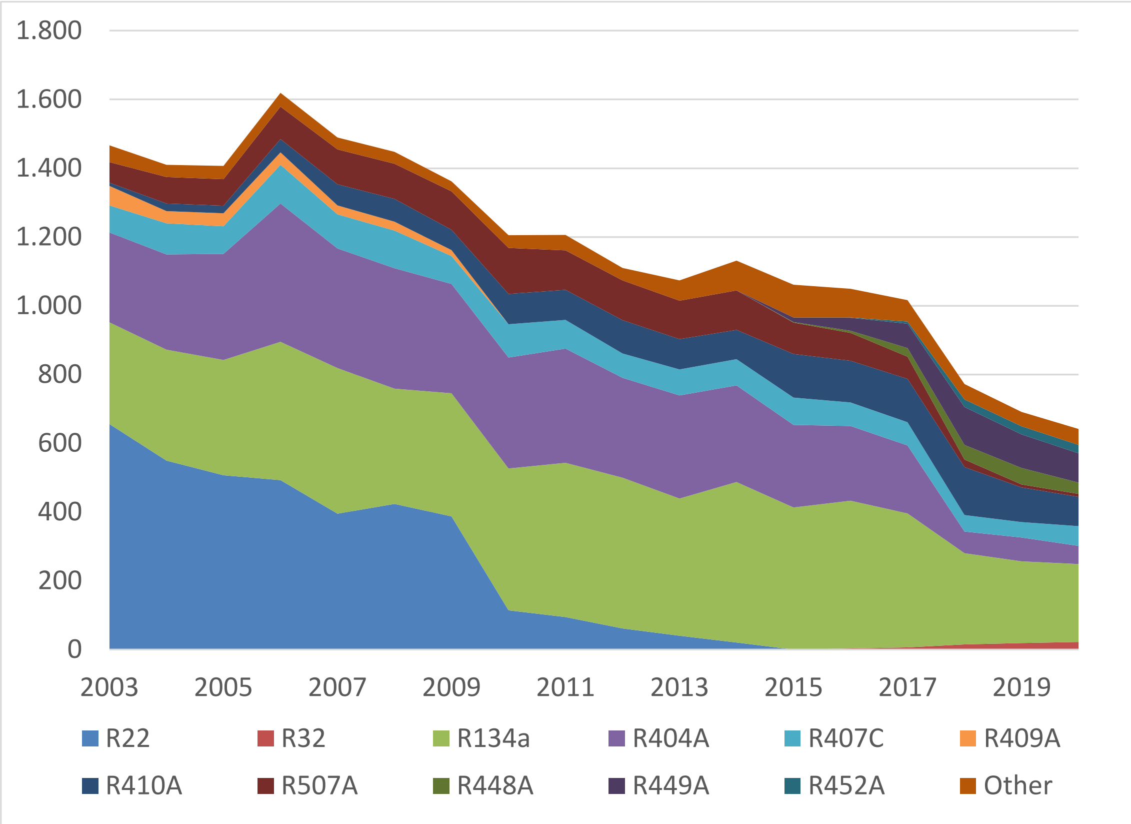
(*) Up to 2013 not necessarily complete

Source: VITO, Econotec (survey, own calculations, 2021)

The latest survey shows again a significant (though smaller than in 2019) decline in the overall supply in 2020 (-10,5% compared with 2019). This is again caused by the strong quota reduction at EU level in the framework of Art. 15 of EU Regulation 517/2014.

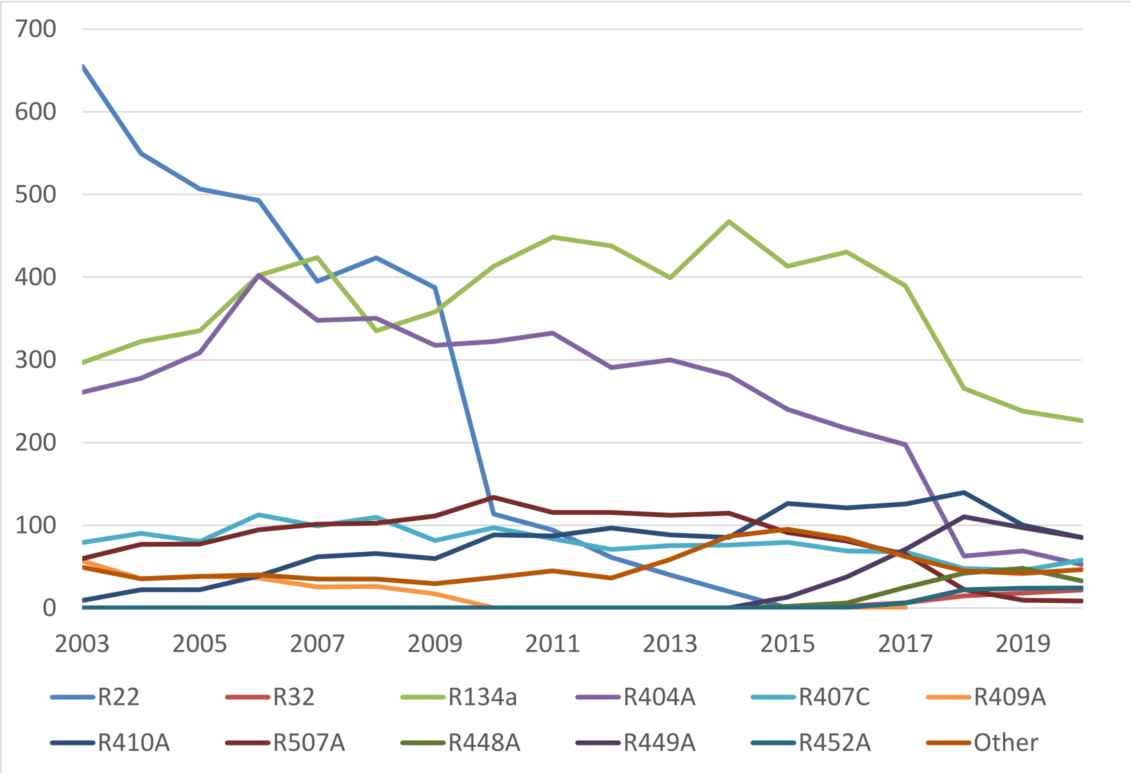
The evolution by individual refrigerant is displayed on Figure 4-5 and Figure 4-6. The decline in 2019 is due to R404A, R410A, R448A and R449A. Note that there is an increase for R407C, mainly used for stationary air conditioning.

Figure 4-5. Supply of fluorinated refrigerants in Belgium (tonnes)



Source: VITO, Econotec (survey, own calculations, 2021)

Figure 4-6. Supply of fluorinated refrigerants in Belgium, by refrigerant (tonnes)



Source: VITO, Econotec (survey, own calculations, 2021)

Annual leakage rate

As for every update, an assumption must be made about the average yearly leakage rate of the "installations". The assumptions made and their rationale are as follows.

For up to 2004, we had assumed a constant bank[9] and a constant emission rate from the refrigerant bank. However, there has been a significant decrease in the total consumption of refrigerants, confirmed by the results of the survey. It is likely that because of the EU regulations on CFC and HCFC refrigerants, and EU Regulation 517/2014 on fluorinated greenhouse gases, the regional policies and measures, as well as of the higher prices of the new HFC based refrigerants, the emission rates (the losses) have decreased on average.

Evidence of the decrease can be found in the results of the inspection campaigns carried out on refrigerant plants in Flanders up to 2016[10] (see Table 4-2 and Figure 4-7). Leakages still occur at a significant fraction of the investigated plants (in 2016, 43% of the inspected plants still had leakages), but there has on average been a decreasing trend over the last 8 years. It should be noted that the installations concerned are not necessarily representative of the existing stock of

[9] The assumption of a constant bank had originally been made because the refrigerant supply statistics of UBF/ACA were incomplete for the years up to 1993. Therefore, for these years only the proportions of the various refrigerants in the supply were being used.

[10] 2016 is the latest year for which such data are available. Many cooling plants are in use in 'Class 2 companies', which means that they are now more and more being controlled by municipalities.

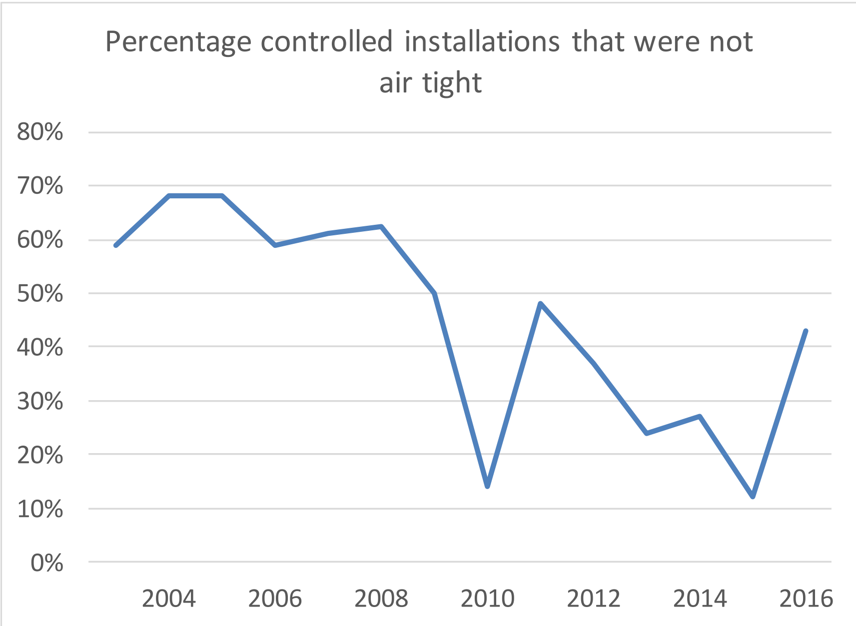
installations and that inspections have tended to focus on plants that are more likely to be leaking.

Table 4-2. Results of inspection campaigns on refrigeration plants in Flanders

	Cooling systems tested on behalf of Milieu-inspectie	
	Number of installations	Not airtight
2016	139	43%
2015	141	12%
2014	151	27%
2013	178	24%
2012	154	37%
2011	72	48%
2010	164	14%
2009	157	50%
2008	220	62%
2007	248	61%
2006	272	59%
2005	238	68%
2004	130	68%
2003	123	56%

Source: Milieuhandhavingsrapport Afdeling Milieu-Inspectie (for the years 2003-2016)

Figure 4-7. Percentage controlled installations that were not airtight in Flanders



Source: Milieuhandhavingsrapporten Afdeling Milieu-Inspectie, own calculations

Table 4-3. Leakage by refrigerant on refrigeration plants in Flanders in 2016

	Number of inspected installations	Number of leaking installations	Leaking installations (%)
R22	8	7	88%
R507 and R507A	27	13	48%
R404A	24	15	62%
R134a	38	21	55%
R407 + R407C	42	4	10%
Total	139	60	43%

Source: Milieuhandhavingsrapporten Afdeling Milieu-Inspectie (2016)

Unsurprisingly, the percentage of leaking installations in 2016 was higher for R22 than for HFCs (88%, compared with 43% on average for the whole sample).

No data is available on the amounts leaked. The 2010 report of Milieu-Inspectie had mentioned that it was not possible to estimate the actual leakage rate properly, but that for 28 installations for which that leakage rate was above 5% that year, it reached an average of 110%.

Overall, there has been progress in the reduction of leakage rates, but the fact that the overall quantity of refrigerant delivered to installations in the latest years is only decreasing progressively tends to indicate that the average leakage rate is still significantly higher than the 5% aimed at by the legislation.

At the steering group meeting of 15 October 2010, it has been agreed to make a difference according to the type of refrigerant and keep the leakage rate of R22 plants constant. These plants were to disappear, be retrofitted or be working with HFC drop-in refrigerants, as it is not allowed anymore to place on the market or use HCFCs since 1 January 2015 (Art 11 of EC Regulation 1005/2009).

In the absence of statistical data on the bank or on the emission rate and given the context just described, we have kept our previous assumptions, which we had chosen as simple as possible. For cooling installations including stationary air conditioning, that was:

- a constant 20% leakage rate for R22 and for the other refrigerants containing at least an HCFC substance (typically 'drop-ins', which are used in existing plants);
- for the pure HFC refrigerants, after being constant at a level of 20% up to 1996, the emission rate decreases with a constant percentage to reach 15% in 2003 and continues the same decline afterwards.

For industrial and commercial refrigeration (i.e., after subtracting the chillers for air conditioning), this translates to a constant level of 22% until 1996, decreasing exponentially to reach 9,8% in 2020.

In the framework of consultations that we held with service companies, operators, refrigerant suppliers, and experts in the field of refrigeration or air conditioning in 2017, this topic was addressed. Opinions were often diverging, but it could not be concluded that our assumptions would be unrealistic. Besides, although there remains a significant uncertainty on the levels of stocks and emission rates, given the mass balance approach used, the uncertainty on the emissions themselves is lower than that on the stock or the emission rate, as the uncertainties on the bank and on the yearly emission rate tend to compensate each other (see section on the uncertainty analysis).

The calculation of the 'amount in systems at time of disposal' and the percentage recovery are therefore being kept for the time being.

For the penetration of natural refrigerants in new systems, the estimates are multiplied by an 'F-gas fraction', linearly varying from 100% in 2006 to 75% in 2016, and extrapolated to 2020, to take into account the penetration or increased penetration of CO_2 and NH_3 systems. In the absence of aggregate data for Belgium on this topic, this simple assumption is based on data from the French emission inventories for refrigerants (on which the latest report is (Barrault & Denis, 2017)). However, given the strong quota reduction of the EU regulation in 2018, the high GWPs of refrigerants R404A and R507A, the strong decline in supply of these refrigerants, of which the price has exploded that year, we have assumed that these two refrigerants are not used in new installations anymore since 2018.

Based on consultations with gas suppliers, it has been assumed that 60% refrigerants R448A and R449B have been used for replacing R404A/R507A in existing installations, the remaining 40% being used in new systems.

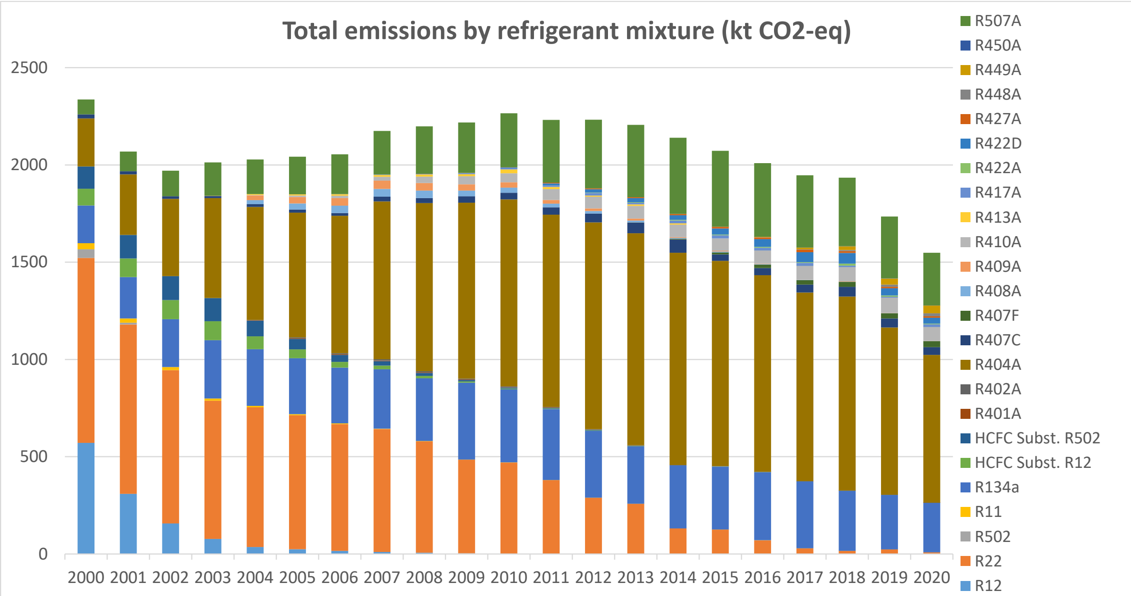
It should be noted that, except for the manufacturing emissions, which are marginal, the refrigerant mix in new systems has no impact on current emissions. Because of the mass balance approach of the emission inventory, it is only at the time of disposal, i.e., after 15 years, that the change of refrigerant mix in new systems will take place.

The modelling of the retrofitting of existing installations is based on the supply figures of drop-in refrigerants (R413A, R417A, R422A, R422D, R427A for replacing R22; R407F, R448A and R449A for replacing R404A and R507A). As a result of the retrofitting, the disposal of the refrigerants replaced takes place earlier than at the end of life, and disposal emissions of R404A and R507A are comparatively higher during the years 2016-2018. This implies that the later disposal emissions of these refrigerants will be lower than had there been no retrofitting.

Results

Figure 4-8 shows the total emissions by refrigerant, in terms of CO_2-equivalents. Dominant are R22 in the first place, progressively replaced by R404A, R507A and R134a.

Figure 4-8. Emissions from industrial and commercial refrigeration installations by refrigerant (kt CO_2-eq)

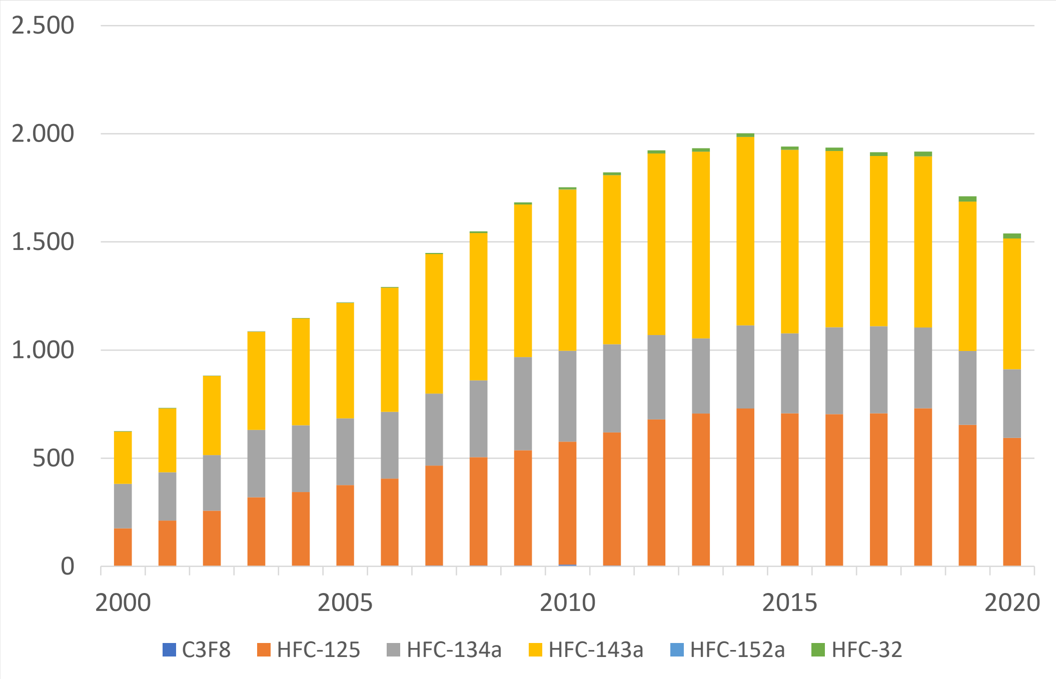


Source: VITO, Econotec (survey, own calculations, 2021)

The emissions of CRF gases, expressed in CO_2-eq (shown by substance on Figure 4-9 and by type on Figure 4-10), have reached a peak in 2014, but with an increasing share of disposal emissions. It should be recalled that there remains a high uncertainty on the level of the latter emissions. They are assessed from the 'amount in systems at time of disposal' (based on assumed consumptions in new equipment, average equipment lifetime and percentage remaining in systems at time of disposal) and the assumed average recovery rate.

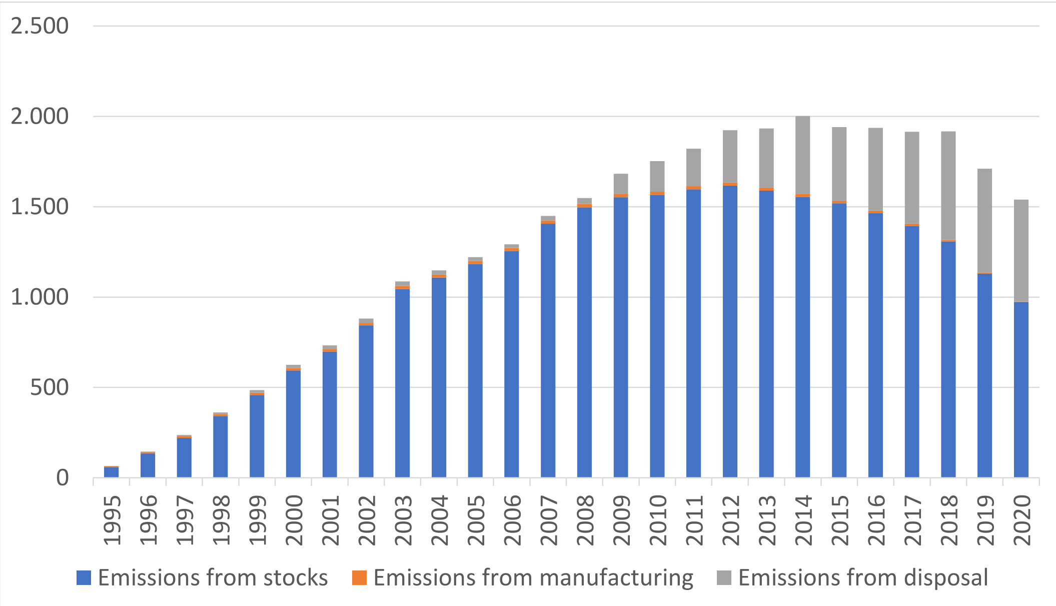
Decreasing emissions from stock are being replaced by increasing emissions from disposal.

Figure 4-9. CRF-gas emissions from industrial and commercial refrigeration installations by substance (kt CO_2-eq)



Source: VITO, Econotec (survey, own calculations, 2021)

Figure 4-10. CRF F-gas emissions from refrigeration installations installations by type (kt CO_2-eq)



Source: VITO, Econotec (survey, own calculations, 2021)

4.4.2. Domestic and commercial hermetically sealed refrigeration (2.F.1.b.)

Introduction

This category consists of domestic refrigeration appliances such as refrigerators, freezes (chest or upright), and fridge freezers. Producers of household refrigerators, freezers, and fridge freezers switched from CFC-12 to HFC-134a from 1994. This was however only a small fraction and most started using isobutane as an alternative. As a results only a small share of domestic refrigerators entering the market since 1994 contained HFC-134a. Under the EU F-Gas Regulation[11], imports of household refrigerators and freezers that use refrigerants with GWPs of 150 or higher are prohibited as of 2015.

Methodology

For the calculation, a difference is made between domestic and commercial refrigerators. Domestic refrigerators are divided into three categories: independent refrigerators, independent freezers, and refrigerator/freezers. Commercial refrigerators include all hermetically sealed refrigerators, used most frequently in retail food stores. Unlike the category industrial and commercial refrigeration, these are not filled when installed, but are prefilled with refrigerants. Because no statistics are available differentiating between hermetically sealed commercial refrigeration types, no distinction is made.

The number of new household refrigerators and freezers is calculated based on the stock of equipment and the estimated number of end-of-life refrigerators. No sale statistics for Belgium are readily available. Of the new refrigerators and freezers, it is assumed that none use R134a as cooling agent and R245fa in foam from 2015. For the period 1999-2010, the Household Budget Survey provides data on the number of refrigerators and freezers per household for Flanders, Wallonia, and Brussels. The survey has changed from an annual to a bi-annual one. However, because the quality of the information is not similar to the previous survey[12], we do not use the household budget enquiry but assume a linear extrapolation of the percentage ownership between 2010 and 2014 for all three types of equipment. To calculate the number of refrigerators and freezers, the percentage ownership is multiplied with the number of households. The number of households in Flanders, Wallonia, and Brussels for 2010 - 2016 was completed with information from the Federal Planning Bureau. Because no new equipment containing HFCs is placed on the market from 2015, assumptions relating to the stock of equipment is not relevant anymore in the calculation of the emissions.

The number of new hermetically sealed commercial refrigerators is calculated based on the number of supermarkets and smaller shops in Belgium from 1995 to 2019. Statistics were used from (Nielsen, 2017) and published statistics from STATBEL. Equipment in smaller shops, e.g., food retail, restaurants, hotels, etc., were included from the 2018 inventory. Assumptions on the use (kg) of refrigerants in hermetically sealed refrigeration per shop (depending on its size)

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11 Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006

12 The household budget enquiry collected data only for refrigerators in 2013 (and not for independent freezers or combination refrigerator/freezers). The 2013 enquiry shows that the ownership of a refrigerator by households has gone up considerably in all three regions (for Wallonia and Brussels more than 44 percentage points). It is assumed that with the new questionnaire respondents also counted refrigerator/freezers.

were taken from the literature. Overall, the load per equipment is assumed to be 500 g on average. The most frequently used refrigerants are R134a and R404A. The shares of each have changed over the years, with an increasing use of non-HFC refrigerants and decreasing shares of R404A because of its high GWP. The time series was reconstructed based on the available literature and inventories from France and the UK.

Manufacturing emissions are set to zero.

The annual emission factor for standing domestic refrigerators and freezers is 1% (HFC-134a) and 0,25% (HFC-245fa), irrespective of the type (refrigerator, freezer, and combination) (see IPCCC methodology below). For commercial refrigerators, the emission factor is also 1%.

Equation: Emissions during equipment lifetime

$$E_{lifetime,t} = B_t \times \frac{x}{100}$$

$E_{lifetime,t}$ = amount of HFC emitted during system operation in year t, kg

B_t = amount of HFC banked in existing systems in year t (per application), kg

x = annual emission rate (i. e. emission factor) of HFC of each application bank during operation accounting for average annual leakage and average annual emisions during servicing, percent

Domestic refrigerators and freezers have an average lifetime of 15 years, this is the same as in Germany, the Netherlands or the UK. The number of refrigerators that are end of life in 2019 is the same as the number of new refrigerators in year x-15. This is an assumption; in reality discarded refrigerators will have different ages. Statistics on the number of refrigerators and freezers collected in Flanders, Brussels and Wallonia are published by Recupel (not publicly available). The Recupel reports also contain information on the amount of HCFC, CFC, HFC and HC recovered. This is the amount recovered from equipment collected in each region, but not necessarily dismantled in that region (see below). The information however does not distinguish between the different types of substances and therefore cannot be used.

Commercial refrigeration has an average lifetime of 10 years. With respect to disposal, commercial refrigeration is in some cases also collected via the Recupel system. For calculating the disposal emissions, the same assumptions were used as for domestic appliances. The study (VITO, Econotec, Öko-Recherche, 2018) showed that emissions from commercial hermetically sealed refrigeration that is dismantled correctly are very limited. There is however a large uncertainty related to the number of refrigerators that are disposed correctly and those that are disposed incorrectly with high emissions as a result.

Emissions from disposal (see IPCC methodology below) can occur at two different stages of the process: 1) on site, during collection, storage and transport from the collector to the dismantling plant; and 2) at the dismantling plant. The emission factor for the first type of emissions is assumed to be 30% and the emissions occur in the region where refrigerators and freezers originate from. Recent information from Recupel showed that around 30% of domestic refrigerators are not dismantled correctly[13].

Equation: Emissions at end of life

$$E_{end\ of\ life,t} = M_{t-d} \times \frac{p}{100} \times \left(1 - \frac{\eta_{rec.d}}{100}\right)$$

$E_{end\ of\ life,t}$ = amount of HFC emitted at time of disposal in year t, kg

M_{t-d} = amount of HFC initially charged into new systems installed in year (t – d), kg

d = lifetime

p = residual charge of HFC in equipment being disposed of expressed in percentage of full charge, %

$\eta_{rec,d}$ = recovery efficiency at disposal, which is the ratio of recovered HFC to the HFC contained in the system, %

Dismantling of refrigerators and freezers does not take place in each region. From 2012, all refrigerators and freezers collected in Flanders are exported for dismantling to either Germany, the Netherlands or Wallonia (only exports for dismantling outside Belgium are considered). All refrigerators and freezers collected in Wallonia and Brussels are assumed to be processed in Wallonia (by Recydel). Recupel provided information on the recovery efficiency which, according to the WEEE forum standard, should be at least 90% (pers. comm. 2014). The recovery efficiency was therefore considered to be 90% for all HFCs in 2020, which is a conservative estimate.

Table 4-4. Assumptions for domestic refrigerators and comparison with IPCC 2006 guidelines

	HFC-134a	HFC-245fa	IPCC 2006	2019 refinement
Charge (kg)	0.1	0.325	0.05 < M < 0.5	0.05 < M < 0.5
Lifetime (y)	15	15	12 < d < 20	12 < d < 20
Manufacturing EF (%)	NA	NA	0.2% < EF < 1%	0.2% < EF < 1%
Fugitive EF (%)	1%[1]	0,25%	0,1% < EF < 0,5%	0,1% < EF < 0,5%
Recovery efficiency (%)	63%[2]	90%	0% < RE < 70%	0% < RE < 70%

Note: 1. Previous IPCC guidelines proposed 1% emission factor, which was kept constant to have consistent time series (impact is limited).

2. Assuming that 30% of HFC-134a is emitted before dismantling and 90% is recovered at dismantling site (based on information of Récydel).

13 Meer dan 200.000 koelkasten en diepvriezers vermist: incorrecte recyclage zorgt voor enorme milieuschade (prezly.com)

Table 4-5. Comparison of assumptions for domestic refrigerators between selected countries

Assumption	BELGIUM	FRANCE	GERMANY	UK
Disposal EF (%)	37%	63%	27%	28%
Fugitive EF (%)	1%	0,01%	0,30%	0,30%
Manufacturing EF (%)	NO	NA	NO	0,60%
Lifetime (y)	15	15	15	15
Charge (g)	100	46 - 60	NR	100
Share R134a (%)	0%	1%	0%	0%

Source: Information taken from NIR (https://unfccc.int/ghg-inventories-annex-i-parties/2021).

Table 4-6. Comparison of assumptions for commercial hermetically sealed refrigerators between selected countries

Assumption	BELGIUM	FRANCE	GERMANY	UK
Disposal EF (%)	37%	83%	46%	28%
Fugitive EF (%)	1%	1%	1% - 1,4%	1,2%
Manufacturing EF (%)	NO	NA	NA	1%
Lifetime (y)	10	15	10	10
Charge (g)	500	300 – 3000 per store	NA	500
Share R404A (%)	7%	10%	NA	NA
Share R134a (%)	36%	50%	NA	NA

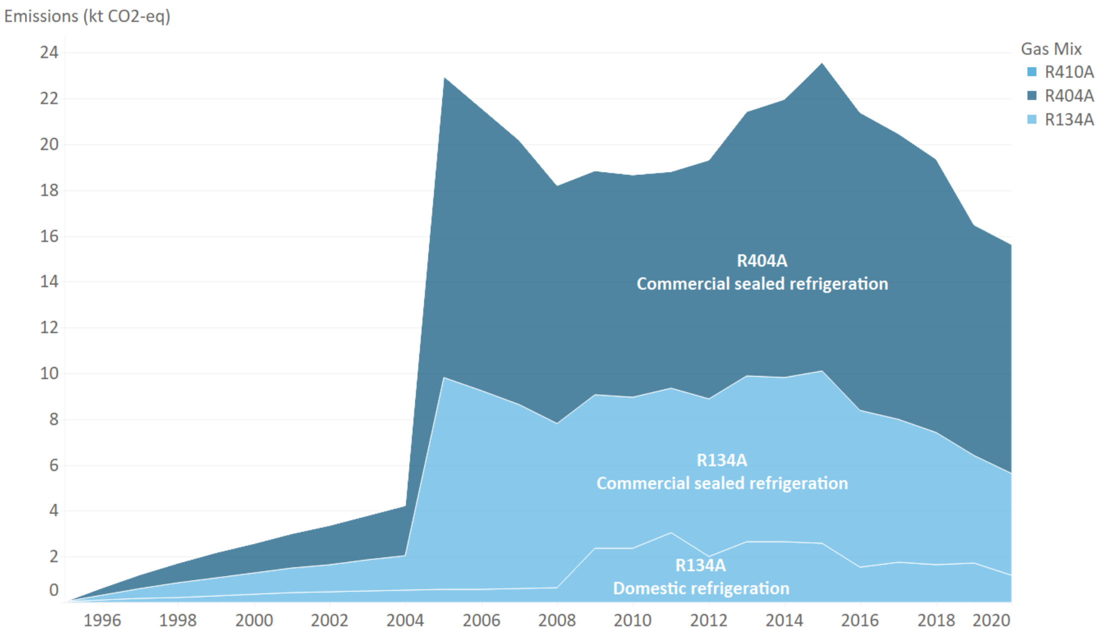
Source: Information taken from NIR (https://unfccc.int/ghg-inventories-annex-i-parties/2021).

Table 4-7. Assumptions for commercial hermetically sealed refrigerators and comparison with IPCC 2006 guidelines

	BELGIUM	2019 refinement
Charge (kg)	0.5	0.2 < M < 6
Lifetime (y)	10	10 < d < 15
Manufacturing EF (%)	NO	0.5% < EF < 3%
Fugitive EF (%)	1%	1% < EF < 15%
Recovery efficiency (%)	63%	0% < RE < 70%

Results

Figure 4-11. Total emissions from domestic and commercial sealed refrigerators in Belgium (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.4.3. Industrial refrigeration (2.F.1.c.)

Introduction

See commercial refrigeration (2.F.1.a).

4.4.4. Transport refrigeration (2.F.1.d.)

Introduction

HFCs have been used as refrigerants in refrigerated vehicles since 1993. Today, HFC-134a, along with the refrigerant mixtures R404A and R410A, are most commonly used. Since 2015, R452A has also been in increased use (Germany, 2021).

Refrigerated containers (reefers) are used primarily for transports by ocean-going ships. Therefore emissions take place in international waters or when reefers are placed on shore. Considering In Germany emissions are calculated on global scale and subsequently Germany's share in the global economy is used to allocate emissions to Germany. Since 1993, the most commonly used refrigerant has been HFC-134a. Since 1997, R404A has also been used.

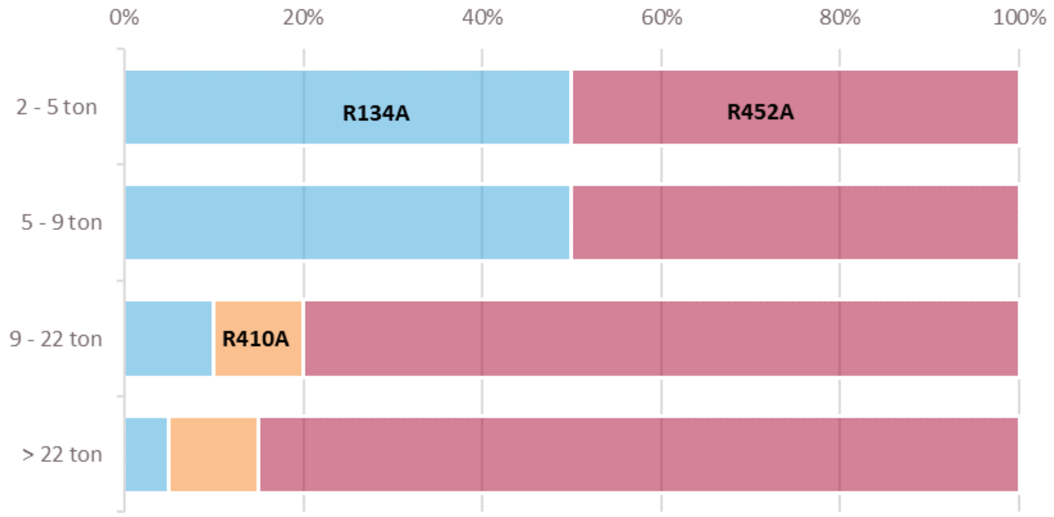
Methodology

Data on the fleet and new registrations of refrigerated trucks and trailers for 2020 were obtained from the FPS Mobility for different weight categories. The stock of refrigerated land transport is relatively stable.

Manufacturing does not occur in Belgium and therefore manufacturing emissions are zero. However, filling of empty systems does occur. Emissions are included in the annual fugitive emissions.

The data shows that in the period 2009-2013 few new refrigerated trucks were registered. Based on a personal communication with the FPS Mobility, data for these years were adjusted based on the percentage of newly registered trucks where this information (refrigerated/non-refrigerated) was not recorded. From 2014 onwards, the statistics were considered reliable. The fleet of refrigerated trucks is modelled based on the number of new registered trucks (starting in 1993) and assuming an average lifetime of 12 years. Information on the substances and average quantities of F-gases in each weight category is based on assumptions taken from Schwarz[14] and personal communication. Based on this new information and the German NIR (2021), assumptions have been adjusted.

Figure 4-12. Share of refrigerants in different weight categories of new refrigerated transport in Belgium (%)



Source: VITO, Econotec

Fugitive emissions are calculated with an emission factor of 15% for both new and retrofitted systems.

14 Schwarz, W. (2005) Emissions, activity data and emission factors of fluorinated greenhouse gases (F-gases) in Germany 1995-2002 – Adaptation to the Requirements of the international reporting and implementation of data into the Centralised System of Emissions (ZSE). Umweltbundesamt, Dessau.

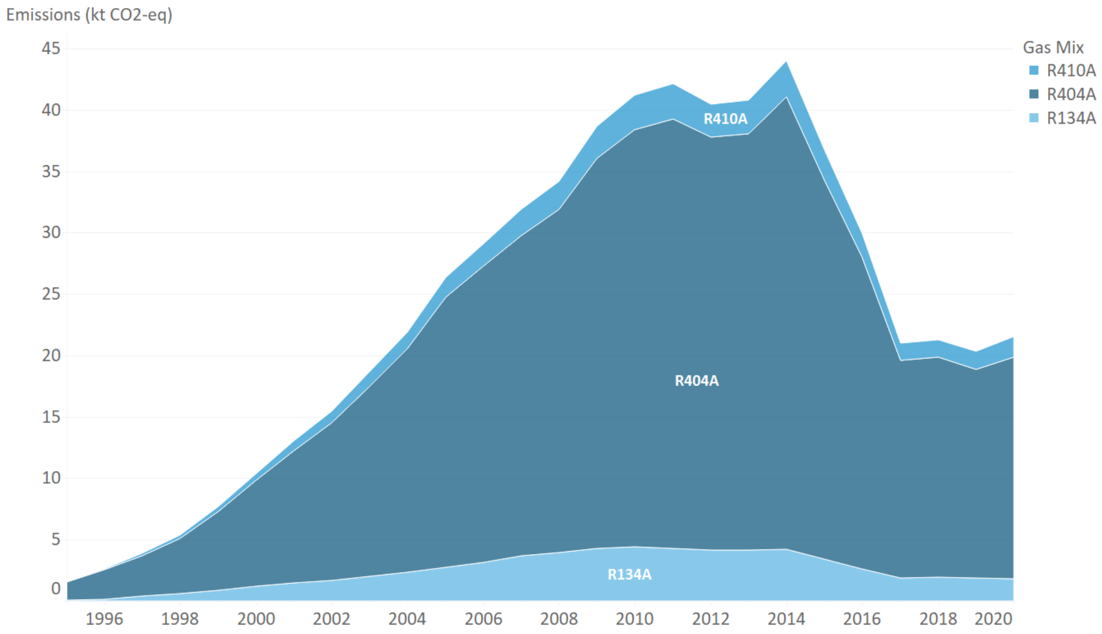
The disposal emission factor is 30% for all gases and all weight classes.

As far as maritime transport is concerned, the emissions of reefers serviced in Belgium are not known, but the reefer service companies operating in the country seem to mostly purchase their refrigerants (directly or indirectly) from companies participating in our survey on the supply of refrigerants. Therefore, the emissions from reefers are to a large extent included in those calculated for the industrial and commercial 'installations'. The situation should be similar for the maintenance of ships.

Results

The decline in emissions between 2014 and 2017 is due to changes in operation emission factors. Most of the emissions occur during operation. While disposal emissions are minor, the emissions are increasing from an estimated 1 kt CO_2-eq. in 2005 to 6 kt CO_2-eq. in 2020.

Figure 4-13. Total emissions from refrigerated transport in Belgium (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.4.5. Mobile air conditioning (2.F.1.e.)

Introduction

The mobile air conditioning systems category includes air conditioning systems in cars, trucks and utility vehicles, buses and coaches, and railway vehicles. HFCs have been used in mobile air conditioning systems since 1991. The share of vehicles equipped with air conditioning has seen an important growth over the years. HFC-134a was by far the most commonly used refrigerant. Due to the Mobile Air Conditioning Directive, HFO-1234yf is increasingly being used in automobile air conditioning systems since 2012.

Methodology

- **Cars**

A questionnaire has been sent to all car manufacturers in Belgium asking for their consumption of HFC-134a and HFO-1234yf in 2020 and their emissions. Data was scaled to match car manufacturing to correct for missing information.

Data on the total number of cars produced in Belgium over the past year were obtained from FEBIAC and the number of new cars registered in Belgium from the national statistics office.

To calculate the emissions from car air conditioning systems, the share of new cars equipped with air conditioning systems must be known. For 2020 the share is estimated to be 96%. This is assumed to be the maximum saturation level, based on Schwartz[15]. We have assumed that in Belgium this value was reached in 2010. In Belgium, no systematic registration of the fact that new cars are equipped with air conditioning is currently performed.

Up to 2012 we have assumed that all cars on the Belgian market with air conditioning are equipped with HFC-134a. From 1 January 2013, the temporary exemption of HFO-1234yf in car air conditioning has been lifted[16]. Few data exist on the use of HFO-1234yf in cars in Europe at the moment. In Germany, only 458 532 cars have been registered between January 2013 and June 2015 that are equipped with HFO-1234yf, which corresponds to approximately 1% of the total car fleet or 6,2% of cars sold (Deutscher Bundestag, 2015). In Belgium, we assume that 1,4% of cars sold in 2013 contain HFO-1234yf[17], 6% in 2014, 24% in 2015, 82% in 2016 and 100% in 2017 taking into account a gradual increase in number of cars.

It is assumed that CO2 has not been used in car mobile air conditioning systems. This is an assumption, but as the GWP values are the same, there is no impact on the emissions expressed in CO_2-eq.

An important assumption is the amount of HFC-134a or HFO-1234yf in the air conditioning system of new cars. We have used the data from Schwartz[18], which are for the years up to 2002, and had kept for the later years the unitary load of 0,7 kg given for 2002. However, the mean weight of HFC-134a in the air conditioning of cars manufactured in Belgium is now significantly lower, ranging between 0,5 and 0,6 kg. If we look at the data from Öko-Recherche with the average amount of HFC-134a for the period 1992 until 2003, we can see a clear linear decrease. We extrapolated this linear trend, which gives 0,5 kg in 2010 and the years thereafter. This

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15 Schwarz, W. (2010) Emissionen fluorierter Treibhausgase in Deutschland 2008,» Umweltbundesamt, Texte 41/2010

16 Declaration by the European Commission regarding Point 9. of the agenda of the 31st meeting of the 'Technical Committee - Motor vehicles' (TCMV): State of Play of the EU Mobile Air-Conditioning directive (2006/40/EC). Brussels, 19th December 2012

17 This was calculated based on the sales statistics in 2013 for car manufacturers and assuming that manufacturers that already have models equipped with HFO-1234yf, 10% of the models sold contain HFO-1234yf and not HFC-134a.

18 Schwarz, W (2005) Emissions, activity data and emission factors of fluorinated greenhouse gases (F-gases) in Germany 1995-2002 – Adaptation to the Requirements of the international reporting and implementation of data into the Centralised System of Emissions (ZSE). Umweltbundesamt, Dessau.

seems to correspond with the information provided by some Belgian car manufacturers (combining both large and small models).

A significant problem with the emission inventory for cars is that we use a model to determine the number of vehicles with air conditioning and the bank of coolants in these vehicles. Statistics from FEBIAC and the national statistics office, and assumptions on the percentage new vehicles with air conditioning are used as input variables. These statistics are reliable, and the assumptions are supported by reports and scientific studies from neighbouring countries. However, when considering vehicles that are end-of-life, there is a significant difference between the model outcome and available statistics published by Febelauto. There are two possible explanations: either the model overestimates or the statistics of Febelauto are not complete.

If the model overestimated the number of cars that are removed from the stock, we would expect the total number of cars based on the model to be much smaller than the total registered cars statistics, published by the national statistics office. This is not the case (a comparison revealed that the model results in a slightly larger stock than based on statistics).

Febelauto confirmed that the published statistics are not a complete representation of the number of cars that have been disposed of in Belgium. There are two explanations. First, not all vehicles are dismantled in official centres. Febelauto estimates that 30% of cars are dismantled illegally. Second, some cars that are end-of-life or near end-of-life are exported (to be dismantled or used). This could be up to 56%, according to Febelauto (personal communication, 2014).

Therefore, we adjusted the calculation methodology from 2013 to align the model output regarding end-of-life cars and the statistics from Febelauto. The number of dismantled vehicles reported by Febelauto is increased with 30% (to account for cars illegally dismantled in Belgium). We assume that all HFC-134a contained in these vehicles will be emitted, except for the quantity recovered in dismantling centres (2,58 t in 2014, of which 90% originates from cars, as published by Febelauto). The remaining cars that according to the model are expected to be end-of-lifetime are assumed to be exported to either EU or non-EU countries. For 2019, this is 67%. Previously, the percentage was an assumption, based on personal communication with Febelauto. With this approach model outcome and statistics from Febelauto are aligned. The underlying assumption is that the characteristics of cars that are dismantled in Belgium and cars that are exported are the same. This is not necessarily the case and cars dismantled in Belgium could be relatively older and/or equipped less with air conditioning than average[19].

The fugitive emission factor for cars is estimated to be 8,8%, including regular and irregular losses. This is in line with assumptions from other neighbouring countries. In addition, the model assumed that cars are refilled twice over their lifetime, with emissions occurring at that point in time. This approach is likely an overestimation and is not consistent with the quantities placed on the market. The approach was therefore adjusted, assuming only one refilling over the lifetime of the car and with smaller emissions (2%).

[19] Febelauto, pers. comm. 2016

- **Buses and coaches**

Information on consumption and emissions of HFC-134a was received from all Belgian manufacturers. Consumption of HFC-134a is decreasing, because of the shift to R-407C (in electric buses) and purchases of prefilled air conditioning systems.

The number of new registrations of buses and coaches was taken from the national statistics office.

The data is split between public buses, other buses and coaches because of differences in the percentage of vehicles with air conditioning and differences in the load of refrigerant. We assume that 100% of coaches, 100% of public buses and 15% of other buses are equipped with air conditioning. The percentage buses with air conditioning was previously calculated based on information from De Lijn, TEC and MIVB. However, also other companies might operate buses. This averages to an assumption of 50%, also used previously, which was supported by Van Hool (personal communication, 2014) as a reasonable assumption.

We use a model approach to estimate the number of buses and coaches with air conditioning in the entire fleet. In 2020, 53% of buses and coaches had air conditioning. The total fleet of buses and coaches for 2020 was obtained from the national statistics office. Fugitive emissions are calculated assuming an emission factor of 15%. It is expected that the quantities emitted annually are compensated by an equivalent recharge in the same year. This is different from the model for cars, where recharging only takes place once.

An average lifetime of 17 years is assumed. The disposal emission factor is 30%. This is relatively low, compared to cars, but there are no statistics on recovery of HFC-134a from buses and coaches or trucks and therefore we use the assumption used by Germany.

- **Trucks**

Information on refrigerant use and emissions of manufacturing was obtained from the only Belgian manufacturer. There is a significant difference between the theoretical emissions resulting from filling the air conditioning system, estimated at 0,2%, and the difference between the quantity filled and the quantity consumed (10% in 2020). For the inventory, we used an emission factor of 1%. The Belgian truck manufacturer is making the transition to HFO-1234yf, so consumption of HFC-134a in manufacturing will disappear in near future.

The number of newly registered trucks was obtained from the FPS Economy. It was allocated to three different weight categories (assumptions taken from Schwartz[20]). In comparison to the previous inventory, road tractors were also included (added to the high weight category). For each weight category, different assumptions are taken with respect to percentages of new vehicles equipped with air conditioning.

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[20] Schwarz W. (2005) Emissions, activity data and emission factors of fluorinated greenhouse gases (F-gases) in Germany 1995-2002 – Adaptation to the Requirements of the international reporting and implementation of data into the Centralised System of Emissions (ZSE)

Fugitive emission factors are taken from Schwartz[21], who estimated this at 8,3% for vans (< 1,5 t) and 11,2 % for larger trucks (=< 1,5 t). These emitted quantities are recharged annually.

The total truck fleet in Belgium and the number of trucks with air conditioning (for each weight category) are calculated based on a model.

The European MAC directive applies to both cars and vans (M1 and N1), at this moment the number of vans equipped with HFO-1234yf is limited but it is assumed that their penetration follows that of passenger cars (100% HFO-1234yf from 2018).

To assess the number of trucks disposed of, an average lifetime of 12 years is assumed. The percentage of trucks with air conditioning is increasing, but at a relatively slow rate because not all new trucks are assumed to be equipped with air conditioning (especially vans and smaller trucks).

It is assumed that 70% of the quantities of HFC-134a contained in disposed trucks are recovered and 30% is emitted.

- **Rail**

There are very few trams and metros with air conditioning, so this source was excluded in this assessment. In contrast, an important part of the trains do have air conditioning. Information of the NMBS/SNCB was requested on the number of trains with air conditioning in 2020.

The average quantity of HFC-134a per vehicle, by type, is used from the NMBS/SNCB. For the HST this was 5, 15 and 30 kg of R407C for respectively the motor wagons, trains and restaurant carriages. For fugitive emissions, the emission factor is calculated based on quantities consumed by the NMBS/SNCB for servicing the air conditioning systems (data from the NMBS/SNCB).

The disposal emissions are estimated at 15%, but it is expected that the first trains with air conditioning will be taken out of service only in 2023.

Results

After the implementation of the MAC Directive, total emissions from car air conditioning peaked in 2014 and decreased rather sharply after. Fugitive emissions followed a similar trend, peaking in 2015 and 2016 and sharply declining after, while manufacturing and disposal emissions follow entirely different trends. Disposal emissions hovered around 50 from 2010 to 2014, peaked in 2018 and have been decreasing since.

The transition to HFO-1234yf is not visible due to its low GWP-value compared to HFCs and CFCs. Expressed in ton, the total emissions in 2020 of HFO-1234yf from car air conditioning was estimated to be 85 t; HFC-134a emissions were 192 t.

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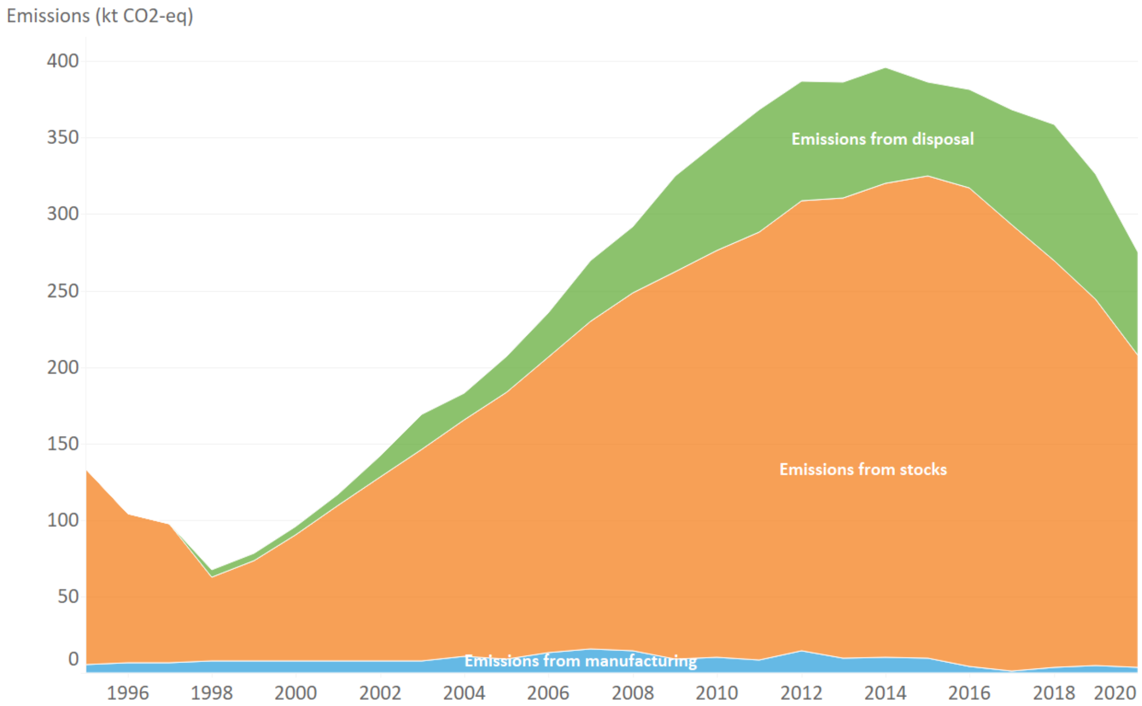
[21] Schwarz W. (2007) Establishment of Leakage Rates of Mobile Air Conditioners in Heavy Duty Vehicles. Part 1 Trucks. Report for DG CLIMA.

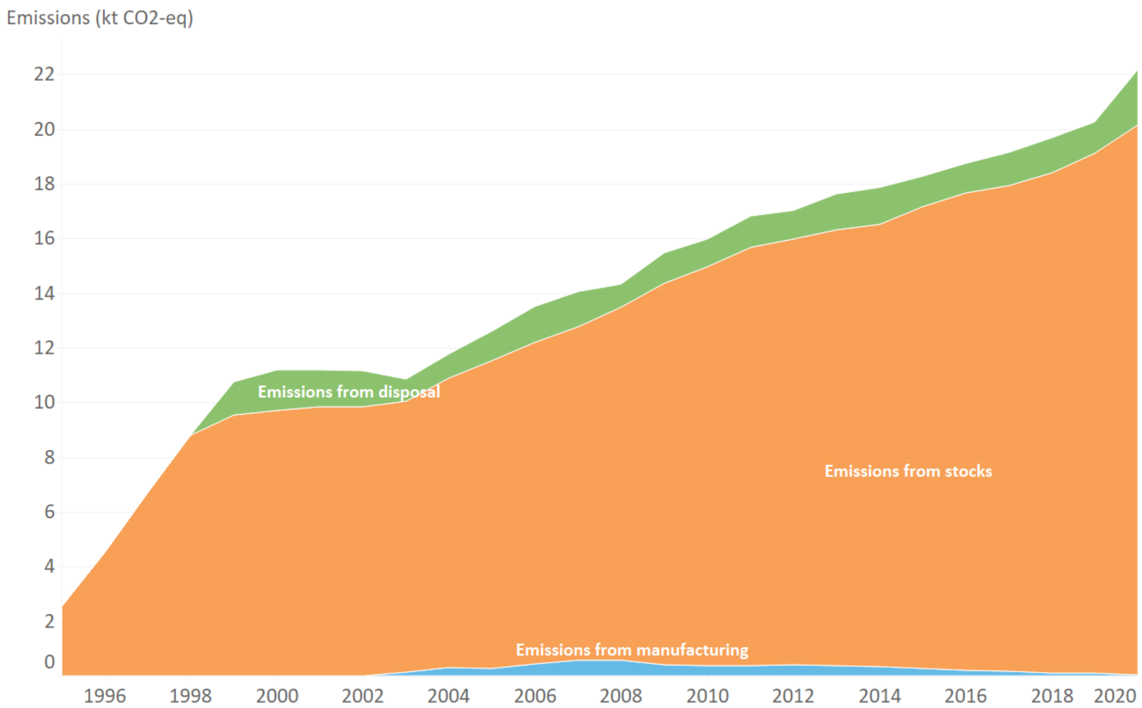
Figure 4-14. Total emissions from car air conditioning in Belgium (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

HFC Emissions in buses and coaches are still increasing, mostly because the stock of bues and coaches equipped with an air conditioning system is increasing, resulting in increased emissions during use. The emissions are however small compared to emissions from cars.

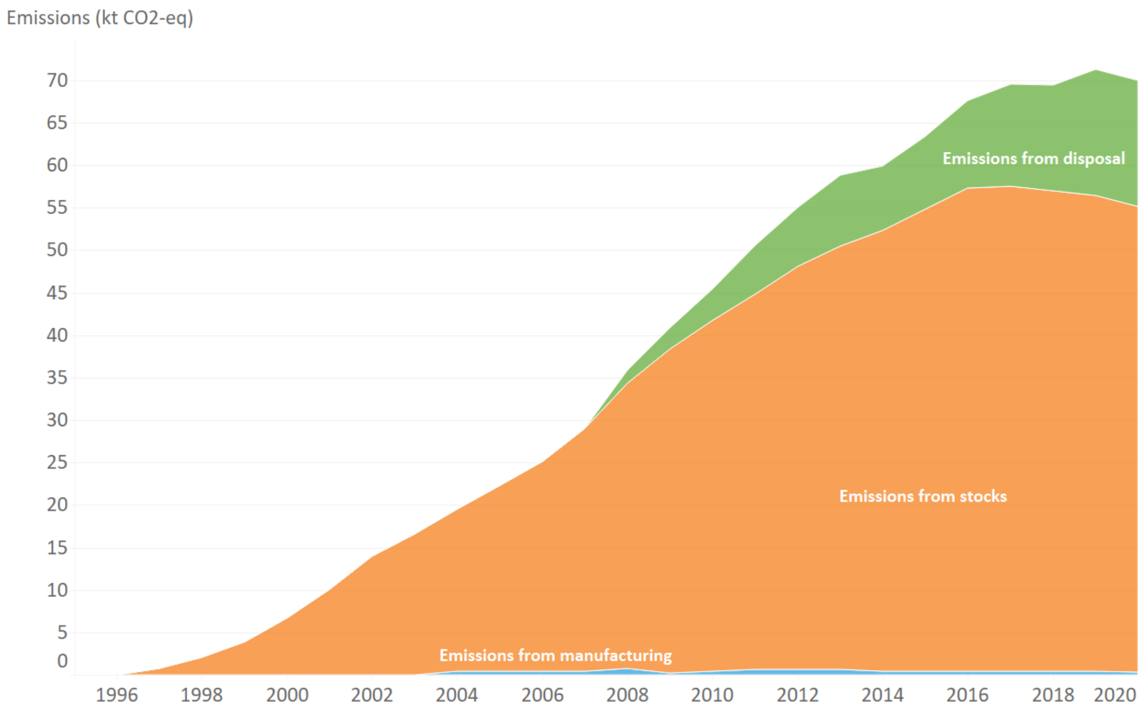
Figure 4-15. Total CRF emissions from bus and coach air conditioning in Belgium (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

In trucks HFC emissions are decreasing. This is caused primarily by the use of HFO-1234yf in small commercial vehicles. It illustrates the potential effect a shift to HFO -1234yf in other commercial vehicles could have. Emissions from disposal are still increasing, as more and more trucks with air conditioning are end of life.

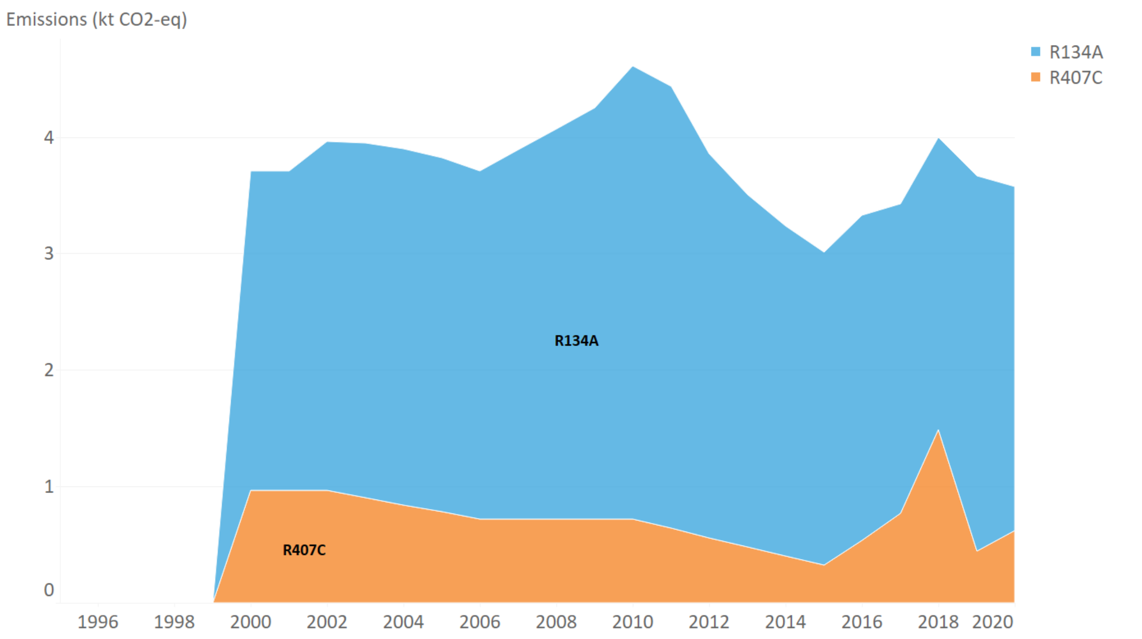
Figure 4-16. Total emissions from truck air conditioning in Belgium (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

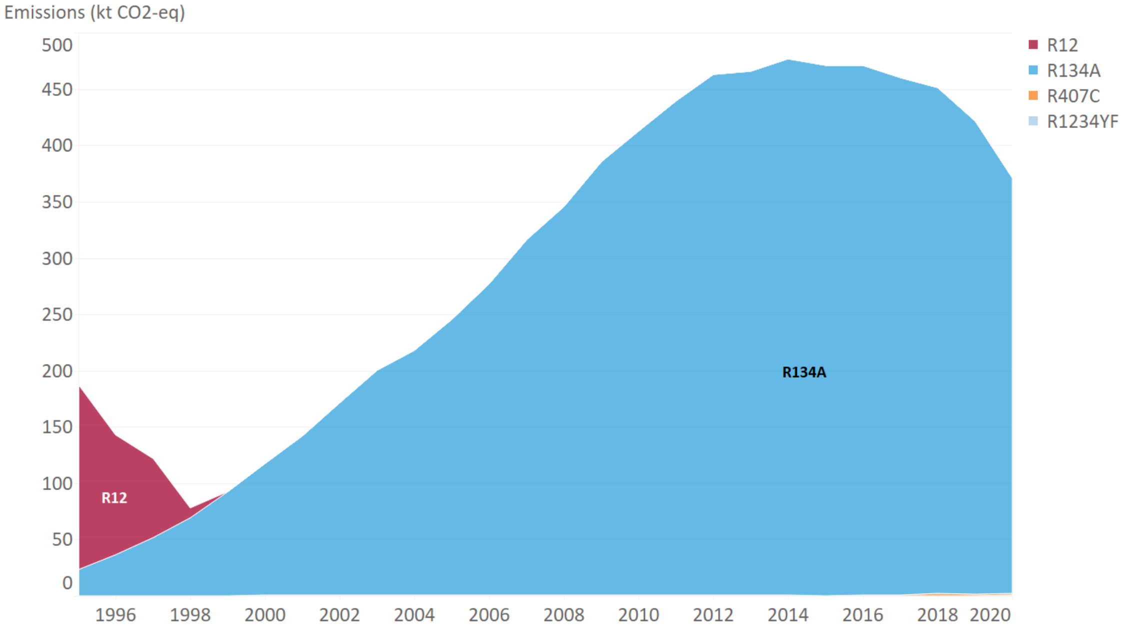
Emissions from rail are stable. The stock of equipment with air conditioning is not increasing and therefore emissions are relatively constant.

Figure 4-17. Total emissions from rail air conditioning in Belgium (in kt CO_2-eq)



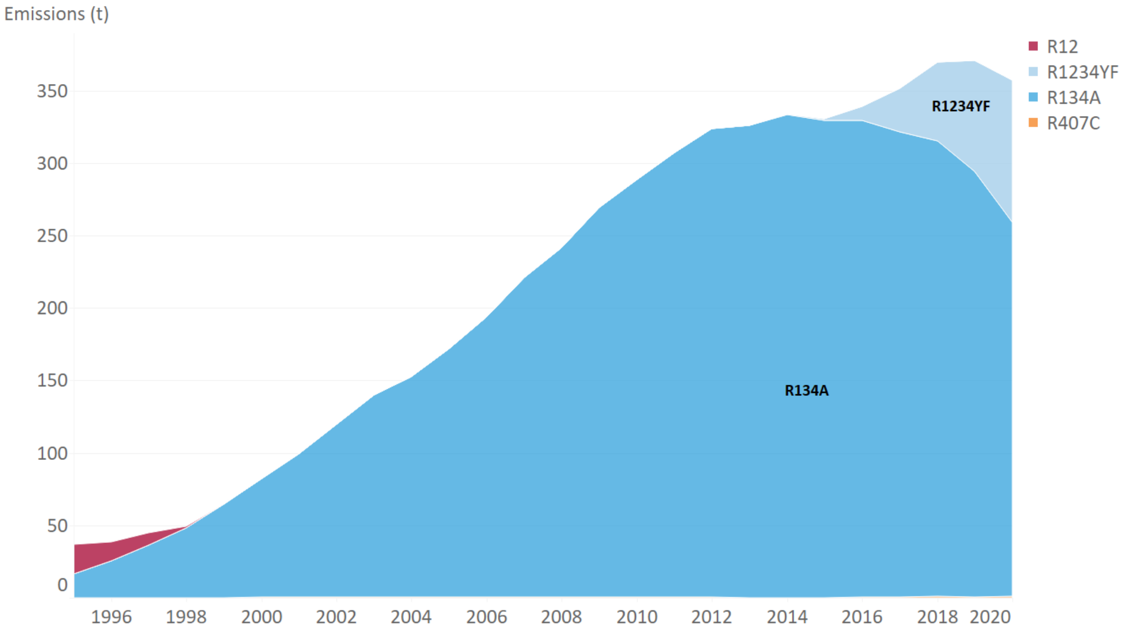
Source: VITO, Econotec (own calculations, 2021)

Figure 4-18. Total emissions from mobile air conditioning in Belgium (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

Figure 4-19. Total emissions from mobile air conditioning in Belgium (in t)



Source: VITO, Econotec (own calculations, 2021)

4.4.6. Stationary air conditioning (2.F.1.f.)

Introduction

This source category comprises chillers, room air conditioners and heat pumps, heat pump boilers, and small movable air conditioners.

Methodology

Data were received from the only manufacturer of air conditioning and heat pumps in Belgium on refrigerant use and emissions during manufacturing of heat pumps and room air conditioners in 2020.

Room air conditioners and heat pumps have been accounted for in the inventory since 2007. Data on the sales of room air conditioners and heat pumps were requested from FRIXIS, previously UBF-ACA (Air Conditioning Association). FRIXIS is the most representative organisation of market players in this sector. Sales data are available for 2005-2020. The total quantity of equipment placed on the market was split among the different categories used for the inventory (i.e. movable air conditioning, heat pump boilers, room air conditioning and heat pumps smaller than 7 kW, room air conditioning and heat pumps larger than 7 kW) based on the division in 2011 and 2020 sales statistics from FRIXIS. As a result the methodology was adjusted to calculate emissions from each category independently.

Chillers used to be considered under 'Industrial and commercial installations', however the recent study for Flanders on disposal emissions[22] showed that most chillers are prefilled. We therefore included them now in this category.

Sales statistics were available for the period 2005-2011 from UBF-ACA. For the period 2012-2020, the number of chillers placed on the market was estimated based on the total sales of air conditioning and heat pumps. This corresponds well with estimates made for Belgium by BSRIA[23].

Assumptions on the characteristics of chillers were taken from the French and German F-gas inventories. Often a distinction is made between categories, but because statistics are not available averages are used for all chillers. BSRIA (Daikin, 2018) assumed that approximately 60% of chillers are below 100 kW and 40% larger than 100 kW. An average lifetime of 15 years was assumed.

The share of refrigerants since 1998 was reconstructed based on the available literature (e.g., from France, Germany, and the UK). This shows changing shares of R407C, R404A and R134a over this time frame. In recent years, the increasing share of R410A is most important. An average load of 100 kg is used, but this hides a much wider variation in loads depending on the capacity of the chiller.

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22 VITO, Econotec, Öko-Recherche (2018) Studie rond afvalproblematiek van F-gas bevattende koeltoepassingen en identificeren van mogelijke verbeterpunten. Departement Omgeving, Flemish Region.

23 Daikin, Pers. Comm., 2018.

Based on these data and assuming an average lifetime of 15 years, the total stock of equipment in Belgium is calculated. Assumptions made by Schwarz[24] were used to estimate the quantity of refrigerants per unit.

The disposal emissions are assumed to be 70%, based on Schwarz et al.[25].

Table 4-8. Assumptions for room air conditioners and heat pumps and comparison with the IPCC 2006 Guidelines

	RAC and heat pumps	IPCC (2006)[1]	2019 refinement
Charge (kg)	0,5 – 6,2 kg	0.5 < M < 100	0.5 < M < 100
Lifetime (y)	15	10 < d < 20	10 < d < 20
Manufacturing EF (%)	NR	0,2 < EF < 1	0,2 < EF < 1
Fugitive EF (%)	2,5 - 5%	1 < EF < 10	1 < EF < 10
Recovery efficiency (%)	30%	0 < RE < 80	0 < RE < 80

Note: 1. Residential and commercial, including heat pumps.

Table 4-9. Assumptions for chillers and comparison with the IPCC 2006 Guidelines

	chillers	2019 refinement
Charge (kg)	70	10 < M < 2000
Lifetime (y)	15	15 < d < 30
Manufacturing EF (%)	NA	0,2 < EF < 1
Fugitive EF (%)	3.8%	2 < EF < 15
Recovery efficiency (%)	30%	0 < RE < 95

24 Schwarz W. (2005) Emissions, activity data and emission factors of fluorinated greenhouse gases (F-gases) in Germany 1995-2002 – Adaptation to the Requirements of the international reporting and implementation of data into the Centralised System of Emissions (ZSE).

25 Schwarz W. et al. (2011) Preparatory study for a review of Regulation (EC) No 842/2006 on certain fluorinated greenhouse gases. Final Report prepared for the European Commission.

Table 4-10. Comparison of assumptions for chillers, room air conditioning and heat pumps between selected countries (in 2016)

Assumption	BELGIUM	FRANCE	GERMANY	UK
Manufacturing EF (%)	0,07%	NR	0,5 - 10%	0,5 - 1%
Charge (kg)	0,5 - 6,2 kg	0,5 - 15 kg	NR	1,8 - 15 kg
Charge chillers (kg)	100 kg	0,3 kg/kW	10 – 630 kg	180 kg
Movable: Share R290 (%)	43%	10%	NR	NR
Movable: Share R407C (%)	2%	0%	NR	NR
Movable: Share R410A (%)	55%	90%	NR	NR
Split: Share R32 (%)	2,5%	5%	NR	NR
Split: Share R407C (%)	2,6%	1%	NR	NR
Split: Share R410A (%)	95%	94%	NR	NR
Multi-split: Share R32 (%)	0%	5%	NR	NR
Multi-split: Share R407C (%)	2%	1%	NR	NR
Multi-split: Share R410A (%)	98%	94%	NR	NR
Chillers: R410A	85%	95%	NR	NR
Chillers: R407C	7%	5%	NR	NR
Chillers: R134a	7%	0%	NR	NR
Lifetime (y)	15	10 - 15	10 - 15	13 - 18
Lifetime chillers (y)	15	15 - 25	15 - 25	18
Fugitive EF – movable (%)	2,5%	2%	2,50%	5 - 6%
Fugitive EF – split (%)	4%	4%	5%	5 - 6%
Fugitive EF – multi-split (%)	5%	5%	5 - 6%	5 - 6%
Fugitive EF – chillers (%)	3,8%	3,3 – 9,5%	3,3%	3,7%
Disposal EF (%)	70%	30 - 82%	33 - 75%	18 - 25%
Disposal EF chillers (%)	70%	5 - 22%	22%	7%

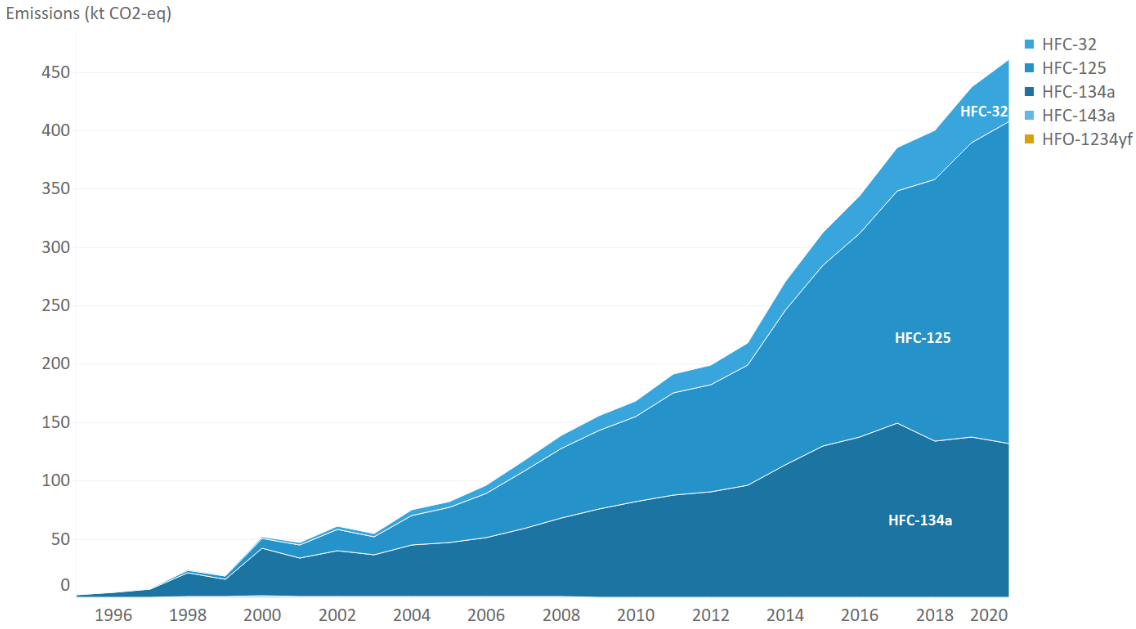
Note: France, Germany and UK distinguish between heat pumps (heat only) and room air conditioning (cooling with or without heating). For Belgium statistics are not available to make this split.

Source: Information taken from NIR (https://unfccc.int/ghg-inventories-annex-i-parties/2021).

Results

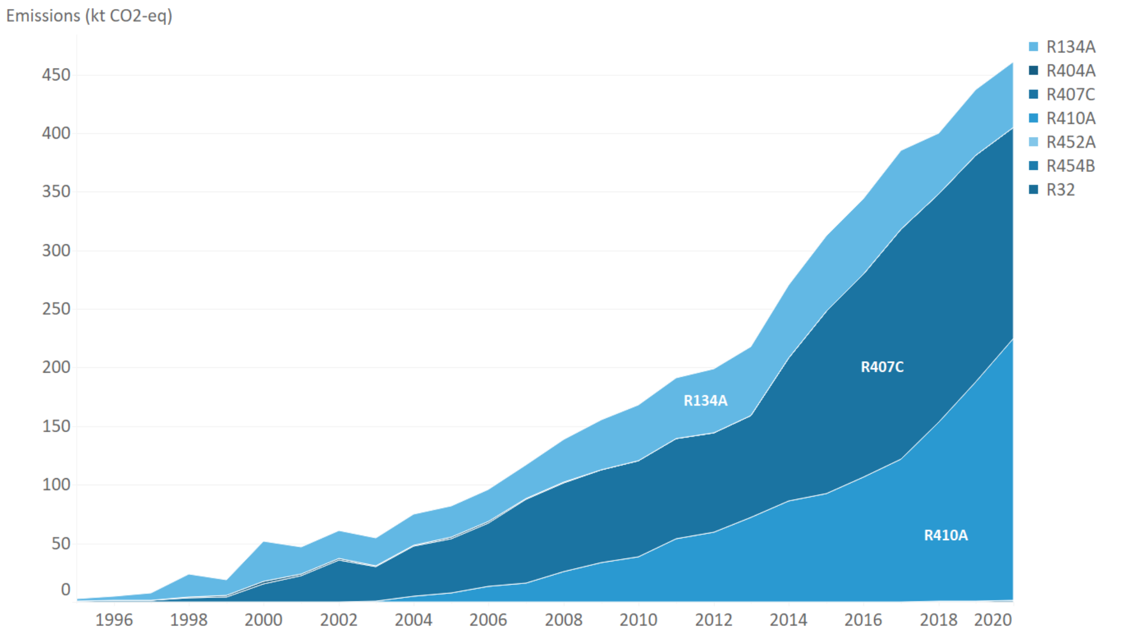
The results are shown below. In recent years, R410A has surpassed R407C as most frequently used refrigerant, this is mainly due to the F-gas regulation. Another trend is the increased use of R32, especially for products in lots 1 and 21.

Figure 4-20. Total F-gas emissions from chillers, RAC, heat pumps, and heat pump boilers per substance (in kt CO_2-eq)



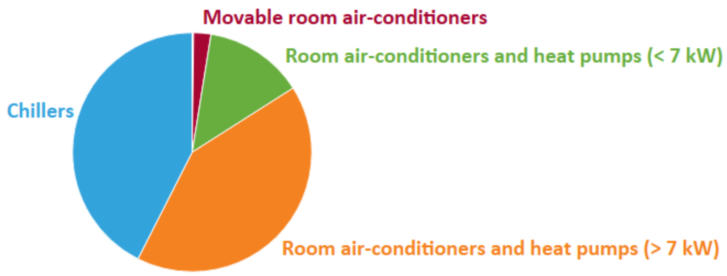
Source: VITO, Econotec (own calculations, 2021)

Figure 4-21. Total F-gas emissions from chillers, RAC, heat pumps, and heat pump boilers per refrigerant (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

Figure 4-22. Share of emissions in CO_2-eq. from chillers, small (< 7 KW) and large (> 7 kW) air conditioners and heat pumps, heat pump boilers and movable air conditioners in 2020



Source: VITO, Econotec (own calculations, 2021)

Heat pump dryers

Heat pump dryers have been on the EU market since 2004 and their penetration is increasing. In Switzerland, already 100% of the tumble dryers are heat pump dryers (data from the Swiss Association of the Domestic Electrical Appliances Industry cited in (topten.eu, 2014)). The share in the EU is lower though. In Germany, it was estimated to be 39% in 2012.

Dryers are equipped with either HFC-134a or R407C, with quantities ranging between 220 and 430 g (Federal Environment Agency, 2014). The systems are hermetically sealed and for the German inventory in 2014 the fugitive emission factor is 0,3%, but the Swiss inventory uses an annual fugitive emission factor of 2%. For our assessment, here we use the average emission factor of 0,3%.

Based on this information, we estimated the scale of emissions from heat pump dryers in Belgium. This was based on generalisations and assumptions that do not warrant inclusion of this emission source in the inventory. For instance, the share of heat pump dryers equipped with HFC-134a or R407C is not known, and we assumed this to be 50% for each gas. Also, the share of heat pump dryers sold is assumed to be similar to Germany (56% of sold tumble dryers in 2014 and assuming similar growth numbers 92% in 2019)[26]. Finally, it is assumed that 60% of households have a tumble drier, based on the household budget survey of 2010.

With these assumptions, emissions are estimated to be in the range of 2,0 kt CO_2-eq in 2020. This is only a small quantity of total HFC emissions but could increase in the future as the stock of heat pump tumble driers increases over time. Currently, HFCs are predominantly used in tumble driers, but as the importance of this emission source increases or if HFC prices increase due to the F-gas regulation, HFCs will increasingly be replaced by low GWP alternatives (R290) in the future (Bellomare & Minetto, 2015).

[26] Statistics for Belgium are not available, but this assumption does not seem unreasonable, considering that between 57 and 62 % of all tumble drier models sold by 4 online retailers have heat pump technology.

4.5. Closed cell foam (2.F.2.)

4.5.1. Closed cell foam (2.F.2.a)

Introduction

The following types of closed cell foam are taken into consideration:

- extruded polystyrene foam
- polyurethane foam (panels or blocks)
- 2 component spray foam
- refrigerator insulation.

The first three are manufactured in Belgium, while the last one is only imported in the equipment.

Methodology

The figures for the consumption of foaming agents are collected directly from the relevant companies and obtained separately for the manufacture of polyurethane foam (PUR) and extruded polystyrene (XPS).

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

The emissions from closed cell foams are calculated from:

- the annual consumptions of F-gases by the manufacturers;
- assumptions on assembly emission factors;
- assumptions about the relative share of external trade;
- assumptions about the emission factors from the foam bank.

The end-of-year bank of F-gases is calculated annually, by substance, from the end-of-year bank of the year before, the quantity added to the bank and the emission from the bank.

The figures for the consumption of foaming agents used to be obtained from Federplast.be (Belgian Association of Plastics and Rubber Converters), separately for the manufacture of polyurethane foam (PUR), One-Component-Foam (OCF) and extruded polystyrene (XPS). Since 2013 they are obtained directly from the companies or from the official emission reporting by the companies.

As refrigerators are not manufactured in Belgium, emissions from domestic refrigerator foams are evaluated in a similar way as emissions from refrigerator refrigerants, based on a model of the refrigerator stock. The foam of domestic refrigerators and freezers contains HFC-245fa. The emissions of Kyoto protocol gases are rather negligible.

The recovery or destruction of F-gases from insulation foams only takes place for refrigerator/freezer foams. Given the long lifetimes of insulation foams in buildings, the fact that such foams are considered to have started to be used only in 1976 and the lack of statistics on recovery of such foams in demolished buildings, no disposal has been considered in the emission inventory. However, since foams from any demolished buildings are generally dumped on a landfill rather than incinerated, and therefore continue to cause emissions, the calculation is probably realistic.

Results

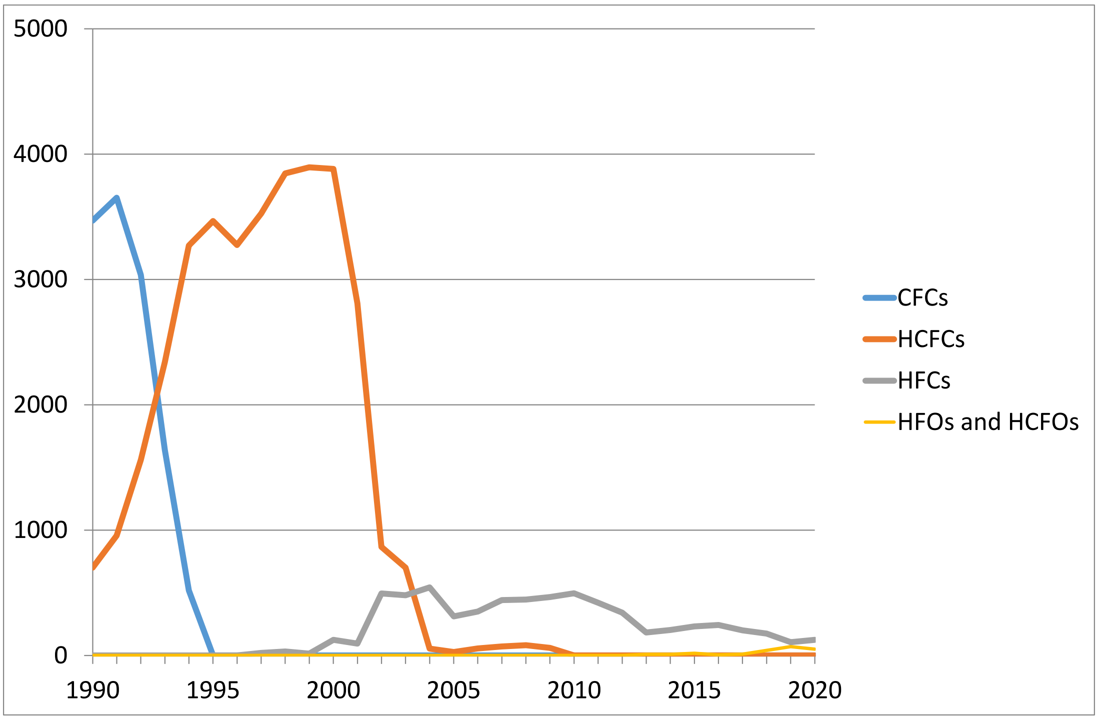
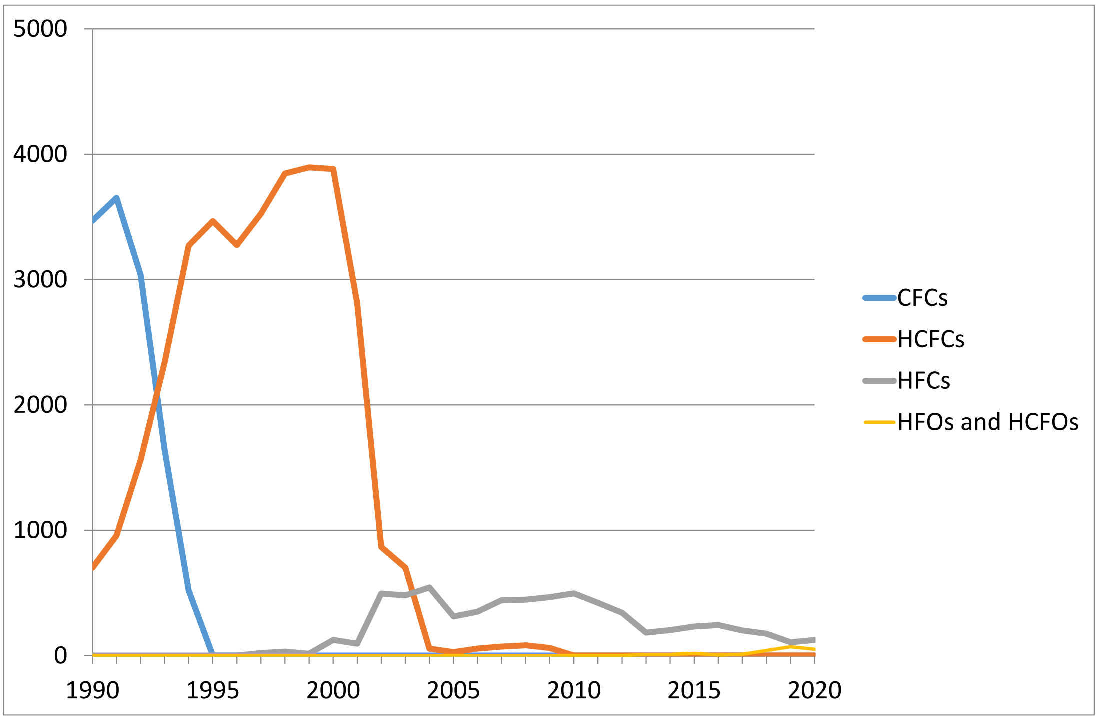


Figure 4-23 below recalls that HCFCs, which had been used in very large quantities in the past, had practically disappeared by 2004, because of European Regulation 2037/2000. They were only very partially replaced by HFCs, which are mainly used for XPS foam, and now also for PU 2-component spray foam. Meanwhile, a growing quantity of HFOs and HCFOs is being used (70 t in 2019): HFO-1234ze(E) since 2013 and HCFO-1233zd and HFO-1336mzz(Z).

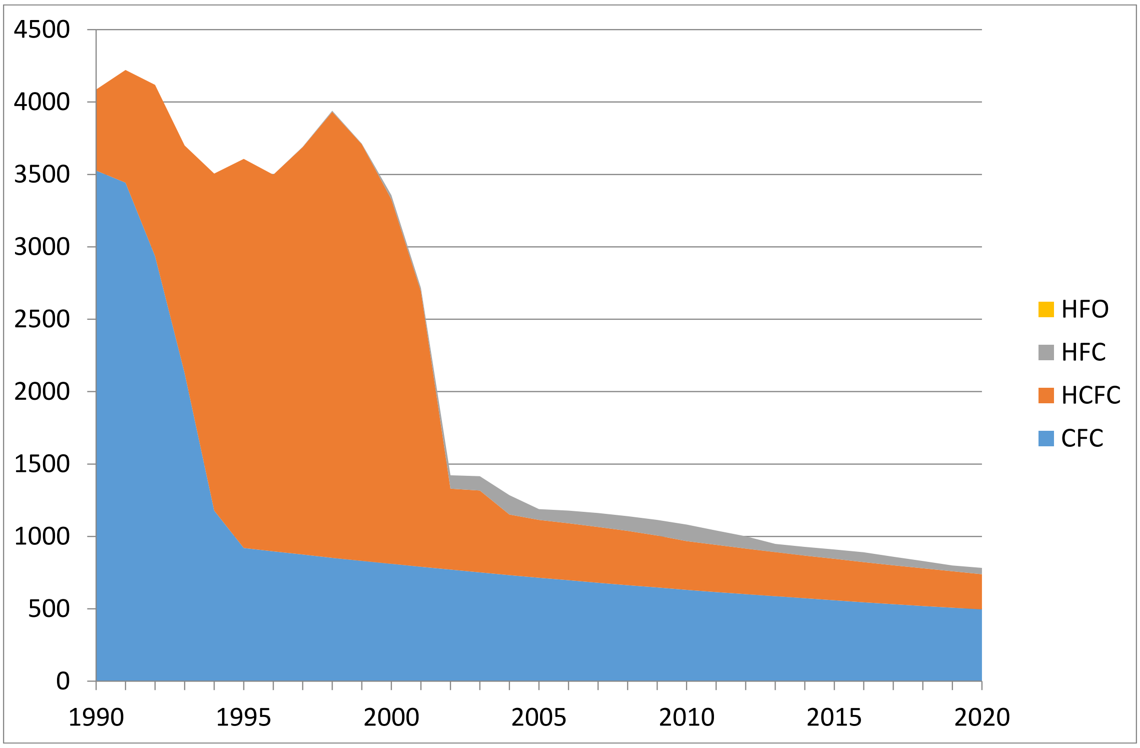
Figure 4-23.   Consumption of F-gases for foam manufacturing (t)



Source: VITO, Econotec (own calculations, 2021)

The evolution of emissions in terms of CO_2-equivalent is shown on Figure 4-24, where one can notice the impact of the regular decline of existing stocks of CFCs and HCFCs, which are still dominant.

Figure 4-24. Emissions of F-gases from closed cell foams (kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.5.2. Open cell foam (2.F.2.b)

Introduction

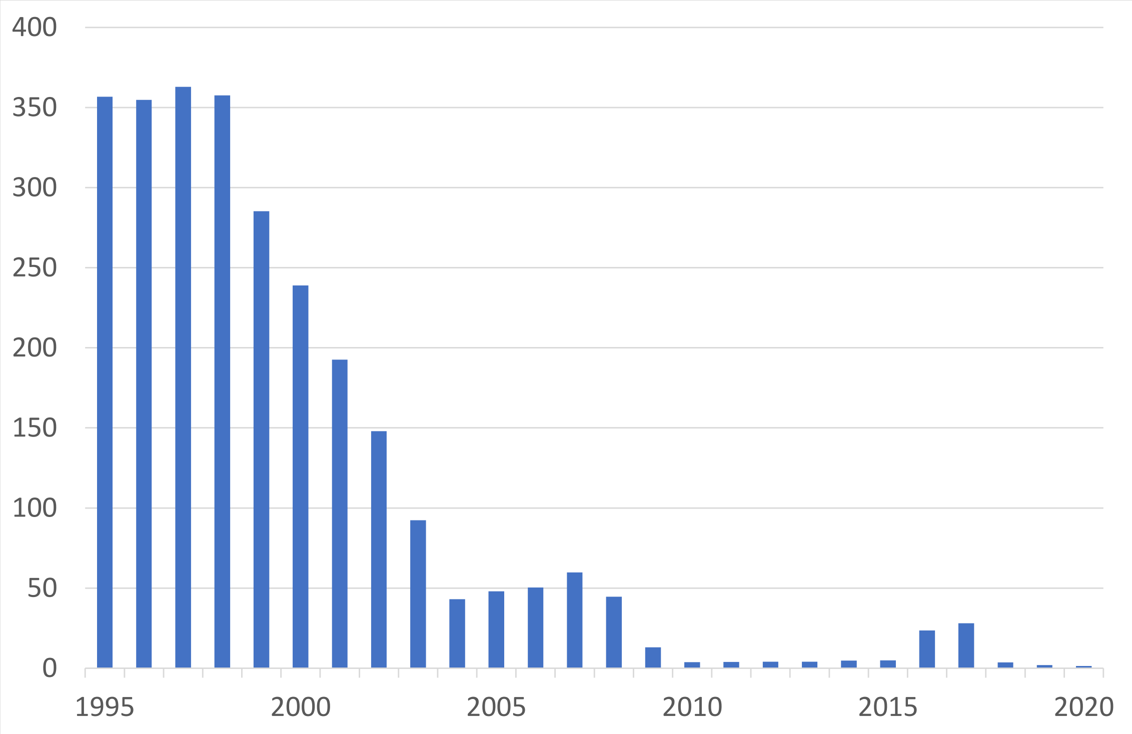
Belgium is a large producer of polyurethane cans ('one component foam') and its production is almost completely exported. However, CO_2-equivalent emissions of HFCs from this sector, which arise both during manufacturing and as a result of their use, have been drastically reduced since 2008, as EU Regulation 842/2006 and EU Regulation 517/2014, which replaced it, have prohibited the sale in the EU of 'one component foams' containing mixtures with a GWP of 150 or more, except when required to meet national safety standards.

Methodology

The emissions during manufacturing are based on data obtained from the manufacturer. The residual emissions of HFCs contained in polyurethane cans sold in Belgium are based on per capita data for Germany.

Results

Figure 4-25. Emissions of F-gases from open cell foam (kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.6. Fire protection (2.F.3.)

Introduction

Manufacturers of fixed suppression systems for firefighting have been using HFCs as an alternative to halons for many years. HFC-based systems are used for the protection of electronic and telecommunications equipment, and in military applications, records offices, bank vaults and oil production facilities. The main HFC used in fixed systems are HFC-227ea and HFC-125.

Methodology

A questionnaire has been sent to all relevant companies. Manufacturing emissions are estimated to be 0,1% for all quantities installed in bulk.

Disposal emissions are taken into account. Although some companies reported recovery of HFCs from dismantled installations, this data is not used. We rather use modelled quantities in equipment that has reached the end of lifetime, for which an emission factor of 10% is used. Most of these emissions are arising from reclamation at reclamation sites and not from dismantling.

Table 4-11. Comparison of assumptions between selected countries

	BELGIUM	GERMANY	FRANCE	UK	SWEDEN
Lifetime (years)	20	20	NA	NA	10
EF manufacturing	0.1%	NA	NA	0%	0.5%
EF use	2.3%	2.5% - 4% [A]	NA	1% - 1.5% [B]	0.1% - 2% [C]
EF disposal	10%	1%	NA	0.1%	5%

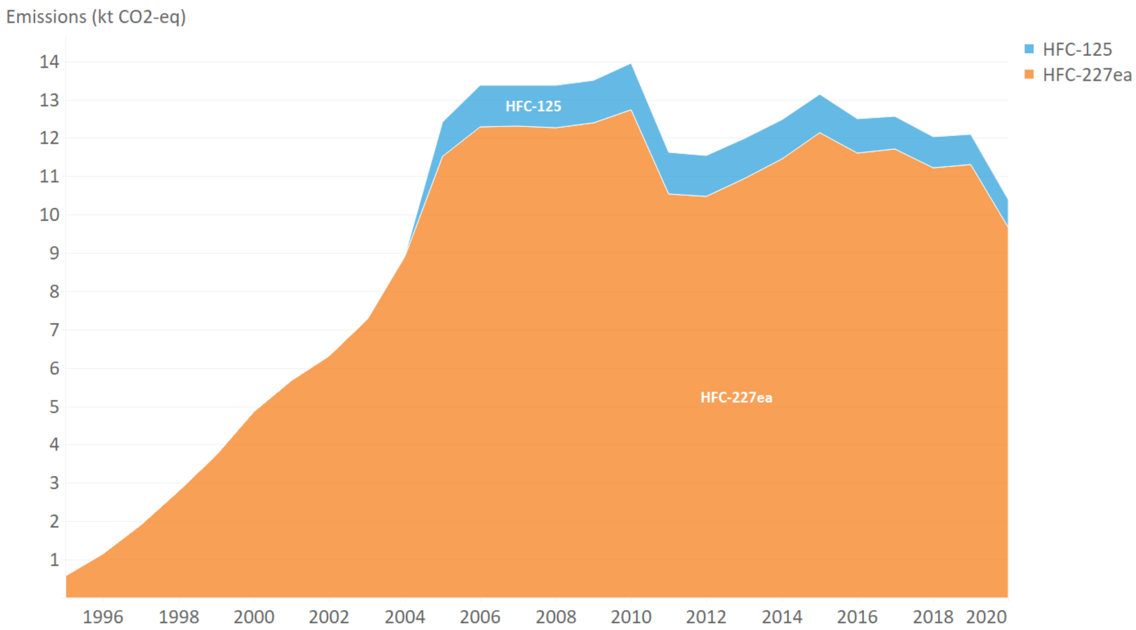
Note: A. 2.5% HFC-227ea, 4% HFC-236fa, HFC-23;
B. 1% servicing, 1.5% fire (lifetime);
C. 0.1% HFC-227ea, 2% other HFCs

Source: Information taken from NIR (https://unfccc.int/ghg-inventories-annex-i-parties/2021).

Results

The emissions are relatively small compared to other sectors, estimated to be 10 kt CO_2-eq in 2020. Operation emissions (from stock) are decreasing, but this decrease is compensated by increased emissions from dismantling.

Figure 4-26. Total HFC emissions from fire extinguishers in Belgium (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.7. Aerosols (2.F.4.)

4.7.1. Metered dose inhalers (2.F.4.a.)

Introduction

The only manufacturer of MDIs in Belgium having stopped producing CFC or HFC containing products, there are no manufacturing emissions anymore since 2006. The only emissions left are those produced during the use or disposal of MDIs.

Methodology

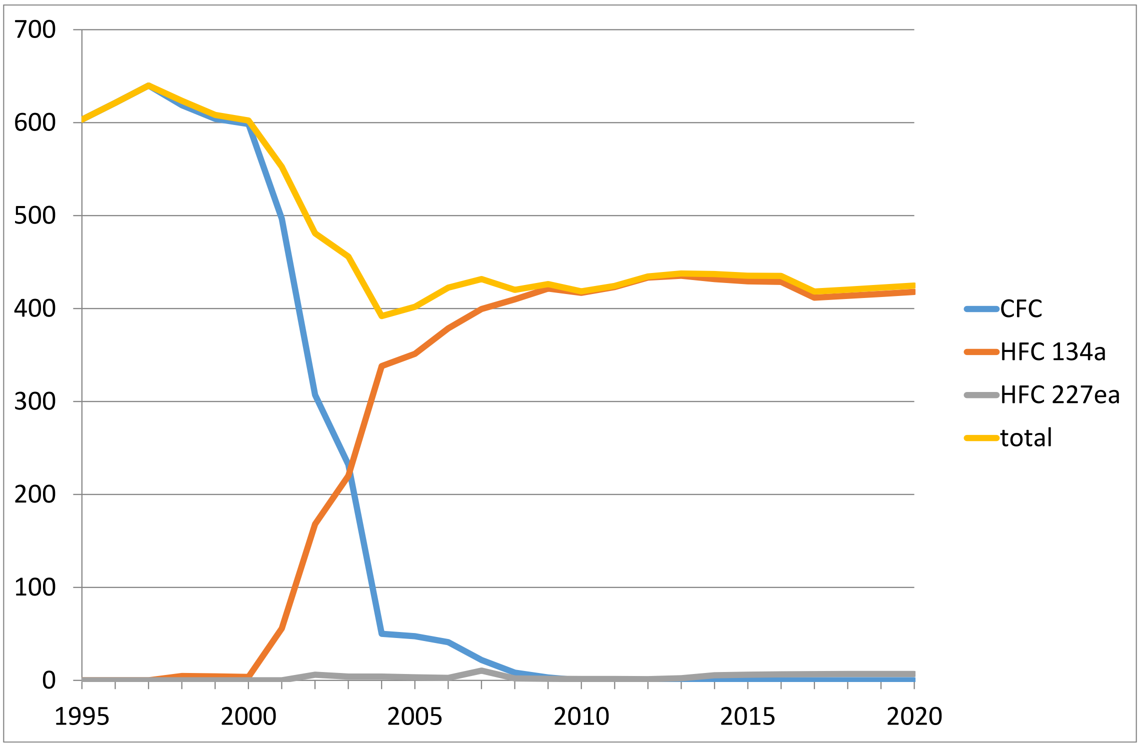
The emissions resulting from the consumption of metered dose inhalers (MDI) are based on the data on annual sales of MDIs in Belgium, both in terms of number of units and number of doses. The emissions are estimated on the basis of the type of gas used in each pharmaceutical product and on assumptions on the average quantity of fluorinated gas per dose.

For up to the year 2008, the figures of annual sales of MDIs in Belgium had been purchased from the market research company IMS Health, both in terms of number of units and number of doses. Figures for 2009-2017 were obtained from GSK through LNE (Personal communications from Sven Claes, Departement Omgeving, 9.12.2014, 29.11.2018). The figures for 2018-2020 were obtained by applying to those of 2017 the population growth.

Results

The figure below shows the development since 1995. Overall, after a stabilisation during the years 2012-2016, a small decline has been observed in 2017.

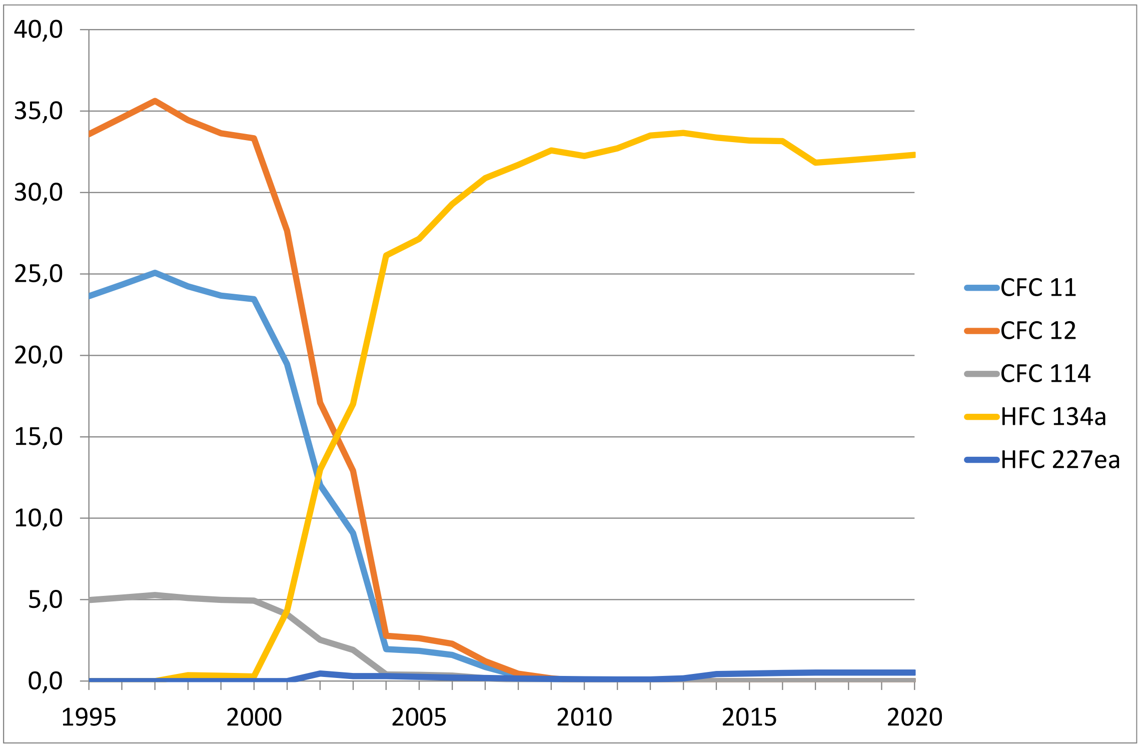
Figure 4-27. Number of MDI doses sold in Belgium (million)



Source: VITO, Econotec (own calculations, 2021)

The emissions, shown on Figure 4-28, have been estimated based on the type of gas used (found in the Compendium of pharmaceutical products, from pharma.be) and on assumptions on the quantity of F-gas per dose, taken from the literature.

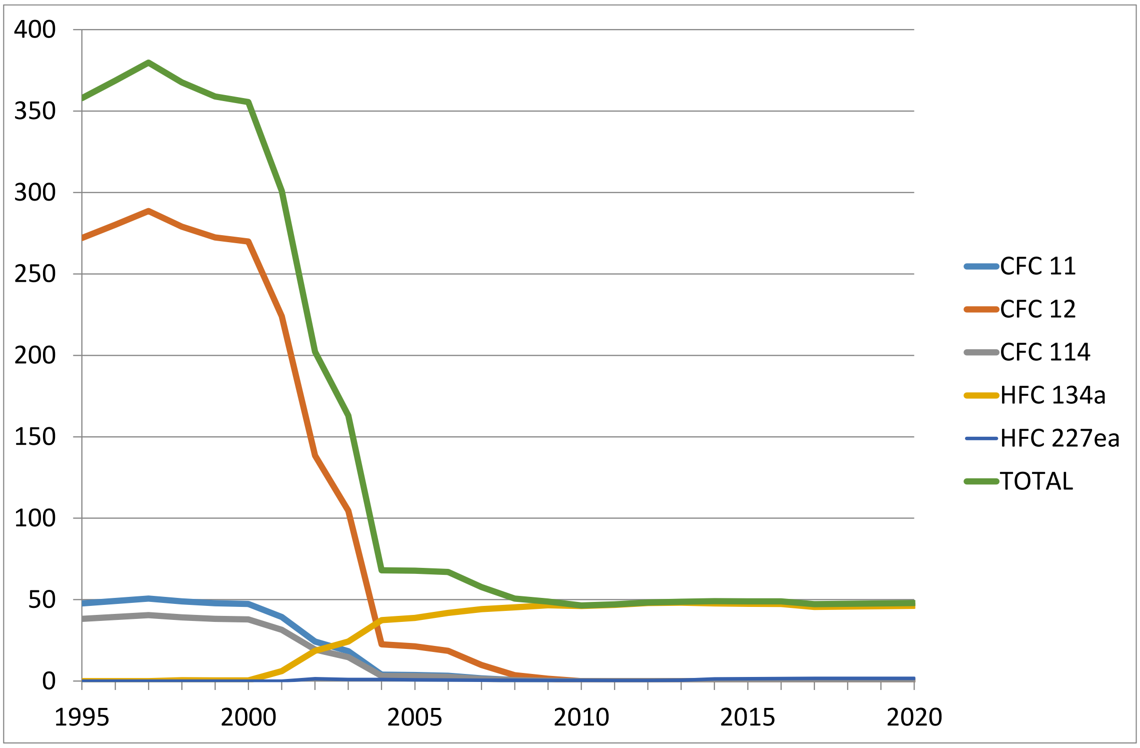
Figure 4-28. Quantity of F-gases in MDIs sold in Belgium (t)



Source: VITO, Econotec (own calculations, 2021)

In terms of greenhouse gas emissions, the evolution is shown on Figure 4-29. In 2020 the emissions reached 48 kt CO_2-eq.

Figure 4-29. Emissions from the use of MDIs (kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.7.2. Other aerosols (2.F.4.b.)

Introduction

Aerosols typically use hydrocarbon propellants but a small proportion of the market use other volatile liquids such as dimethyl ether (DME) and HFCs. HFCs are used only in a few applications where the use of a more expensive propellant is required to provide a non-flammable material. The most important industrial applications in volume terms are air dusters and pipe freezing products; other applications include specialised lubricants and surface treatments, and specialised insecticides[27]. Technical aerosols that contain HFCs with GWP of 150 or more, except when required to meet national safety standards or when used for medical applications are prohibited since 2018. The use of HFCs for novelty applications for entertainment and decorative purposes and signal horns containing HFCs with GWP of 150 or more are prohibited from 2009 onwards.

Methodology

Up to 2012 we received data from DETIC of HFCs (HFC-134a and HFC-152a) used in Belgium to produce spray cans designed for the European market. DETIC aggregated information received from 4 companies. However, DETIC informed us that from 2013 they would no longer request and aggregate this information. We contacted all companies involved but did not receive

27 UK (2021) NIR

information from all of them (some did not want to disclose information due to confidentiality). We therefore used information from the Flemish IMJVs[28] for 2020, which was split between HFC-134a and HFC-152a. Reporting is now limited to one company and HFC-152a as use of HFCs with a GWP of more than 150 is prohibited for most technical aerosol applications.

Losses from manufacturing are, according to DETIC, very small. However, no quantitative information was given. For the F-gas inventory in Germany an emission factor of 1,5% is assumed[29], which has also been accepted for the Belgian data and confirmed by DETIC for the period before 2013 and which is also used for the period afterwards. This emission factor was used to calculate the consumption of HFCs.

It is an emission source for which there remains quite a lot of uncertainty, because there are no data on the actual consumption of technical aerosols in the country. Alternatively, consumption cannot be estimated from production and trade, as no external trade figures are available. The consumption is also very diffuse, for a variety of sources of small magnitude.

Current estimates of emissions associated with the use of technical aerosols in Belgium are based on German per capita quantities. For Germany, general aerosols import and export are considered by Öko-Recherche to be balanced; therefore, the consumption can be estimated from the production. Emissions in the German inventory are available up to 2018. These per capita emissions have changed in the most recent inventory available and declined from 2,87 g/person in 2006 to 1,87 g/person in 2014 and 0,13 g/person in 2019. For 2020, the same emission factor as for 2019 is assumed. There was a very substantial reduction in German emissions between 2017 and 2018.

Results

The emissions significantly drop in 2018, when ban on the use came into effect. Emissions in 2020 are estimated to be 2.3 kt CO_2-eq, a reduction of almost 94% compared to 2017.

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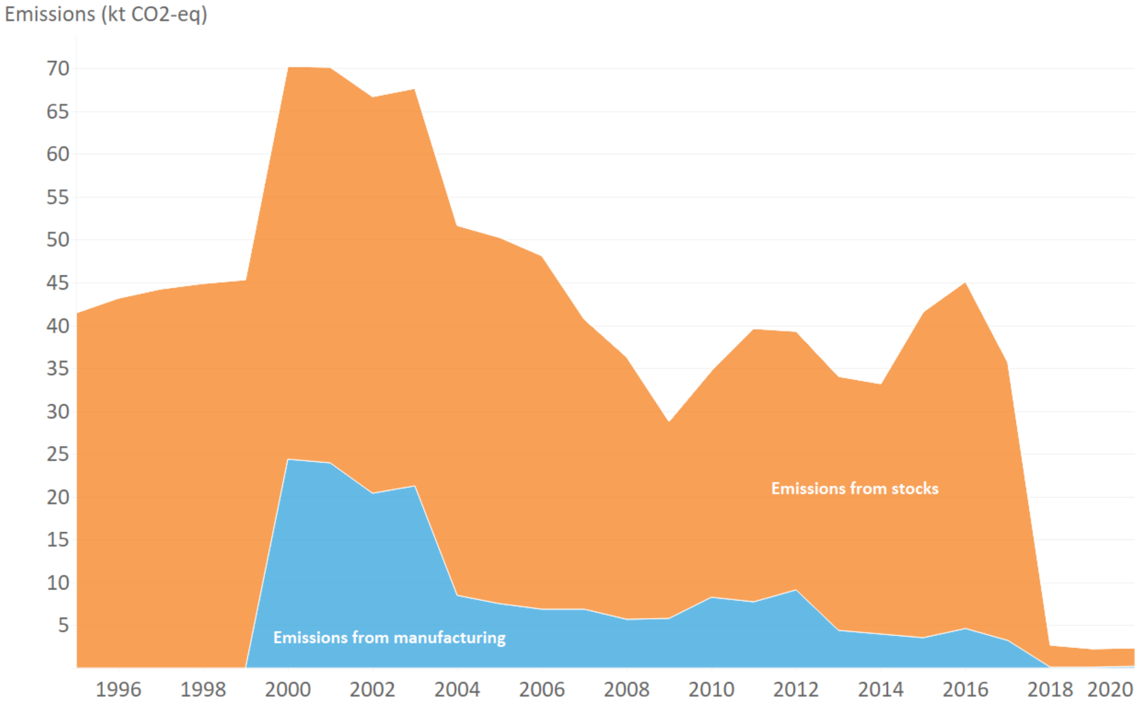
28 IMVJ: Integraal Milieu Jaarverslag.

29 Schwarz, W. (2005) Emissions, activity data and emission factors of fluorinated greenhouse gases (F-gases) in Germany 1995-2002 – Adaptation to the Requirements of the international reporting and implementation of data into the Centralised System of Emissions (ZSE). Umweltbundesamt, Dessau.

Figure 4-30. Emissions from the use of technical aerosols (kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.8. Solvents (2.F.5.)

Introduction

Since 1st January 2002, European Regulation 2037/2000 has forbidden the use of HCFCs for all solvent uses, except for precision cleaning of electrical and other components in aerospace and aeronautics applications. However, for the latter, the prohibition has entered into force on 31st December 2008. Therefore, we consider these emissions to be zero.

HFCs can be used as solvents in a range of applications such as precision cleaning to replace CFCs, HCFCs or 1,1,1-trichloroethane in sectors such as aerospace and electronics. While there was a substantial shift towards other organic solvents, a small residual market remains for HFC-based solvents, with HFC 43-10-mee being the main HFC-based product. Other products are used in production processes such as the semiconductor, the liquid crystal display and the photovoltaic industries. See relevant sections above.

4.9. Electrical equipment (2.G.1.)

Introduction

Switchgear are a combination of switches, fuses or circuit breakers that control, protect and insolate various types of electrical equipment e.g. by avoiding current overload[30]. The medium that provides insulation in a switchgear can be either air, gas, solid or liquid material. In the case of gas insulated switchgear (GIS), typically SF6 is used. SF6 has been used in high and medium voltage switch gear and transformers since the mid-1960s. The physical properties of the gas make it highly effective as an arc-quenching medium and as an insulator. Consequently, it has gradually replaced equipment using older technologies, namely oil filled and air blast equipment. Currently, there are alternative technologies to using SF6 already commercialy available or under development, albeit not for all applications and it will take time to build up the production capacity to serve the full European market[30].

Methodology

We received data from transport and distribution of electricity. Data from production sites are small and do not change considerably over time. SF6 use in wind turbines was added based on the number of wind turbines in Belgium.

We have taken manufacturing emissions on board for the entire time series. To do this, we have assumed that the increase in the bank of SF6 (for production, transport, and distribution) in the period 1990-2000 is caused by new installations and that there is no disposal of SF6 in this period. An emission factor of 1% is used.

The stock of SF6 in all large power stations in 2016 was reported and the average quantity in switch gear in wind turbines, which was also used in 2020 (data from FEBEG is consistent in time). We have included these quantities also in the stock data, using data on the number of wind turbines installed in Belgium (onshore and offshore).

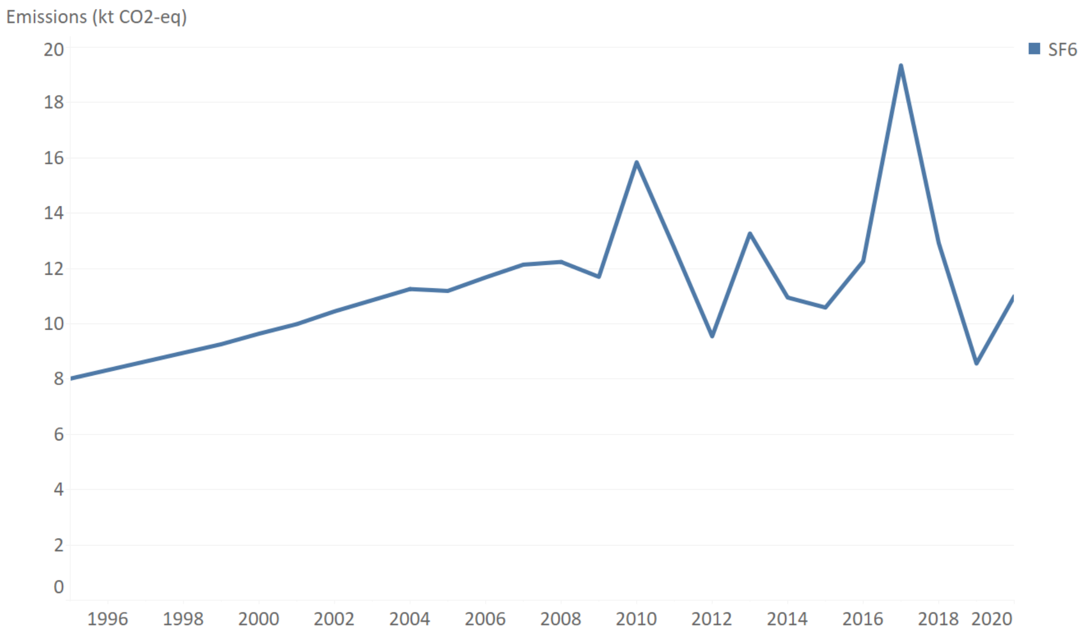
The fugitive emission factor for SF6 in the subsector production was adjusted. The emission factor for new installations is 0,1% and 1% for older installations. As most installations are recent, the average emission factor is 0,11% in 2020.

Results

SF6 emissions from electrical switchgear fluctuates from year to year, but does not seem to increase or decrease. In 2020 emissions were 11 kt CO_2-eq. The average emissions of the last 15 years is 12 kt CO_2-eq. In this 15-year period the bank of SF6 in switchgear did increase with a factor of almost 2.5. This difference in trends can be explained by the measures taken to limit SF6 emissions.

30 European Commission (2020) REPORT FROM THE COMMISSION assessing the availability of alternatives to fluorinated greenhouse gases in switchgear and related equipment, including medium-voltage secondary switchgear. DG Climate Action, C(2020)6635, https://ec.europa.eu/clima/sites/default/files/news/docs/c_2020_6635_en.pdf

Figure 4-31. SF6 emissions from switchgear in Belgium (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.10. SF6 and PFCs from Other Product Use (2.G.2.)

4.10.1. Particle accelerators (2.G.2.b.)

Introduction

The insulating gas SF6 is used to protect human safety and to safeguard equipment parts (to guard against burning of insulators). In relevant applications, high-voltage parts are insulated by being enveloped with the gas (which guards against electrical arc flashes between high-voltage parts and equipment walls).

In some cases, such protection can also be achieved by using other gases (such as nitrogen, nitrogen/CÖ2 mixtures), by providing adequate physical distance (air insulation) or by enclosing equipment in concrete walls. The criteria entering into decisions for or against SF6 as an insulating gas for equipment (either by itself or as an additive) include technical circumstances, design considerations and voltage levels. For this reason, the quantities of SF6 that non-standardised equipment and components require will vary. The SF6 charge in any given unit or system thus depends on the unit's/system's setup, and not on its size class (measured in MV, for example).

The SF6-insulated particle accelerators in use differ in terms of size, design and function. High-voltage accelerator systems (0.3 to more than 23 MV) are used by university institutes, research groups and industry. In such high-voltage systems, the accelerator and the high-voltage source (Van de Graaff generator, or a more-compact high-voltage generator with cascaded diodes) sit within a tank that is insulated with SF6 or an SF6-containing mixture. In some cases, such tanks are also pressurised. Such tanks often have to be opened when equipment has to be adjusted or repaired. In such cases, the insulating gas is pumped into reserve tanks. SF6 losses occur during such pumping, and they occur whenever overpressure valves of accelerator or reserve tanks are activated. Research accelerators, which are operated under varying conditions, have to be opened more frequently than industrially used electron accelerators do.

In industry, low-voltage devices with less than 0.3 MV are also used. In low-voltage systems, the depth to which electrons penetrate materials being processed is considerably lower than the depths occurring in connection with high-voltage systems. In industry, "electron-beam tools" are used for cross-linking of polymers, primarily polymers in cable and wire insulation. Low-voltage systems, with lower accelerator voltages, require less shielding (= smaller quantities of SF6) than high-voltage systems do.

Yet another relevant category consists of radiation-therapy devices in medical facilities. In cancer treatments with electron or photon radiation, industrially pre-set particle accelerators are used. Such accelerators accelerate particles within waveguides that are filled with the insulating gas SF6, which guards against electrical flashovers. Prior to 1996, CFCs were used in such equipment.

SF6 is also used as an insulating gas in large electron microscopes (with accelerator voltages >100 kV) and in electron-beam lithography systems. Such devices, which are combined within the category "other equipment, have now been covered for the first time – for the year 2010.

In general, the following applies: The SF6 consumption tied to initial charging and recharging of equipment, and to replacements of emission, depends on equipment size, pressure conditions and operating conditions.

Methodology

Not included in the inventory.

4.10.2. Soundproof windows (2.G.2.c.)

Introduction

Since 1975, SF6 has been inserted into the spaces between multi-pane windows to enhance the soundproofing properties[31].

Regulation 842/2006/EC, replaced by EU Regulation 517/2014, has prohibited the placing on the market of windows containing SF6 in July 2007 for domestic use and in July 2008 for other windows. Both main manufacturers of acoustic double glass had stopped using SF6 in 2006, the only smaller manufacturer still using SF6 in 2007 did not use it from 2008 onwards.

Methodology

For the calculation of emissions, we used the IPCC 2006 guidelines. Data on manufacturing emissions were calculated based on the consumption of SF6 by glass producers and an annual emission factor of 33 %.

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[31] Germany (2021) National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2019.

To calculated fugitive emissions, we assume that around 1% of the SF6 bank, i.e. SF6 contained in installed double glazing in Belgium, is emitted annually.

We assumed a linear increase of disposal emissions with 0,32 t per year between 2001 and 2012. After 2012, disposal emissions were calculated based on the estimated quantities installed 25 years before. The disposal emission factor is 100 %.

Equation: Emissions from soundproof windows

$$Assembly\ Emissions\ in\ year\ t = 0.33\ \times SF6\ purchased\ to\ fill\ windows\ assembled\ in\ year\ t$$

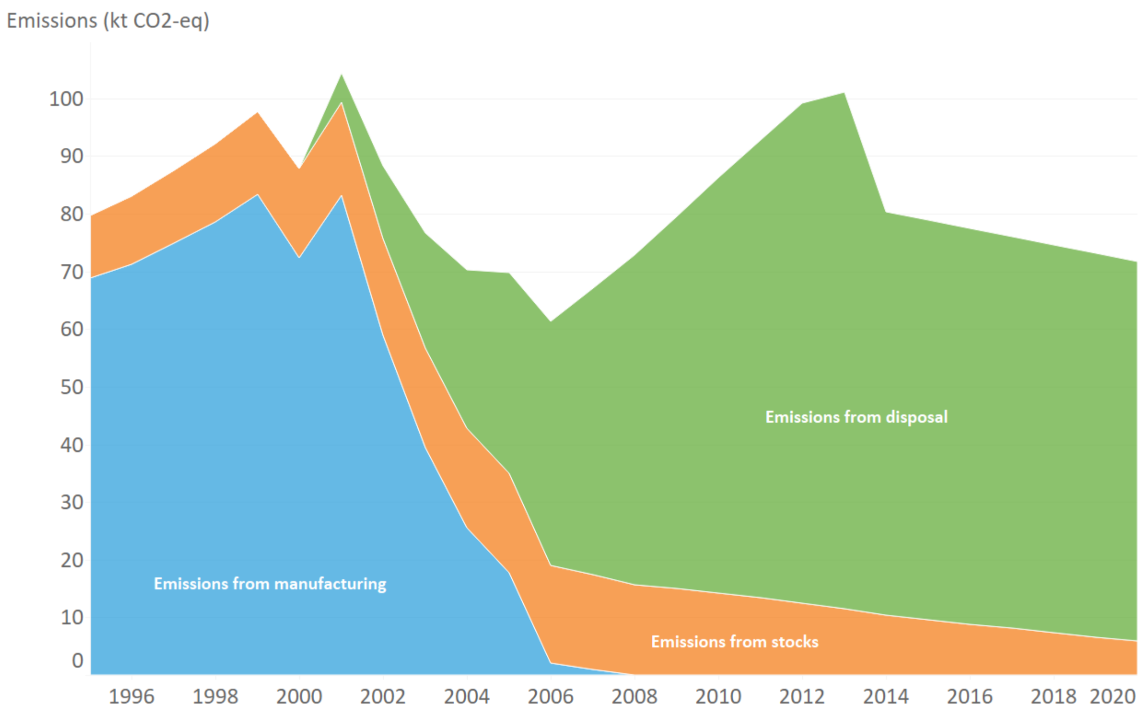
$$Leakage\ Emissions\ in\ year\ t = 0.01\ \times capacity\ of\ existing\ windows\ in\ year\ t$$

$$Disposal\ Emissions\ in\ year\ t = Amount\ left\ in\ Window\ at\ End\ of\ Lifetime\ in\ year\ t\ \times (1 - Recovery\ Factor)$$

Results

Since 2008, emissions from this sector only occur due to SF6 containing double glass that is replaced and decommissioned. The emissions in 2020 of SF6 from disposal were 72 kt CO_2-eq. It is estimated that by 2030 no further emissions will occur from this emission source.

Figure 4-32. SF6 emissions from double glass in Belgium (in kt CO_2-eq)



Source: VITO, Econotec (own calculations, 2021)

4.10.3. Adiabatic properties: shoes (2.G.2.d.)

Introduction

One global sport brand (Nike) used SF6 and C3F8 in the gas cushioned sole of sport shoes. Nike started using SF6 in the early 1990s and started phasing this out in 1997 gradually. In some of the applications, SF6 was deemed not yet replaceable in that period, so it took until 2003 for Nike to stop using SF6 in sport shoes. In most cases, SF6 was replaced by nitrogen gas but between 2003 and 2006 also C3F8 was used.

Methodology

There was no production of these shoes in Belgium, so no manufacturing emissions are considered. We also assume that there are not fugitive emissions resulting from leakages in the gas cushioned sole. The lifetime of the shoes was estimated at 3 years, after which the entire quantity contained in the soles was considered to be emitted to the air during disposal.

For the calculation of the disposal emissions from this source, we used the methodology and assumptions also used by Schwarz[32]. Global data on SF6 use and data of the quantity of C3F8 placed on the EU market in sport soles are available. Schwarz assumes that 25% of the quantity of SF6 that was used to fill soles was sold in the EU. Based on the population, a part of this quantity was allocated to Belgium.

Results

The emissions are limited to the period 1996 – 2010. The highest annual SF6 emissions are estimated to be below 50 kt CO_2-eq.

4.10.4. SF6 and PFCs from other product use (2.G.2.e.)

This includes the small quantities of C6F14 placed on market for laboratory uses. Data was received from company placing quantities on the market for laboratory use in the period 2008-2013. Quantities ranged from 24 kg to 58 kg, which are assumed to be all emited.

4.11. Ozone-depleting substances

Introduction

According to EC Regulation 2037/2000, the use of methyl bromide was prohibited since 1st January 2006, except for essential uses, critical uses for which a licence was awarded by the Commission, or for temporary emergency uses.

[32] Schwarz W. (2005) Emissions, activity data and emission factors of fluorinated greenhouse gases (F-gases) in Germany 1995-2002 – Adaptation to the Requirements of the international reporting and implementation of data into the Centralised System of Emissions (ZSE)

According to art. 4(2) of Commission Regulation 2032/2003, methyl bromide could not be placed on the market as biocidal product since 1st September 2006, and the use of methyl bromide for Quarantine & Preshipment (QPS) stopped in 2010.

The remaining emissions of methyl bromide are process emissions resulting from the manufacturing of purified terephthalate acid (PTA).

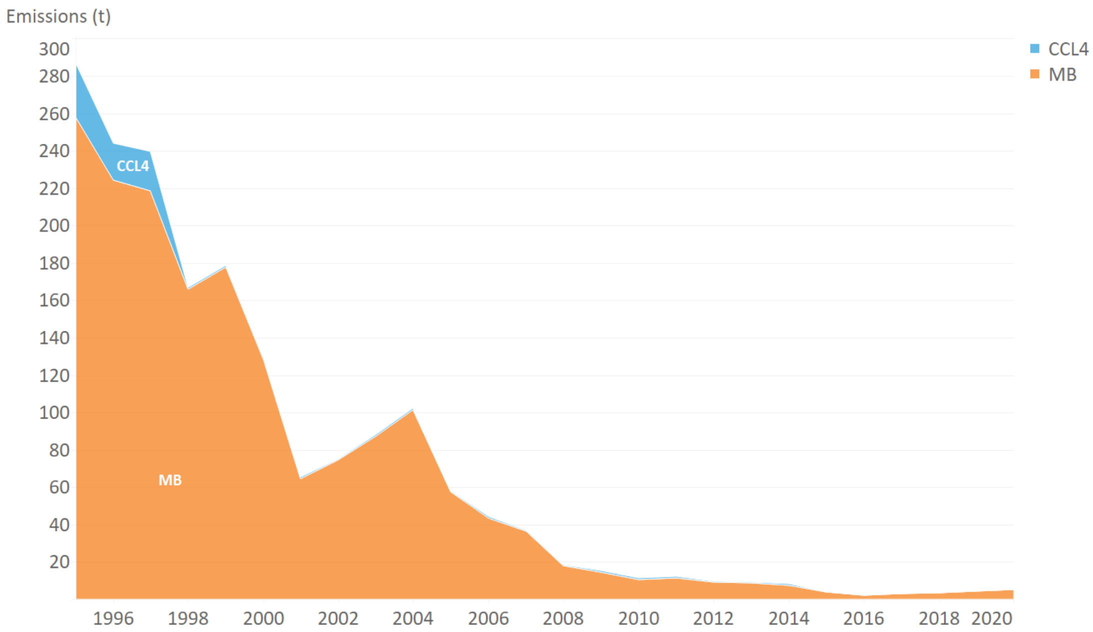
Methodology

The data for process emissions are those provided to the Vlaamse Milieumaatchappij by the company.

Results

The evolution of emissions is shown on Figure 4-33. In 2020 these emissions reached 5,4 t.

Figure 4-33. Emissions of methyl bromide (MB) and carbon tetrachloride (CCL4; t)



Source: VITO, Econotec (own calculations, 2021)

4.12. Other substances

4.12.1. Sulfuryl fluoride

Sulfuryl fluoride (SO_2F_2) is used as a fumigant to replace methyl bromide that was phased out under the Montreal protocol. The IPCC's fifth assessment report GWP value for SO_2F_2 is 4.090 and thus similar than the GWP value of CFC-11 and higher than the majority of HFCs.

At present there are few studies available that quantified SO_2F_2 emissions. Measurements on archived air samples and in situ observations from the Advanced Global Atmospheric Gases

Experiment showed a global increase of the SO_2F_2 mole fraction from 0,3 to 2,5 ppt in the atmosphere, corresponding with a global increase in annual emissions from 0,5 to 2,9 Gg from 1978 to 2019. The global emissions increase is driven by the growing use of SO_2F_2 in structural fumigation in North America and in postharvest treatment of grains and other agricultural products worldwide[33]. Also in Australia, use and emissions of SO_2F_2 is driven by wheat production and wheat export[34]. SO_2F_2 emissions averaged about 350 kt CO_2-eq in 2012-2013, compared to 650 kt CO_2-eq for SF6 and 790 kt CO_2-eq for PFCs.

Estimated global production of SO_2F_2 was 3000 t in 2011-2012[34], assuming that all is emited in the atmosphere, this amounts to an estimated global emission of 12.270 kt CO_2-eq. In Belgium SO_2F_2 is used as fumigants for imported food products (such as flour or cocoa), wood, furniture, etc. The most important users seem to be located in different ports but has also been used in the milling industry. The use of the gas has seen an important increase since 2005 and appears to be now one of the most important fumigants. The distributor of SO_2F_2 in Belgium informed us that 4 companies use SO_2F_2 as fumigant, for example EWS group, Decroes, and Anticimex.

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33 Gressent, A., et al. (2016) Optimal Estimation of Sulfuryl Fluoride Emissions on Regional and Global Scales Using Advanced 3D Inverse Modeling and AGAGE Observations," J. Geophys. Res.: 126(9). doi: https://doi.org/10.1029/2020JD034327

34 Dunse, B.L., Fraser, P.J., Krummel, P.B., Steele, L.P. and Derek, N. (2016) Australian and global HFC, PFC, Sulfur Hexafluoride, Nitrogen Trifluoride and Sulfuryl Fluoride Emissions," Report prepared for Australian Government Department of the Environment, by the Collaboration for Australian Weather and Climate Research, CSIRO Oceans and Atmosphere Flagship, Aspendale, Australia.

5.1. Methodology

5.1.1. Introduction

The methodology used for the uncertainty analysis was described in detail in the update for 2004 [28]. Therefore, it will only be summarised here.

This methodology follows the prescriptions of the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* [29], which itself relies on the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* [30].

It remains consistent with Approach 1 of the 2006 IPCC Guidelines (called Tier 1 in the Revised 1996 IPCC Guidelines). The new UNFCCC Guidelines specify that the Parties to the Convention must quantify uncertainty for all sources according to at least one approach, for at least the base year and the inventory year, and the uncertainty on the trend between the two years.

To this end, we have filled in as required Table 3.3 of Volume 1 of the 2006 IPCC Guidelines [2], for the years 1995, 2012 and 2013.

As stated in [29][35], the greenhouse gas inventory is principally the sum of products of activity data and emission factors. In a simplified way[36]:

$$E_T = \Sigma E_i = \Sigma AV_i . EF_i,$$

where E_T is the total emission, AV is the activity variable, EF is the emission factor and i denotes each emission source category.

In order to evaluate the uncertainty on E, it is necessary, in a first step, to evaluate the uncertainty on the individual components AV_i and EF_i, and in a second step, to combine these uncertainties on the individual components.

As we shall see below, a peculiarity of F-gas emissions that makes the evaluation of emissions uncertainty trickier for these gases is the correlation between activity variables and emission factors.

5.1.2. Indicators of uncertainty

An uncertain parameter can be considered as a stochastic variable. Its uncertainty can be represented by a probability distribution, but it is more often expressed as uncertainty margins,

35 Page 6.12.

36 In fact, the calculation is often more complicated, because emissions can depend on past activity variables. But it is generally possible to bring it down to the above formula, for example by representing an existing stock of fluid as an activity variable.

which correspond to a confidence interval. The IPCC guidelines recommend, where data are sufficient, a confidence interval of 95% (IPCC, 2006, Vol. 1, p. 3.13), that is to say having a 95% probability of containing the true value.

In mathematical statistics, a parameter commonly used to express the uncertainty of a random variable is the standard deviation. The concept of standard deviation is useful for deriving relationships allowing to evaluate the uncertainty of combinations of random variables (see below), using error propagation equations.

The link between confidence interval and standard deviation depends on the type of probability distribution. Often a normal distribution is assumed for the variable under consideration; in this case, the confidence limits are symmetric about the mean and for a 95% confidence interval, the confidence limits are approximately 2 standard deviations of the variable, above and below the mean.

We represent these intervals by uncertainty margins expressed as percentage deviations from the mean.

In the case of the F-gas emissions, there is generally not enough statistical information available to establish probability distributions. Therefore, the uncertainty margins are based on expert judgement or on the literature.

5.1.3. Combination of uncertainties

Product of stochastic variables

In the case of a normal distribution, the uncertainty margin is proportional to the standard deviation of the distribution (and equal to 1,96 σ). Expressed relative to the mean, it is proportional to the coefficient of variation (CV = σ/m):

$$U = 1{,}96\ \sigma/m.$$

Therefore, if the emissions of source i can be calculated as:

$$E = AV.\ EF,$$

and the two variables are not correlated, then an approximate evaluation of the uncertainty on E is given by:

$$U_E = \pm\sqrt{U_{AV}^{\ 2} + U_{EF}^{\ 2}} \qquad (1)$$

where U_{AV} and U_{EF} are the uncertainties on the activity variable and the emission factor, respectively. This equation is called ***Rule B*** in [29].

However, this formula is only valid as long as $|U_{AV}|$ et $|U_{EF}|$ do not exceed 60%. In the case of F-gas emissions, this condition is not always met. A more general formula, which is valid without this restriction, provided the two variables are independent, is:

$$U_E = \pm\sqrt{U_{AV}^{\ 2} + U_{EF}^{\ 2} + \frac{1}{3{,}8} U_{AV}^{\ 2} \cdot U_{EF}^{\ 2}} \qquad (2)$$

This formula is derived from that of the coefficient of variation of the product of two independent random variables X and Y (see e.g. [31], p. 227):

$$CV_{XY} = \sqrt{CV_X{}^2 + CV_Y{}^2 + CV_X{}^2 \cdot CV_Y{}^2},$$

Since CV = σ/m and U = 1,96 σ/m, one has indeed: CV = U/1,96.

Sum of stochastic variables

If the total emission of a gas is :

$$E = \Sigma E_i,$$

where E_i is the central estimate of the emission of the gas in source category i, and if the E_i variables are not correlated, then the uncertainty margin on E is :

$$U_E = \pm \frac{\sqrt{\Sigma U_{E,i}{}^2 \cdot C_i{}^2}}{\sum C_i}, \qquad (3)$$

where $U_{E,i}$ is the overall percentage uncertainty for source category i of the gas.

This equation is equation 3.2 of [2], volume 1, p. 3.28.

Approaches 1 and 2 of the IPCC

The 2006 IPCC Guidelines provide two approaches[37] for combining source category uncertainties into an uncertainty estimate for total national emissions :

Approach 1 consists in applying first IPCC *equation (1)* and afterwards equation (3). Hence it is based on simplifying assumptions (no correlation between variables and $|U_{AV}|$ et $|U_{EF}|$ below 60%). It calculates the uncertainty in terms of the standard deviation of the probability distribution, and hence can not calculate asymmetric confidence intervals.

Approach 2 consists in applying a Monte Carlo simulation technique to calculate the probability distribution of the result. Its advantages is that it is generally applicable, as it can handle any sort of probability distributions, any size of uncertainty as well as correlation between the variables. However, it requires to know the probability distributions of the variables to be combined and the correlation between them, and are more complex to handle, given the number of emission sources and gases.

The data required for using Approach 2 (probability distributions and correlations) are generally not available, as there exist no statistical data allowing to estimate the parameters of the distributions. These parameters are therefore usually expert judgement estimates.

In general, the product of two variables with a normal distribution does not have a symmetrical distribution. Therefore, Approach 1 method does not always allow calculating the confidence

[37] These approaches used to be called Tier 1 and Tier 2 in the 1996 IPCC Guidelines.

intervals in a precise manner. However, there are several reasons why Approach 1 can be considered satisfactory:

- It provides the standard deviations (at least when the variables combined are uncorrelated), which are good indicators of the level of uncertainty even for asymmetric distributions.
- According to the central limit theorem[38], emission totals, which are sums of mostly independent variables, will tend to be normally distributed. Hence for these totals, it will often be enough to know the standard deviations.
- "An uncertainty analysis should be seen, first and foremost, as a means to help prioritise national efforts to reduce the uncertainty of inventories in the future, and guide decisions on methodological choice" ([2], Volume 1, p. 3.6). For that purpose, it can be considered unnecessary to know precisely all the confidence intervals as long as the standard deviations are known, as well as the confidence intervals on the main emission totals.
- Finally, it should be remembered that the F-gases only represent a small fraction of total Kyoto greenhouse gas emissions (in the order of 3% in 1995, when they were at their highest level).

5.1.4. Method retained

For the emission inventory, it has been agreed by the steering group to use Approach 1, while enhancing it in two ways:

- by replacing formula (1) with formula (2), which is more accurate, in particular in the case of F-gases;
- by taking into account the correlation between activity variable and emission factor for the emission source categories where it is relevant.

Such a correlation exists in the case of cooling installations and insulation foams. Indeed, for these emission sources, the activity variable used (the stock of F-gas in equipment) is estimated as an analytical function of the emission factor (the average loss rate).

To take into account the correlation has consisted in carrying out sensitivity analyses on individual uncertain parameters, taking into account the analytical links between 'activity variable' and 'emission factor'.

For each substance, only the emission sources for which the uncertainty is expected to influence the uncertainty of the overall emissions of the substance significantly, has been taken into account.

38 This theorem states that the sum of a large number of independent random variables is approximately normally distributed, even though the random variables themselves may follow any distribution or be taken from different distributions. The only conditions are that the original random variables must have finite expectation and variance (the sum should not be dominated by one or a few components).

5.1.5. Trend uncertainties

As required by the IPCC, trend uncertainties are estimated using two sensitivities ([2], Volume 1, pp 3.29-3.32):

Type A sensitivity: the change in the difference in overall emissions between the base year and the current year, expressed as a percentage, resulting from a 1% increase in emissions of a given source category and gas in both the base year and the current year.
Type B sensitivity: the change in the difference in overall emissions between the base year and the current year, expressed as a percentage, resulting from a 1% increase in emissions of a given source category and gas in the current year only.

5.2. Results of the uncertainty analysis

5.2.1. Introduction

As requested, the uncertainty evaluation has been updated for the years 1995, 2019 and 2020. The results are presented in tables in section 5.2.2.

These tables use the format of Table 6.1 of the IPCC Good Practice Guidance [29], which is to be used for the official reporting.

As the results of the emission inventory show, the size of emission level can differ very widely from one source to another. Therefore, we have limited the uncertainty analysis to the largest individual sources, which together account for 99% of the Kyoto F-gas emissions in 1995 and 95% of emissions in 2005, and used extrapolation to cover the remaining emissions (identified as “other” categories).

After some comments on the data sources, this section analyses the assumptions by emission source and by substance. The sources identified and their respective numbers are those of the Common Reporting Format of the National Emission Inventory.

The analysis by emission source of the data sources for uncertainty margins is presented in the update for 2004 [28].

5.2.2. Result tables

The results are presented in the tables hereafter, which have the format of Table 6.1 of the IPCC Guidelines and relate to the years 1995 (update), 2019 (update) and 2020.

It should be remembered that Tier 1 method uses symmetric deviations (proportional to standard deviations) as inputs. Therefore, when uncertainty margins on activity variables or emission factors are asymmetric, they are translated into symmetric deviations with an equivalent confidence interval.

Note that one type of uncertainty that is not taken into account in the Tier 1 calculation table is the underestimation arising because of sources that are unknown and hence not taken into account, e.g.:

- In the refrigeration, the foam and the fire extinguishing sectors, consumption data are obtained from a survey among consumers. While the data may be considered as accurate, it might be that unknown consumers or distributors have not been taken into account in the survey.
- It is also possible that some other applications have not been covered, especially if they concern small individual consumptions.

One difficulty in getting accurate emission figures stems from the fact that the F-gases are all imported, and that there are no statistics on external trade of these substances. This is particularly the case for a small country like Belgium which is characterised by a high level of external trade.

Overall, the results show for the F-gases an uncertainty of 0,7% of the total greenhouse gas emissions in 2020. The trend uncertainty is estimated at 0,6%.

Table 3.2: Approach 1 uncertainty calculation and reporting for year 1995 - page 1												
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
IPCC Source category	**Gas**	**Base year emissions (F-gases : 1995 otherwise : 1990)**	**1995 emissions**	**Activity data uncertainty (%)**	**Emission factor uncertainty (%)**	**Combined uncertainty**	**Contribution to Variance by Category in 1995**	**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**
		Gg CO2 eq	**Gg CO2 eq**									
		Input data	Input data	Input data	Input data	$\sqrt{E^2+F^2+\frac{1}{3,8}E^2.F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\frac{D}{\sum C}$	$I*F$	$J*E*\sqrt{2}$	$\sqrt{K^2+L^2}$
2 B 9 a By-product emissions	CF4	511,68	511,68	26%	0%	26%	0,0001%					
2 B 9 a By-product emissions	C2F6	875,85	875,85	26%	0%	26%	0,0002%					
2 B 9 a By-product emissions	C3F8	294,50	294,50	26%	0%	26%	0,0000%					
2 B 9 a By-product emissions	C4F10	333,52	333,52	26%	0%	26%	0,0000%					
2 B 9 a By-product emissions	C5F12	58,04	58,04	26%	0%	26%	0,0000%					
2 B 9 a By-product emissions	SF6	2.005,28	2.005,28	26%	0%	26%	0,0012%					
2 B 9 b Fugitive emissions	C4F10	37,06	37,06	26%	0%	26%	0,0000%					
2 B 9 b Fugitive emissions	C5F12	497,50	497,50	26%	0%	26%	0,0001%					
2 B 9 b Fugitive emissions	C6F14	306,15	306,15	26%	0%	26%	0,0000%					
2 E 1 Semiconductors	HFC-23	0,00	0,00		100%	100%	0,0000%					
2 E 1 Semiconductors	CF4	0,00	0,00		100%	100%	0,0000%					
2 E 1 Semiconductors	C2F6	0,00	0,00		100%	100%	0,0000%	**NOT RELEVANT FOR BASE YEAR**				
2 E 1 Semiconductors	c-C4F8	0,00	0,00		100%	100%	0,0000%					
2 E 1 Semiconductors	SF6	0,00	0,00		100%	100%	0,0000%					
2 E 1 Semiconductors	NF3	0,00	0,00		100%	100%	0,0000%					
2 E 4 Heat transfer fluid	HFC-32	0,00	0,00		100%	100%	0,0000%					
2 E 4 Heat transfer fluid	HFC-125	0,00	0,00		100%	100%	0,0000%					
2 F 1 a Commercial refrigeration	HFC-125	4,29	4,29		75%	75%	0,0000%					
2 F 1 a Commercial refrigeration	HFC-134a	55,40	55,40		75%	75%	0,0000%					
2 F 1 a Commercial refrigeration	HFC-143a	6,42	6,42		75%	75%	0,0000%					
2 F 1 a Commercial refrigeration	HFC-152a	0,00	0,00		75%	75%	0,0000%					
2 F 1 a Commercial refrigeration	C3F8 (PFC-218)	0,00	0,00		75%	75%	0,0000%					
2 F 1 b Domestic refrigeration	HFC-134a	0,05	0,05		*75%*	75%	0,0000%					
2 F 1 d Transport refrigeration	HFC-32	0,00	0,00	*100%*	*50%*	115%	0,0000%					
2 F 1 d Transport refrigeration	HFC-125	0,57	0,57	*100%*	*50%*	115%	0,0000%					
2 F 1 d Transport refrigeration	HFC-134a	0,12	0,12	*100%*	*50%*	115%	0,0000%					
2 F 1 d Transport refrigeration	HFC-143a	0,86	0,86	*100%*	*50%*	115%	0,0000%					

Table 3.2 : Approach 1 uncertainty calculation and reporting for the year 1995 - page 2

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions (F-gases : 1995 otherwise : 1990) Gg CO2 eq	1995 emissions Gg CO2 eq	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty	Contribution to Variance by Category in 1995	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
		Input data	Input data	Input data	Input data	$\sqrt{E^2+F^2+\frac{1}{3,8}E^2.F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\frac{D}{\sum C}$	$I*F$	$J*E*\sqrt{2}$	$\sqrt{K^2+L^2}$
2 F 1 e Mobile air-conditioning	HFC-134a	23,51	23,51	100%	50%	115%	0,0000%					
2 F 1 f Stationary air-conditioning	HFC-32	0,09	0,09	100%	50%	115%	0,0000%					
2 F 1 f Stationary air-conditioning	HFC-125	0,50	0,50	100%	50%	115%	0,0000%					
2 F 1 f Stationary air-conditioning	HFC-134a	2,22	2,22	*15%*	*5%*	16%	0,0000%					
2 F 2 a Closed cell foam	HFC-134a	356,73	356,73	*15%*	*5%*	16%	0,0000%					
2 F 2 a Closed cell foam	HFC-152a	0,06	0,06	*15%*	*5%*	16%	0,0000%					
2 F 2 a Closed cell foam	HFC-227ea	0,00	0,00	*15%*	*5%*	16%	0,0000%					
2 F 2 a Closed cell foam	HFC-245fa	0,01	0,01	*15%*	*5%*	16%	0,0000%					
2 F 2 a Closed cell foam	HFC-365mfc	0,00	0,00	*10%*	*50%*	51%	0,0000%	NOT RELEVANT FOR BASE YEAR				
2 F 3 Fire protection	HFC-125	0,00	0,00	*10%*	*50%*	51%	0,0000%					
2 F 3 Fire protection	HFC-227ea	0,58	0,58	25%	50%	56%	0,0000%					
2 F 4 a Metered dose inhalers	HFC-134a	0,00	0,00	25%	50%	56%	0,0000%					
2 F 4 a Metered dose inhalers	HFC-227ea	0,00	0,00		200%	200%	0,0000%					
2 F 4 b Technical aerosols	HFC-134a	41,41	41,41		200%	200%	0,0000%					
2 F 4 b Technical aerosols	HFC-152a	0,04	0,04		50%	50%	0,0000%					
2 G 1 Electrical equipment	SF6	8,01	8,01		100%	100%	0,0000%					
2 G 2 c Soundproof windows	SF6	79,77	79,77		100%	100%	0,0000%					
2 G 2 d Adiabatic properties: shoes	SF6	46,93	46,93		100%	100%	0,0000%					
Total F-gases		**5.547,14**	**5.547,14**				0,0017%					
Total 6 GHG (without LUCF)		**153.616,79**	**153.616,79**			Percentage uncertainty in total inventory	**0,411%**					

Note A: when only total uncertainty is known (not for emission factor and activity data separately), then :
- when uncertainty is correlated across years, the uncertainty is entered into column F, and 0 is entered in column E;
- when uncertainty is not correlated across years, the uncertainty is entered into column E, and 0 is entered in column F.

Note B: Entries in column I show how the difference in emissions between the base year and year t changes in response to a 1% increase in the emissions of source category x in the base year and year t.
This shows the sensitivity of the trend t in emissions to a systematic uncertainty in the emission estimate.

$$\frac{0{,}01\cdot D_x+\Sigma D_i-(0{,}01\cdot C_x+\Sigma C_i)}{(0{,}01\cdot C_x+\Sigma C_i)}\cdot 100-\frac{\Sigma D_i-\Sigma C_i}{\Sigma C_i}\cdot 100$$

Column J: Type B sensitivity shows how the difference in emissions between the base year and year t changes in response to a 1% increase of souce category x in emissions in year t only.

Table 3.2: Approach 1 uncertainty calculation and reporting for year 2019 - page 1												
A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	**Gas**	**Base year emissions (F-gases : 1995 otherwise : 1990)** **Gg CO2 eq**	**2019 emissions** **Gg CO2 eq**	**Activity data uncertainty (%)**	**Emission factor uncertainty (%)**	**Combined uncertainty**	**Contribution to Variance by Category in 2019**	**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**
		Input data	Input data	Input data	Input data	$\sqrt{E^2+F^2+\frac{1}{3{,}8}E^2.F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\frac{D}{\sum C}$	$I*F$	$J*E*\sqrt{2}$	$\sqrt{K^2+L^2}$
2 B 9 a By-product emissions	CF4	511,68	89,44	26%	0%	26%	0,0000%	-0,002%	0,001%	0,00%	0,02%	0,021%
2 B 9 a By-product emissions	C2F6	875,85	0,00	26%	0%	26%	0,0000%	-0,004%	0,000%	0,00%	0,00%	0,000%
2 B 9 a By-product emissions	C3F8	294,50	0,00	26%	0%	26%	0,0000%	-0,001%	0,000%	0,00%	0,00%	0,000%
2 B 9 a By-product emissions	C4F10	333,52	0,00	26%	0%	26%	0,0000%	-0,002%	0,000%	0,00%	0,00%	0,000%
2 B 9 a By-product emissions	C5F12	58,04	0,00	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 B 9 a By-product emissions	SF6	2.005,28	0,00	26%	0%	26%	0,0000%	-0,010%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	HFC-23	0,00	1.142,85	26%	0%	26%	0,0006%	0,007%	0,007%	0,00%	0,27%	0,274%
2 B 9 b Fugitive emissions	HFC-125	0,00	107,68	26%	0%	26%	0,0000%	0,001%	0,001%	0,00%	0,03%	0,026%
2 B 9 b Fugitive emissions	HFC-134a	0,00	0,72	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	HFC-227ea	0,00	37,14	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,01%	0,009%
2 B 9 b Fugitive emissions	C4F10	37,06	22,58	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,01%	0,005%
2 B 9 b Fugitive emissions	C5F12	497,50	0,00	26%	0%	26%	0,0000%	-0,002%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	C6F14	306,15	6,26	26%	0%	26%	0,0000%	-0,001%	0,000%	0,00%	0,00%	0,001%
2 E 1 Semiconductors	HFC-23	0,00	1,64		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%
2 E 1 Semiconductors	HFC-32	0,00	0,00		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 E 1 Semiconductors	HFC-41	0,00	0,00		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 E 1 Semiconductors	HFC-125	0,00	0,16		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 E 1 Semiconductors	CF4	0,00	4,82		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,003%
2 E 1 Semiconductors	C2F6	0,00	4,75		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,003%
2 E 1 Semiconductors	c-C4F8	0,00	0,40		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 E 1 Semiconductors	SF6	0,00	6,36		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,004%
2 E 1 Semiconductors	NF3	0,00	0,53		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 1 a Commercial refrigeration	HFC-32	0,00	24,06		75%	75%	0,0000%	0,000%	0,000%	0,01%	0,00%	0,012%
2 F 1 a Commercial refrigeration	HFC-125	4,29	654,46		75%	75%	0,0018%	0,004%	0,004%	0,32%	0,00%	0,318%
2 F 1 a Commercial refrigeration	HFC-134a	55,40	341,39		75%	75%	0,0005%	0,002%	0,002%	0,15%	0,00%	0,146%
2 F 1 a Commercial refrigeration	HFC-143a	6,42	690,60		75%	75%	0,0020%	0,004%	0,004%	0,33%	0,00%	0,335%
2 F 1 a Commercial refrigeration	HFC-152a	0,00	0,00		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 1 a Commercial refrigeration	C3F8	0,00	0,02		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 1 b Domestic refrigeration	HFC-125	0,00	3,95		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,002%
2 F 1 b Domestic refrigeration	HFC-134a	0,05	6,57		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,003%
2 F 1 b Domestic refrigeration	HFC-143a	0,00	5,96		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,003%

Table 3.2 : Approach 1 uncertainty calculation and reporting for the year 2019 - page 2												
A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions (F-gases : 1995 otherwise : 1990) Gg CO2 eq	2019 emissions Gg CO2 eq	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty	Contribution to Variance by Category in 2019	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
		Input data	Input data	Input data	Input data	$\sqrt{E^2+F^2+\frac{1}{3,8}E^2.F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\frac{D}{\sum C}$	$I*F$	$J*E*\sqrt{2}$	$\sqrt{K^2+L^2}$
2 F 1 d Transport refrigeration	HFC-32	0,00	0,25	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 1 d Transport refrigeration	HFC-125	0,57	8,39	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,01%	0,008%
2 F 1 d Transport refrigeration	HFC-134a	0,12	2,10	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,002%
2 F 1 d Transport refrigeration	HFC-143a	0,86	10,10	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,01%	0,010%
2 F 1 e Mobile air-conditioning	HFC-32	0,00	0,08	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 1 e Mobile air-conditioning	HFC-125	0,00	0,48	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 1 e Mobile air-conditioning	HFC-134a	23,51	420,56	100%	50%	115%	0,0017%	0,003%	0,003%	0,13%	0,39%	0,409%
2 F 1 f Stationary air-conditioning	HFC-32	0,09	47,67		75%	75%	0,0000%	0,000%	0,000%	0,02%	0,00%	0,023%
2 F 1 f Stationary air-conditioning	HFC-125	0,50	252,47		75%	75%	0,0003%	0,002%	0,002%	0,12%	0,00%	0,123%
2 F 1 f Stationary air-conditioning	HFC-134a	2,22	137,22		75%	75%	0,0001%	0,001%	0,001%	0,07%	0,00%	0,066%
2 F 1 f Stationary air-conditioning	HFC-143a	0,00	0,01		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 2 a Closed cell foam	HFC-134a	356,73	22,95	15%	5%	16%	0,0000%	-0,002%	0,000%	-0,01%	0,00%	0,009%
2 F 2 a Closed cell foam	HFC-152a	0,06	12,48	15%	5%	16%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,002%
2 F 2 a Closed cell foam	HFC-227ea	0,00	2,35	15%	5%	16%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 2 a Closed cell foam	HFC-245fa	0,01	0,53	15%	5%	16%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 2 a Closed cell foam	HFC-365mfc	0,00	4,10	15%	5%	16%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%
2 F 3 Fire protection	HFC-125	0,00	0,79	10%	50%	51%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 3 Fire protection	HFC-227ea	0,58	11,31	10%	50%	51%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,004%
2 F 4 a Metered dose inhalers	HFC-134a	0,00	45,96	25%	50%	56%	0,0000%	0,000%	0,000%	0,01%	0,01%	0,018%
2 F 4 a Metered dose inhalers	HFC-227ea	0,00	1,69	25%	50%	56%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%
2 F 4 b Technical aerosols	HFC-134a	41,41	2,10		200%	200%	0,0000%	0,000%	0,000%	-0,04%	0,00%	0,038%
2 F 4 b Technical aerosols	HFC-152a	0,04	0,10		200%	200%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 G 1 Electrical equipment	SF6	8,01	8,56		50%	50%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%
2 G 2 c Soundproof windows	SF6	79,77	73,14		100%	100%	0,0000%	0,000%	0,000%	0,01%	0,00%	0,008%
2 G 2 d Adiabatic properties: shoes	SF6	46,93	0,00		100%	100%	0,0000%	0,000%	0,000%	-0,02%	0,00%	0,023%
Total F-gases		**5.547,14**	**4.217,73**				0,0070%					0,005%
Total 7 GHGs (without LUCF)		**153.616,79**	**116.651,49**			Percentage uncertainty in total inventory	**0,836%**				Trend uncertainty	**0,708%**

Notes: see under calculation for base year (1995)

Table 3.2: Approach 1 uncertainty calculation and reporting for year 2020 - page 1												
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
IPCC Source category	**Gas**	**Base year emissions (F-gases : 1995 otherwise : 1990)** Gg CO2 eq	**2020 emissions** Gg CO2 eq	**Activity data uncertainty (%)**	**Emission factor uncertainty (%)**	**Combined uncertainty**	**Contribution to Variance by Category in 2020**	**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**
		Input data	Input data	Input data	Input data	$\sqrt{E^2+F^2+\frac{1}{3{,}8}E^2.F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\frac{D}{\sum C}$	$I*F$	$J*E*\sqrt{2}$	$\sqrt{K^2+L^2}$
2 B 9 a By-product emissions	CF4	511,68	61,44	26%	0%	26%	0,0000%	-0,002%	0,000%	0,00%	0,01%	0,015%
2 B 9 a By-product emissions	C2F6	875,85	0,00	26%	0%	26%	0,0000%	-0,004%	0,000%	0,00%	0,00%	0,000%
2 B 9 a By-product emissions	C3F8	294,50	0,00	26%	0%	26%	0,0000%	-0,001%	0,000%	0,00%	0,00%	0,000%
2 B 9 a By-product emissions	C4F10	333,52	0,00	26%	0%	26%	0,0000%	-0,002%	0,000%	0,00%	0,00%	0,000%
2 B 9 a By-product emissions	C5F12	58,04	0,00	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 B 9 a By-product emissions	SF6	2.005,28	0,00	26%	0%	26%	0,0000%	-0,010%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	HFC-23	0,00	721,15	26%	0%	26%	0,0003%	0,005%	0,005%	0,00%	0,17%	0,173%
2 B 9 b Fugitive emissions	HFC-32	0,00	0,00	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	HFC-125	0,00	56,82	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,01%	0,014%
2 B 9 b Fugitive emissions	HFC-134	0,00	0,00	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	HFC-134a	0,00	0,14	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	HFC-143a	0,00	0,07	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	HFC-152a	0,00	0,00	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	HFC-227ea	0,00	17,20	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,004%
2 B 9 b Fugitive emissions	HFC-236fa	0,00	0,34	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	CF4	0,00	1,79	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	C2F6	0,00	7,95	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,002%
2 B 9 b Fugitive emissions	C3F8	0,00	17,02	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,004%
2 B 9 b Fugitive emissions	C4F10	37,06	64,41	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,02%	0,015%
2 B 9 b Fugitive emissions	C5F12	497,50	0,06	26%	0%	26%	0,0000%	-0,002%	0,000%	0,00%	0,00%	0,000%
2 B 9 b Fugitive emissions	C6F14	306,15	9,66	26%	0%	26%	0,0000%	-0,001%	0,000%	0,00%	0,00%	0,002%
2 B 9 b Fugitive emissions	SF6	0,00	2,68	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%
2 B 9 b Fugitive emissions	NF3	0,00	7,57	26%	0%	26%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,002%
2 E 1 Semiconductors	HFC-23	0,00	4,34		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,003%
2 E 1 Semiconductors	HFC-32	0,00	0,00		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 E 1 Semiconductors	HFC-41	0,00	0,00		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 E 1 Semiconductors	HFC-125	0,00	0,15		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 E 1 Semiconductors	CF4	0,00	2,51		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,002%
2 E 1 Semiconductors	C2F6	0,00	6,64		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,004%
2 E 1 Semiconductors	c-C4F8	0,00	0,40		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 E 1 Semiconductors	SF6	0,00	5,13		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,003%
2 E 1 Semiconductors	NF3	0,00	0,94		100%	100%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%

Table 3.2 : Approach 1 uncertainty calculation and reporting for the year 2020 - page 2												
A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	**Gas**	**Base year emissions (F-gases : 1995 otherwise : 1990)**	**2020 emissions**	**Activity data uncertainty (%)**	**Emission factor uncertainty (%)**	**Combined uncertainty**	**Contribution to Variance by Category in 2020**	**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**
		Gg CO2 eq	**Gg CO2 eq**									
		Input data	Input data	Input data	Input data	$\sqrt{E^2+F^2+\frac{1}{3,8}E^2.F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\frac{D}{\sum C}$	$I*F$	$J*E*\sqrt{2}$	$\sqrt{K^2+L^2}$
2 F 1 a Commercial refrigeration	HFC-32	0,00	23,96		75%	75%	0,0000%	0,000%	0,000%	0,01%	0,00%	0,012%
2 F 1 a Commercial refrigeration	HFC-125	4,29	593,65		75%	75%	0,0015%	0,004%	0,004%	0,29%	0,00%	0,288%
2 F 1 a Commercial refrigeration	HFC-134a	55,40	317,98		75%	75%	0,0004%	0,002%	0,002%	0,13%	0,00%	0,135%
2 F 1 a Commercial refrigeration	HFC-143a	6,42	603,88		75%	75%	0,0015%	0,004%	0,004%	0,29%	0,00%	0,292%
2 F 1 a Commercial refrigeration	HFC-152a	0,00	0,00		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 1 a Commercial refrigeration	C3F8	0,00	0,03		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 1 b Domestic refrigeration	HFC-125	0,00	3,91		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,002%
2 F 1 b Domestic refrigeration	HFC-134a	0,05	5,79		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,003%
2 F 1 b Domestic refrigeration	HFC-143a	0,00	5,91		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,003%
2 F 1 d Transport refrigeration	HFC-32	0,00	0,30	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 1 d Transport refrigeration	HFC-125	0,57	9,30	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,01%	0,009%
2 F 1 d Transport refrigeration	HFC-134a	0,12	2,09	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,002%
2 F 1 d Transport refrigeration	HFC-143a	0,86	10,69	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,01%	0,010%
2 F 1 e Mobile air-conditioning	HFC-32	0,00	0,15	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 1 e Mobile air-conditioning	HFC-125	0,00	0,84	100%	50%	115%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%
2 F 1 e Mobile air-conditioning	HFC-134a	23,51	369,51	100%	50%	115%	0,0013%	0,002%	0,002%	0,11%	0,34%	0,359%
2 F 1 f Stationary air-conditioning	HFC-32	0,09	53,08		75%	75%	0,0000%	0,000%	0,000%	0,03%	0,00%	0,026%
2 F 1 f Stationary air-conditioning	HFC-125	0,50	276,05		75%	75%	0,0003%	0,002%	0,002%	0,13%	0,00%	0,135%
2 F 1 f Stationary air-conditioning	HFC-134a	2,22	131,82		75%	75%	0,0001%	0,001%	0,001%	0,06%	0,00%	0,064%
2 F 1 f Stationary air-conditioning	HFC-143a	0,00	0,00		75%	75%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%

Table 3.2 : Approach 1 uncertainty calculation and reporting for the year 2020 - page 3												
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
IPCC Source category	**Gas**	**Base year emissions (F-gases : 1995 otherwise : 1990)**	**0,00050625**	**Activity data uncertainty (%)**	**Emission factor uncertainty (%)**	**Combined uncertainty**	**1,88343E-17**	**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**
		Gg CO2 eq	**Gg CO2 eq**									
		Input data	Input data	Input data	Input data	$\sqrt{E^2+F^2+\frac{1}{3,8}E^2.F^2}$	$\frac{(G * D)^2}{(\sum D)^2}$	Note B	$\frac{D}{\sum C}$	$I * F$	$J * E * \sqrt{2}$	$\sqrt{K^2+L^2}$
2 F 2 a Closed cell foam	HFC-134a	356,73	22,16	15%	5%	16%	0,0000%	-0,002%	0,000%	-0,01%	0,00%	0,009%
2 F 2 a Closed cell foam	HFC-152a	0,06	9,54	15%	5%	16%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%
2 F 2 a Closed cell foam	HFC-227ea	0,00	4,82	15%	5%	16%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%
2 F 2 a Closed cell foam	HFC-245fa	0,01	0,17	15%	5%	16%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 2 a Closed cell foam	HFC-365mfc	0,00	8,12	15%	5%	16%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%
2 F 3 Fire protection	HFC-125	0,00	0,72	10%	50%	51%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 F 3 Fire protection	HFC-227ea	0,58	9,66	10%	50%	51%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,003%
2 F 4 a Metered dose inhalers	HFC-134a	0,00	46,20	25%	50%	56%	0,0000%	0,000%	0,000%	0,02%	0,01%	0,018%
2 F 4 a Metered dose inhalers	HFC-227ea	0,00	1,70	25%	50%	56%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,001%
2 F 4 b Technical aerosols	HFC-134a	41,41	2,12		200%	200%	0,0000%	0,000%	0,000%	-0,04%	0,00%	0,038%
2 F 4 b Technical aerosols	HFC-152a	0,04	0,20		200%	200%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,000%
2 G 1 Electrical equipment	SF6	8,01	10,99		50%	50%	0,0000%	0,000%	0,000%	0,00%	0,00%	0,002%
2 G 2 c Soundproof windows	SF6	79,77	71,75		100%	100%	0,0000%	0,000%	0,000%	0,01%	0,00%	0,007%
2 G 2 d Adiabatic properties: shoes	SF6	46,93	0,00		100%	100%	0,0000%	0,000%	0,000%	-0,02%	0,00%	0,023%
Total F-gases		**5.547,14**	**3.585,48**				0,0054%					0,004%
Total 7 GHGs (without LUCF)		**153.616,79**	**116.651,49**	(2019)		Percentage uncertainty in total inventory	**0,736%**				Trend uncertainty	**0,610%**

Notes: see under calculation for base year (1995)

ANNEX 1 EMISSION TABLES

See separate Excel file ANNEX 1 Emission Tables.xlsx

Table A1-1. Evolution of emissions by substance in Belgium (t)

	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
ODS	**4.054,7**	**3.591,2**	**1.473,6**	**882,8**	**465,9**	**391,7**	**332,8**	**281,1**	**266,0**	**251,6**
CFC	**1.125,4**	**626,1**	**380,2**	**118,2**	**107,6**	**105,6**	**103,8**	**102,0**	**100,2**	**98,5**
CFC-11	428,7	379,0	269,6	53,1	51,3	51,0	50,7	50,4	50,1	49,8
CFC-12	624,9	237,2	110,3	65,1	56,3	54,7	53,1	51,6	50,2	48,8
CFC-114	5,0	4,9	0,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CFC-115	66,8	5,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
HCFC	**2.629,8**	**2.823,7**	**1.028,8**	**749,1**	**351,8**	**282,0**	**224,2**	**173,4**	**159,3**	**145,9**
HCFC-22	1.874,6	1.517,8	756,3	548,3	186,6	122,6	69,8	23,9	14,4	5,4
HCFC-124		19,0	16,8	6,5	1,0	0,5	0,4	0,3	0,2	0,2
HCFC-141b	269,5	454,7	36,1	10,3	10,0	9,9	9,9	9,8	9,7	9,7
HCFC-142b	485,7	832,2	219,6	184,0	154,1	148,9	144,1	139,5	135,0	130,7
Halons	**12,5**	**12,5**	**6,6**	**4,2**	**2,6**	**2,0**	**2,0**	**2,0**	**1,8**	**1,8**
Halon 1211	1,7	1,7	0,7	0,2	0,2	0,1	0,1	0,1	0,1	0,1
Halon 1301	10,8	10,8	5,9	4,0	2,4	1,8	1,8	1,9	1,7	1,7
Other ODS	**287,1**	**129,0**	**58,0**	**11,3**	**4,0**	**2,1**	**2,9**	**3,7**	**4,6**	**5,4**
CCl4	29,2	0,7	0,7	0,7	0,0	0,0	0,0	0,0	0,0	0,0
CH3Br	257,9	128,3	57,3	10,6	4,0	2,1	2,9	3,7	4,6	5,4
CRF	**743,2**	**767,3**	**1.119,0**	**1.612,1**	**1.572,1**	**1.648,4**	**1.614,6**	**1.586,3**	**1.464,7**	**1.323,6**
HFC	**339,6**	**712,3**	**1.096,2**	**1.595,6**	**1.550,9**	**1.595,2**	**1.587,8**	**1.565,4**	**1.444,4**	**1.298,8**
HFC-23	0,0	0,0	45,6	35,1	67,0	63,4	85,9	101,9	77,3	49,0
HFC-32	0,1	4,9	12,4	36,1	64,0	72,5	82,2	94,6	106,8	114,8
HFC-41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
HFC-125	1,5	53,9	137,0	205,0	278,7	280,8	295,9	306,2	293,8	269,0
HFC-134	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
HFC-134a	335,3	483,9	549,2	745,5	780,3	821,8	811,9	728,9	685,0	627,8
HFC-143a	1,6	55,6	124,2	172,7	195,9	187,4	180,1	181,1	158,1	138,8
HFC-152a	0,8	112,4	205,3	370,0	140,9	145,9	100,2	134,3	101,4	78,6
HFC-227ea	0,2	1,5	7,1	10,7	15,2	13,1	17,3	8,8	16,3	10,4
HFC-236fa	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
HFC-245fa	0,0	0,1	10,6	0,6	0,8	0,7	0,5	0,5	0,5	0,2
HFC-365mfc	0,0	0,0	4,9	19,9	8,3	9,5	13,7	9,1	5,2	10,2
PFC	**309,8**	**48,7**	**18,8**	**11,8**	**17,1**	**48,8**	**22,3**	**16,7**	**16,4**	**20,4**
CF4	69,2	1,0	1,2	2,1	6,6	22,5	13,9	12,8	12,8	8,9
C4F10	41,8	2,0	3,9	2,6	7,7	22,7	7,2	2,8	2,5	7,3
c-C4F8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C5F12	60,6	26,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C6F14	32,9	19,2	12,5	6,0	2,5	3,2	0,6	0,6	0,7	1,0
C3F8	33,4	0,0	0,3	0,9	0,0	0,0	0,0	0,0	0,0	1,9
C2F6	71,8	0,0	1,0	0,1	0,3	0,5	0,5	0,5	0,4	1,2
SF6	**93,9**	**6,3**	**4,0**	**4,6**	**4,1**	**4,3**	**4,5**	**4,2**	**3,9**	**4,0**
NF3	0,0	0,0	0,0	**0,1**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,5**
Other	**258,2**	**75,4**	**42,9**	**57,2**	**87,4**	**71,0**	**99,2**	**168,8**	**190,4**	**185,6**
PFC	**96,3**	**49,7**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
C7F16	23,9	9,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C8F18	72,5	40,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
HFO	0,0	0,0	0,0	0,0	**27,9**	**16,0**	**42,6**	**81,6**	**103,3**	**129,7**
HFO-1234ze(E)	0,0	0,0	0,0	0,0	26,3	5,8	10,8	23,3	19,3	21,6
HFO-1234yf	0,0	0,0	0,0	0,0	1,6	10,3	31,8	58,3	84,0	108,1
Other	**161,9**	**25,6**	**42,9**	**57,1**	**59,5**	**54,9**	**56,6**	**87,2**	**87,2**	**55,9**
C8F16O	71,0	25,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CF3SF5	90,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
PFPMIE	0,0	0,0	0,0	0,6	1,0	0,5	0,3	0,4	0,3	0,2
Unspecified mix	0,0	0,0	42,9	56,5	58,5	54,4	56,3	86,8	86,9	55,7
General total	**5.056,1**	**4.433,8**	**2.635,5**	**2.552,1**	**2.125,4**	**2.111,1**	**2.046,5**	**2.036,2**	**1.921,2**	**1.760,9**

Table A1-2. Evolution of emissions by substance in Belgium (kt CO_2-eq)

	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
ODS	**9.833,3**	**6.449,8**	**2.815,3**	**1.720,6**	**1.057,2**	**951,4**	**842,4**	**742,1**	**710,6**	**676,1**
CFC	**6.463,5**	**2.761,6**	**1.440,6**	**634,3**	**559,3**	**545,7**	**532,7**	**520,0**	**507,6**	**495,6**
CFC-11	865,9	765,7	544,5	107,3	103,6	103,0	102,4	101,7	101,1	100,5
CFC-12	38,2	37,9	3,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CFC-114	497,8	37,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CFC-115	5.061,6	1.921,0	893,1	527,0	455,7	442,7	430,3	418,2	406,5	395,1
HCFC	**4.143,9**	**4.289,8**	**1.685,2**	**1.256,1**	**597,6**	**481,5**	**384,8**	**299,9**	**275,9**	**252,9**
HCFC-22	3.115,5	2.522,5	1.256,9	911,3	310,2	203,8	116,0	39,7	23,9	8,9
HCFC-124	0,0	9,2	8,1	3,1	0,5	0,2	0,2	0,1	0,1	0,1
HCFC-141b	140,4	236,9	18,8	5,4	5,2	5,2	5,1	5,1	5,1	5,0
HCFC-142b	887,9	1.521,2	401,4	336,3	281,8	272,3	263,5	255,0	246,8	238,8
Halons	**-441,1**	**-441,1**	**-238,8**	**-156,4**	**-94,8**	**-73,1**	**-71,5**	**-73,2**	**-67,2**	**-65,7**
Halon 1211	-28,5	-28,5	-12,3	-4,1	-2,9	-2,6	-2,5	-2,5	-2,4	-2,3
Halon 1301	-412,7	-412,7	-226,5	-152,3	-91,9	-70,6	-69,0	-70,8	-64,8	-63,3
Other ODS	**-333,0**	**-160,4**	**-71,8**	**-13,5**	**-5,0**	**-2,7**	**-3,6**	**-4,6**	**-5,7**	**-6,8**
CCl4	-11,1	-0,3	-0,3	-0,3	0,0	0,0	0,0	0,0	0,0	0,0
CH3Br	-321,9	-160,1	-71,5	-13,2	-5,0	-2,7	-3,6	-4,6	-5,7	-6,8
CRF	**5.547,1**	**1.741,9**	**2.830,4**	**3.407,2**	**4.312,7**	**4.553,4**	**4.689,4**	**4.774,8**	**4.217,7**	**3.585,5**
HFC	**492,9**	**1.151,4**	**2.565,6**	**3.196,2**	**4.075,5**	**4.052,4**	**4.408,1**	**4.548,0**	**4.000,9**	**3.314,5**
HFC-23	0,0	0,0	674,4	519,7	991,6	939,0	1.271,2	1.507,8	1.144,5	725,5
HFC-32	0,1	3,3	8,4	24,4	43,2	48,9	55,5	63,9	72,1	77,5
HFC-41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
HFC-125	5,4	188,8	479,4	717,5	975,3	982,9	1.035,7	1.071,8	1.028,4	941,4
HFC-134	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
HFC-134a	479,4	692,0	785,4	1.066,1	1.115,8	1.175,2	1.161,1	1.042,3	979,6	897,8
HFC-143a	7,3	248,5	555,1	771,8	875,7	837,8	804,9	809,6	706,7	620,5
HFC-152a	0,1	13,9	25,5	45,9	17,5	18,1	12,4	16,7	12,6	9,7
HFC-227ea	0,6	4,9	22,8	34,5	49,0	42,2	55,8	28,2	52,5	33,4
HFC-236fa	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3
HFC-245fa	0,0	0,1	10,9	0,6	0,8	0,7	0,5	0,5	0,5	0,2
HFC-365mfc	0,0	0,0	3,9	15,8	6,6	7,5	10,9	7,2	4,1	8,1
PFC	**2.914,3**	**446,1**	**173,8**	**104,8**	**143,7**	**402,7**	**179,2**	**131,3**	**128,3**	**171,9**
CF4	511,7	7,4	9,2	15,8	48,6	166,0	103,1	94,6	94,3	65,7
C4F10	875,9		11,6	1,7	4,2	5,5	6,2	5,8	4,7	14,6
c-C4F8	294,5	0,2	2,8	7,8		0,0	0,0	0,0	0,0	17,0
C5F12	370,6	17,7	34,3	23,4	68,0	201,3	64,0	25,2	22,6	64,4
C6F14	555,5	242,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1
C3F8	306,1	178,1	115,9	55,8	22,8	29,7	5,7	5,6	6,3	9,7
C2F6	0,0	0,0	0,0	0,3	0,1	0,2	0,1	0,1	0,4	0,4
SF6	**2.140,0**	**144,4**	**91,0**	**105,0**	**92,6**	**97,5**	**101,5**	**94,9**	**88,1**	**90,5**
NF3	0,0	0,0	0,0	1,3	**0,8**	**0,7**	**0,6**	**0,6**	**0,5**	**8,5**
Other	**3.012,0**	**635,9**	**391,4**	**529,2**	**558,2**	**509,7**	**515,3**	**642,6**	**487,7**	**475,5**
PFC	**763,5**	**395,0**	**0,1**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
C7F16	183,8	72,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0
C8F18	579,6	322,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
HFO	0,0	0,0	0,0	0,0	**0,2**	**0,1**	**0,2**	**0,4**	**0,5**	**0,6**
HFO-1234ze(E)	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,3	0,4
HFO-1234yf	0,0	0,0	0,0	0,0	0,2	0,0	0,1	0,1	0,1	0,1
Other	**2.248,5**	**241,0**	**391,3**	**529,1**	**558,0**	**509,6**	**515,1**	**642,2**	**487,2**	**474,9**
C8F16O	667,1	241,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CF3SF5	1.581,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
PFPMIE	0,0	0,0	0,0	6,3	9,8	5,1	3,2	3,4	2,8	2,2
Unspecified mix	0,0	0,0	391,3	522,9	548,2	504,5	511,9	638,8	484,4	472,8
General total	**18.392,4**	**8.827,7**	**6.037,2**	**5.657,0**	**5.928,1**	**6.014,4**	**6.047,1**	**6.159,5**	**5.416,0**	**4.737,1**

Table A1-3. Evolution of total emissions per source in Belgium (t)

	1995	2000	2005	2010	2015	2018	2019	2020
01. Dom. refrig. - Coolant	47,34	46,21	40,18	8,74	10,51	8,24	7,06	6,49
02. Dom. refrig. - Foam	286,08	282,10	210,76	0,42	0,38	0,34	0,34	0,00
03. Stationary airco	285,98	383,48	341,54	344,74	285,39	233,85	238,72	249,69
04. Car airco	28,58	67,10	144,82	242,47	271,48	298,48	294,87	277,00
05. Bus&Coach airco	8,06	7,82	8,81	11,17	12,78	13,74	14,10	15,37
06. Trucks airco		4,72	15,58	31,77	44,35	54,64	59,49	62,46
07. Refrigerated transport	0,44	3,37	8,37	13,12	11,44	6,70	6,57	7,07
08. Passenger rail transport		2,46	2,57	3,13	2,06	2,60	2,50	2,42
10. Ind.&comm. refrig.	1.163,22	1.003,04	941,22	951,30	751,87	694,03	638,69	578,81
11. Closed cell foam	1.876,23	1.806,06	603,40	704,39	454,62	407,49	357,76	337,64
12. PU cans	249,95	204,15	34,08	25,36	20,99	28,52	28,38	26,06
13. Aerosols MDI	69,39	66,48	32,35	32,41	33,66	32,50	32,66	32,84
14. Other aerosols	29,29	58,54	36,74	32,85	30,85	2,99	2,27	3,08
15. CCl4	29,18	0,68	0,68	0,68				
16. Methylbr.	257,93	128,32	57,30	10,60	3,97	3,66	4,59	5,43
17. SF6 electr. Sector	0,35	0,42	0,49	0,69	0,46	0,57	0,38	0,48
18. SF6 in glass sector	3,50	3,85	3,06	3,78	3,46	3,27	3,21	3,15
19. Fire Extinguishers	12,63	13,96	10,47	8,53	6,63	5,71	5,57	5,00
20. Chemical Ind	655,91	124,00	126,18	124,05	178,35	236,86	222,22	146,17
21. Semiconductors			1,53	1,85	2,16	2,06	1,84	1,77
22. Nike shoes	2,06	2,06	0,35					
23. Solvents	50,00	225,00	15,00					
Total	**5.056,12**	**4.433,83**	**2.635,51**	**2.552,07**	**2.125,41**	**2.036,24**	**1.921,21**	**1.760,93**

Table A1-4. Evolution of total emissions per source in Belgium (kt CO_2-eq)

	1995	2000	2005	2010	2015	2018	2019	2020
01. Dom. refrig. - Coolant	383,2	367,0	265,6	18,7	23,6	19,4	16,5	15,6
02. Dom. refrig. - Foam	577,9	569,8	425,6	0,4	0,4	0,4	0,4	0,0
03. Stationary airco	475,1	633,7	568,3	578,4	492,6	423,0	437,4	460,9
04. Car airco	133,7	96,0	207,1	346,7	386,1	358,6	326,2	275,2
05. Bus&Coach airco	53,5	11,2	12,6	16,0	18,3	19,7	20,3	22,2
06. Trucks airco	0,0	6,8	22,3	45,4	63,4	69,4	71,3	70,0
07. Refrigerated transport	1,5	10,6	26,6	41,3	36,8	21,5	20,8	22,4
08. Passenger rail transport	0,0	3,7	3,8	4,6	3,0	4,0	3,7	3,6
10. Ind.&comm. refrig.	5.048,3	2.336,8	2.042,2	2.265,3	2.072,9	1.934,9	1.734,9	1.548,8
11. Closed cell foam	3.607,9	3.357,5	1.188,7	1.082,6	910,5	830,3	799,4	782,8
12. PU cans	356,8	239,0	48,0	3,8	5,0	3,7	2,0	1,5
13. Aerosols MDI	394,4	378,7	67,9	46,6	49,0	47,4	47,6	47,9
14. Other aerosols	41,5	70,3	50,3	34,6	41,5	2,7	2,2	2,3
15. CCl4	-11,1	-0,3	-0,3	-0,3	0,0	0,0	0,0	0,0
16. Methylbr.	-321,9	-160,1	-71,5	-13,2	-5,0	-4,6	-5,7	-6,8
17. SF6 electr. Sector	8,0	9,6	11,2	15,8	10,6	12,9	8,6	11,0
18. SF6 in glass sector	79,8	87,8	69,9	86,2	78,9	74,5	73,1	71,7
19. Fire Extinguishers	-440,5	-436,3	-226,3	-142,4	-81,6	-61,2	-55,1	-55,3
20. Chemical Ind	7.931,6	1.081,8	1.291,6	1.207,0	1.798,9	2.378,7	1.891,1	1.441,1
21. Semiconductors	0,0	0,0	17,8	19,4	23,4	24,1	21,4	22,3
22. Nike shoes	46,9	47,0	8,0	0,0	0,0	0,0	0,0	0,0
23. Solvents	26,1	117,2	7,8	0,0	0,0	0,0	0,0	0,0
Total	**18.392,4**	**8.827,7**	**6.037,2**	**5.657,0**	**5.928,1**	**6.159,5**	**5.416,0**	**4.737,1**

Table A1-5. 2020 emissions by gas and aggregate source category (in kt CO_2-eq) for Belgium

	Refrigeration & air conditioning	Foams	Fire pro-tection	Aerosols	Solvents	Chemical industry	Electro-nics industry	Other	General total
ODS	**9,2**	**739,3**	**-65,7**					**-6,8**	**676,1**
CFC	**0,1**	**495,6**							**495,6**
CFC-11	0,0	100,5							100,5
CFC-12	0,1	395,1							395,1
HCFC	**9,2**	**243,7**							**252,9**
HCFC-22	8,9								8,9
HCFC-124	0,1								0,1
HCFC-141b		5,0							5,0
HCFC-142b	0,2	238,7							238,8
Halons			**-65,7**						**-65,7**
Halon 1211			-2,3						-2,3
Halon 1301			-63,3						-63,3
Other ODS								**-6,8**	**-6,8**
CH3Br								-6,8	-6,8
CRF	**2.408,9**	**44,8**	**10,4**	**50,2**		**968,3**	**20,1**	**82,7**	**3.585,5**
HFC	**2.408,9**	**44,8**	**10,4**	**50,2**		**795,7**	**4,5**		**3.314,5**
HFC-23						721,2	4,3		725,5
HFC-32	77,5					0,0	0,0		77,5
HFC-41							0,0		0,0
HFC-125	883,8		0,7			56,8	0,2		941,4
HFC-134						0,0			0,0
HFC-134a	827,2	22,2		48,3		0,1			897,8
HFC-143a	620,5					0,1			620,5
HFC-152a	0,0	9,5		0,2		0,0			9,7
HFC-227ea		4,8	9,7	1,7		17,2			33,4
HFC-236fa						0,3			0,3
HFC-245fa		0,2							0,2
HFC-365mfc		8,1							8,1
PFC	**0,0**					**162,3**	**9,5**		**171,9**
CF4						63,2	2,5		65,7
C2F6						7,9	6,6		14,6
C3F8	0,0					17,0			17,0
C4F10						64,4			64,4
C5F12						0,1			0,1
C6F14						9,7			9,7
c-C4F8							0,4		0,4
SF6						**2,7**	**5,1**	**82,7**	**90,5**
NF3						**7,6**	**0,9**		**8,5**
Other	**0,4**	**0,1**				**472,8**	**2,2**		**475,5**
PFC						**0,0**			**0,0**
C7F16						0,0			0,0
HFO	**0,4**	**0,1**							**0,6**
HFO-1234yf	0,4								0,4
HFO-1234ze(E)	0,0	0,1							0,1
Other						**472,8**	**2,2**		**474,9**
PFPMIE							2,2		2,2
Unspecified mix						472,8			472,8
General total	**2.418,6**	**784,2**	**-55,3**	**50,2**		**1.441,1**	**22,3**	**76,0**	**4.737,1**

Table A1-6. 2020 emissions by gas and aggregate source category (in kt CO_2-eq) for Flanders

	Refrigeration & air conditioning	**Foams**	**Fire pro-tection**	**Aerosols**	**Solvents**	**Chemical industry**	**Electro-nics industry**	**Other**	**General total**
ODS	**5,3**	**426,4**	**-37,9**					**-6,8**	**387,1**
CFC	**0,0**	**285,9**							**285,9**
CFC-11	0,0	58,0							58,0
CFC-12	0,0	227,9							227,9
HCFC	**5,3**	**140,6**							**145,9**
HCFC-22	5,2								5,2
HCFC-124	0,0								0,0
HCFC-141b		2,9							2,9
HCFC-142b	0,1	137,7							137,8
Halons			**-37,9**						**-37,9**
Halon 1211			-1,3						-1,3
Halon 1301			-36,5						-36,5
Other ODS								**-6,8**	**-6,8**
CH3Br								-6,8	-6,8
CRF	**1.398,4**	**33,5**	**6,0**	**29,0**		**968,3**	**20,1**	**48,3**	**2.503,7**
HFC	**1.398,4**	**33,5**	**6,0**	**29,0**		**795,7**	**4,5**		**2.267,1**
HFC-23						721,2	4,3		725,5
HFC-32	44,8					0,0	0,0		44,8
HFC-41							0,0		0,0
HFC-125	511,9		0,4			56,8	0,2		569,2
HFC-134						0,0			0,0
HFC-134a	481,5	12,8		27,9		0,1			522,3
HFC-143a	360,2					0,1			360,2
HFC-152a	0,0	9,4		0,2		0,0			9,6
HFC-227ea		4,2	5,6	1,0		17,2			28,0
HFC-236fa						0,3			0,3
HFC-245fa		0,1							0,1
HFC-365mfc		7,0							7,0
PFC	**0,0**					**162,3**	**9,5**		**171,9**
CF4						63,2	2,5		65,7
C2F6						7,9	6,6		14,6
C3F8	0,0					17,0			17,0
C4F10						64,4			64,4
C5F12						0,1			0,1
C6F14						9,7			9,7
c-C4F8							0,4		0,4
SF6						**2,7**	**5,1**	**48,3**	**56,1**
NF3						**7,6**	**0,9**		**8,5**
Other	**0,3**	**0,1**				**472,8**	**2,2**		**475,3**
PFC						**0,0**			**0,0**
C7F16						0,0			0,0
HFO	**0,3**	**0,1**							**0,3**
HFO-1234yf	0,3								0,3
HFO-1234ze(E)	0,0	0,1							0,1
Other						**472,8**	**2,2**		**474,9**
PFPMIE							2,2		2,2
Unspecified mix						472,8			472,8
General total	**1.404,0**	**460,0**	**-31,9**	**29,0**		**1.441,1**	**22,3**	**41,5**	**3.366,1**

Table A1-7. 2020 emissions by gas and aggregate source category (in kt CO_2-eq) for Wallonia

	Refrigeration & air conditioning	Foams	Fire pro-tection	Aerosols	Solvents	Chemical industry	Electro-nics industry	Other	General total
ODS	**2,9**	**234,5**	**-20,8**						**216,6**
CFC	**0,0**	**157,2**							**157,2**
CFC-11	0,0	31,9							31,9
CFC-12	0,0	125,3							125,3
HCFC	**2,9**	**77,3**							**80,2**
HCFC-22	2,8								2,8
HCFC-124	0,0								0,0
HCFC-141b		1,6							1,6
HCFC-142b	0,0	75,7							75,8
Halons			**-20,8**						**-20,8**
Halon 1211			-0,7						-0,7
Halon 1301			-20,1						-20,1
CRF	**757,2**	**8,5**	**3,3**	**15,9**				**25,9**	**810,8**
HFC	**757,2**	**8,5**	**3,3**	**15,9**					**784,9**
HFC-32	24,5								24,5
HFC-125	278,7		0,2						279,0
HFC-134a	259,0	7,0		15,3					281,3
HFC-143a	195,0								195,0
HFC-152a	0,0	0,1							0,1
HFC-227ea		0,5	3,1	0,5					4,1
HFC-245fa		0,1							0,1
HFC-365mfc		0,8							0,8
PFC	**0,0**								**0,0**
C3F8	0,0								0,0
SF6								**25,9**	**25,9**
Other	**0,1**	**0,1**							**0,2**
HFO	**0,1**	**0,1**							**0,2**
HFO-1234yf	0,1								0,1
HFO-1234ze(E)	0,0	0,1							0,1
General total	**760,3**	**243,0**	**-17,5**	**15,9**				**25,9**	**1.027,6**

Table A1-8. 2020 emissions by gas and aggregate source category (in kt CO_2-eq) for Brussels

	Refrigeration & air conditioning	**Foams**	**Fire pro-tection**	**Aerosols**	**Solvents**	**Chemical industry**	**Electro-nics industry**	**Other**	**General total**
ODS	**1,0**	**78,4**	**-7,0**						**72,4**
CFC	**0,0**	**52,5**							**52,5**
CFC-11	0,0	10,7							10,7
CFC-12	0,0	41,9							41,9
HCFC	**1,0**	**25,8**							**26,8**
HCFC-22	0,9								0,9
HCFC-124	0,0								0,0
HCFC-141b		0,5							0,5
HCFC-142b	0,0	25,3							25,3
Halons			**-7,0**						**-7,0**
Halon 1211			-0,2						-0,2
Halon 1301			-6,7						-6,7
CRF	**253,3**	**2,8**	**1,1**	**5,3**				**8,5**	**271,0**
HFC	**253,3**	**2,8**	**1,1**	**5,3**					**262,5**
HFC-32	8,2								8,2
HFC-125	93,2		0,1						93,2
HFC-134a	86,7	2,3		5,1					94,2
HFC-143a	65,3								65,3
HFC-152a	0,0	0,0							0,0
HFC-227ea		0,2	1,0	0,2					1,4
HFC-245fa		0,0							0,0
HFC-365mfc		0,3							0,3
PFC	**0,0**								**0,0**
C3F8	0,0								0,0
SF6								**8,5**	**8,5**
Other	**0,0**	**0,0**							**0,1**
HFO	**0,0**	**0,0**							**0,1**
HFO-1234yf	0,0								0,0
HFO-1234ze(E)	0,0	0,0							0,0
General total	**254,3**	**81,2**	**-5,9**	**5,3**				**8,5**	**343,5**

ANNEX 2 GWP AND ODP

Substance	Group of substances	ODS/CRF	GWP 100 years (CO_2 = 1)	Source GWP values	ODP (CFC-11 = 1)
HFC-125	HFC	CRF	3500	AR4	0
HFC-134	HFC	CRF	1100	AR4	0
HFC-134a	HFC	CRF	1430	AR4	0
HFC-143	HFC	CRF	353	AR4	0
HFC-143a	HFC	CRF	4470	AR4	0
HFC-152	HFC	CRF	53	AR4	0
HFC-152a	HFC	CRF	124	AR4	0
HFC-161	HFC	CRF	12	AR4	0
HFC-227ea	HFC	CRF	3220	AR4	0
HFC-23	HFC	CRF	14800	AR4	0
HFC-236cb	HFC	CRF	1340	AR4	0
HFC-236ea	HFC	CRF	1370	AR4	0
HFC-236fa	HFC	CRF	9810	AR4	0
HFC-245fa	HFC	CRF	1030	AR4	0
HFC-32	HFC	CRF	675	AR4	0
HFC-365mfc	HFC	CRF	794	AR4	0
HFC-41	HFC	CRF	92	AR4	0
HFC-43-10mee	HFC	CRF	1640	AR4	0
HFC-245ca	HFC	CRF	716	AR4	0
NF3	NF3	CRF	17200	AR4	0
C10F18	PFC	CRF	7500	AR4	0
C2F6	PFC	CRF	12200	AR4	0
C3F8	PFC	CRF	8830	AR4	0
c-C3F6	PFC	CRF	17340	AR4	0
c-C4F8	PFC	CRF	10300	AR4	0
CF4	PFC	CRF	7390	AR4	0
C5F12	PFC	CRF	9160	AR4	0
C6F14	PFC	CRF	9300	AR4	0
C4F10	PFC	CRF	8860	AR4	0
SF6	SF6	CRF	22800	AR4	0
CFC-11	CFC	ODS	2020	AR5	1
CFC-113	CFC	ODS	6130	AR5	0,8
CFC-114	CFC	ODS	7676	AR5	1
CFC-115	CFC	ODS	7447	AR5	0,6
CFC-12	CFC	ODS	8100	AR5	1
CFC-13	CFC	ODS	14000	AR5	1
Halon 1211	Halons	ODS	-17250	AR5	3
Halon 1301	Halons	ODS	-38210	AR5	10
HCFC-123	HCFC	ODS	77	AR5	0,02
HCFC-124	HCFC	ODS	481	AR5	0,022
HCFC-141b	HCFC	ODS	521	AR5	0,11
HCFC-142b	HCFC	ODS	1828	AR5	0,065
HCFC-22	HCFC	ODS	1662	AR5	0,055

Substance	Group of substances	ODS/CRF	GWP 100 years (CO_2 = 1)	Source GWP values	ODP (CFC-11 = 1)
CCL4	Other ODS	ODS	-380	AR5	1,1
MB	Other ODS	ODS	-1248	AR5	0,6
HCFO-1233zd	HCFO	Other	7	AR5	0
HFO-1234mzz	HFO	Other	7	AR5	0
HFO-1234yf	HFO	Other	4	AR5	0
HFO-1234ze	HFO	Other	6	AR5	0
(C2F5)OF	Other	Other	10000	3M	0
ANDERE_OFCS	Other	Other	8985	3M	0
C3F7NF2	Other	Other	10000	3M	0
C7F17N	Other	Other	10000	3M	0
C8F16O	Other	Other	9400	3M	0
C8F19N	Other	Other	10000	3M	0
CF3CF2CH3	Other	Other	4620	3M	0
CF3CF2CHF2	Other	Other	2640	3M	0
CF3CH2CF3	Other	Other	8060	3M	0
CF3CHFOCF3	Other	Other	3350	3M	0
CF3COF	Other	Other	2000	3M	0
CF3SF5	Other	Other	17400	AR5	0
CH2=CF2	Other	Other	1	3M	0
CHF2CF2CF2CF3	Other	Other	2360	3M	0
COF2	Other	Other	2	3M	0
HFP	Other	Other	0,05	3M	0
HFP_dimeer	Other	Other	1	3M	0
HFP_trimeer	Other	Other	1	3M	0
LBA	Other	Other	8985	3M	0
OPEN_RINGEN	Other	Other	10357	3M	0
PBSF	Other	Other	2000	3M	0
PEM	Other	Other	10000	3M	0
PFPMIE	Other	Other	9710	AR5	0
PFS	Other	Other	2000	3M	0
PIPM	Other	Other	10960	3M	0
PMM	Other	Other	9509	3M	0
PNPM	Other	Other	10960	3M	0
PTBA	Other	Other	9073	3M	0
PTPA	Other	Other	8896	3M	0
SF5CF3	Other	Other	17400	3M	0
SO2F2	Other	Other	4090	3M	0
C7F16	PFC	Other	7700	3M	0
C8F18	PFC	Other	8000	3M	0

Note : For ozone depleting substances, the GWP values used are, as far as the relevant data are available, net GWPs, taking into account the indirect greenhouse effect of these substances, evaluated as the average of two extreme values.
AR4: Fourth Assessment Report of the IPCC (IPCC, 2007)
AR5: Fifth Assessment Report of the IPCC (IPCC, 2013)

ANNEX 3 REFRIGERANT MIX COMPOSITION

ASHRAE Number	GWP AR4	R22 HCFC	R124 HCFC	R142b HCFC	R32 HFC	R23 HFC	R125 HFC	R134a HFC	R143a HFC	R152a HFC	R227ea HFC	R116 PFC	R218 PFC	R1234yf HFO	R1234ze HFO	R290 Propane	R600 Butane	R600a Isobutane	R601 Pentane	R601a Isopentane	R744 CO2
R401A	1061	53,0%	34,0%							13,0%											
R402A	2732	38,0%					60,0%									2,0%					
R403B	4374	56,0%											39,0%			5,0%					
R404A	3922						44,0%	4,0%	52,0%												
R407A	2107				20,0%		40,0%	40,0%													
R407C	1774				23,0%		25,0%	52,0%													
R407F	1825				30,0%		30,0%	40,0%													
R407H	1495				32,5%		15,0%	52,5%													
R408A	3082	47,0%					7,0%		46,0%												
R409A	1392	60,0%	25,0%	15,0%																	
R410A	2088				50,0%		50,0%														
R413A	2053							88,0%					9,0%					3,0%			
R417A	2346						46,6%	50,0%										3,4%			
R421B	3190						85,0%	15,0%													
R422A	3143						85,1%	11,5%										3,4%			
R422D	2729						65,1%	31,5%										3,4%			
R423A	2280							52,5%			47,5%										
R424A	2440						50,5%	47,0%									1,0%	0,9%		0,6%	
R426A	1508						5,1%	93,0%									1,3%			0,6%	
R427A	2138				15,0%		25,0%	50,0%	10,0%												
R428A	3607						77,5%		20,0%							0,6%	1,9%				
R434A	3245						63,2%	16,0%	18,0%									2,8%			
R437A	1805						19,5%	78,5%										1,4%	0,6%		
R438A	2264				8,5%		45,0%	44,2%									1,7%			0,6%	
R442A	1888				31,0%		31,0%	30,0%		3,0%	5,0%										
R448A	1387				26,0%		26,0%	21,0%						20,0%	7,0%						
R449A	1397				24,3%		24,7%	25,7%						25,3%							
R450A	604							42,0%							58,0%						
R452A	2140				11,0%		59,0%							30,0%							
R452B	698				67,0%		7,0%							26,0%							
R454A	239				35,0%									65,0%							
R454B	466				68,9%									31,1%							
R454C	148				21,5%									78,5%							
R455A	148				21,5%									75,5%							3,0%
R507A	3985						50,0%		50,0%												
R508A	13214					39,0%						61,0%									
R508B	13396					46,0%						54,0%									
R513A	631							44,0%						56,0%							
R513B	596							41,5%						58,5%							
R515A	390										12,0%			88,0%							

ANNEX 4 INTERNATIONAL TRADE IN F-GASES

Official statistics on external trade used to only be available for a limited number of substances. And they are not necessarily complete (for the EU internal trade, they cover only companies with at least 250.000 EUR in external trade), nor entirely reliable. From 2016, however, they at last provide figures for a number of HFC gases, individually or for mixtures; in parallel the detail by substance for CFCs has been dropped.

From 2016, import and export figures are available for the following 12 product categories:

- HFC 32,
- HFC 23,
- HFC 125 & HFC 143a,
- HFC 152a,
- HFC 134a,
- PFCs,
- HFO 1234yf,
- HFO 123ze,
- HFC 507A,
- HFC 404A,
- HFC 410A,
- HFC 407C, HFC 407A and HFC 407F.

The figures are given in . Note that the figures for 2018 and 2019 have been revised, as it is each year the case with the data of the previous years.

One should be careful in interpreting the figures of such a table. Indeed, this table shows for example in the past imports of methylbromide that are much larger than the exports, leading to large apparent domestic consumption. The explanation is that Belgium is re-exporting most of the methylbromide as a packaged product which in the trade statistics appears not under methylbromide (custom No. 29033033), but under custom No. 38081090 (other insecticides).

One can notice that the apparent net consumption is sometimes small compared to the amounts of import and export, implying a relatively large uncertainty on this net consumption. This is the case of R134a, for which 66% of the import in 2020 is reexported.

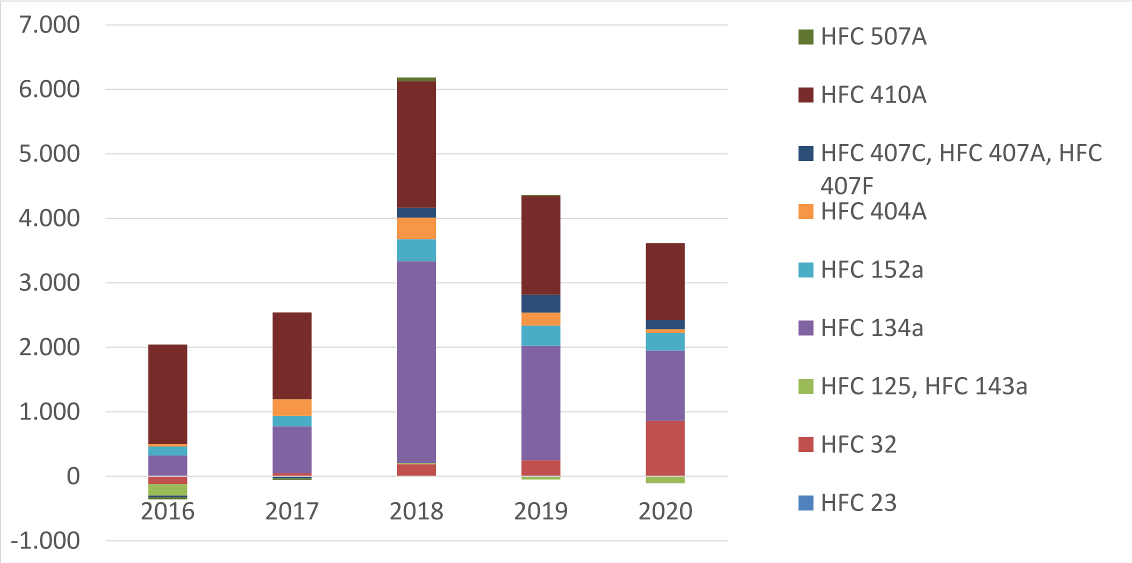
Table A4-1. External trade in substances considered

	Import							Export							Net Import						
(tonnes)	2010	2015	2016	2017	2018	2019	2020	2010	2015	2016	2017	2018	2019	2020	2010	2015	2016	2017	2018	2019	2020
CFC	**14,3**	**3,9**	**4,1**	**0,0**	**0,0**	**0,0**	**0,0**	**0,2**	**0,4**	**0,7**	**0,2**	**0,0**	**0,0**	**0,0**	**14,1**	**3,5**	**3,4**	**-0,2**	**0,0**	**0,0**	**0,0**
(CFC112)	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CFC 13	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CFC 11	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CFC 11 to 115	0,0	0,0	4,1	0,0	0,0	0,0	0,0	0,0	0,0	0,7	0,2	0,0	0,0	0,0	0,0	0,0	3,4	-0,2	0,0	0,0	0,0
CFC 111	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CFC 113	13,2	3,9	0,0	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,0	13,2	3,5	0,0	0,0	0,0	0,0	0,0
CFC 114	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CFC 115	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CFC 12	1,1	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,9	0,0	0,0	0,0	0,0	0,0	0,0
HCFC	**4.701,9**	**1.831,7**	**2.014,6**	**1.077,4**	**508,3**	**538,7**	**78,1**	**4.763,1**	**1.956,2**	**1.770,5**	**1.128,7**	**1.031,2**	**541,6**	**302,4**	**-61,2**	**-124,5**	**244,1**	**-51,3**	**-522,9**	**-2,9**	**-224,3**
HCFC 123	0,0	0,0	0,0	0,0	37,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	37,2	0,0	0,0
HCFC 141	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	20,6	0,0	7,3	0,1	0,0	0,0	0,0	-20,6	0,0	-7,3	-0,1	0,0	0,0
HCFC 142	0,0	0,0	324,2	100,0	68,0	0,0	0,0	0,0	0,0	5,0	2,2	0,0	0,0	0,0	0,0	0,0	319,2	97,8	68,0	0,0	0,0
HCFC 22	4.701,9	1.831,7	1.690,4	977,4	403,1	538,7	78,1	4.763,1	1.935,6	1.765,5	1.119,2	1.031,1	541,6	302,4	-61,2	-103,9	-75,1	-141,8	-628,0	-2,9	-224,3
HCFC 225	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Halon	**0,2**	**21,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,1**	**22,6**	**42,3**	**2,0**	**0,0**	**6,8**	**0,0**	**0,0**	**-22,4**	**-21,3**	**-2,0**	**0,0**	**-6,8**	**0,0**	**0,1**
halon 1211	0,2	21,0	0,0	0,0	0,0	0,0	0,0	16,1	38,0	2,0	0,0	0,0	0,0	0,0	-15,9	-17,0	-2,0	0,0	0,0	0,0	0,0
halon 1301	0,0	0,0	0,0	0,0	0,0	0,0	0,0	6,5	4,3	0,0	0,0	6,8	0,0	0,0	-6,5	-4,3	0,0	0,0	-6,8	0,0	0,0
halon 2402	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1
CCl4	**2,8**	**0,0**	**0,1**	**0,0**	**0,0**	**0,0**	**0,0**	**0,1**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**2,7**	**0,0**	**0,1**	**0,0**	**0,0**	**0,0**	**0,0**
CCl4	2,8	0,0	0,1	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	2,7	0,0	0,1	0,0	0,0	0,0	0,0
TRE	**190,7**	**235,7**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**121,0**	**151,9**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**69,7**	**83,8**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**
1,1,1,-trichloroethane	190,7	235,7	0,0	0,0	0,0	0,0	0,0	121,0	151,9	0,0	0,0	0,0	0,0	0,0	69,7	83,8	0,0	0,0	0,0	0,0	0,0
Mebrom	**3.999,0**	**243,4**	**253,1**	**191,6**	**374,1**	**140,6**	**250,9**	**1.719,0**	**159,6**	**370,8**	**205,1**	**267,2**	**72,1**	**161,2**	**2.280,0**	**83,8**	**-117,7**	**-13,5**	**106,9**	**68,5**	**89,7**
methylbromide	3.999,0	243,4	253,1	191,6	374,1	140,6	250,9	1.719,0	159,6	370,8	205,1	267,2	72,1	161,2	2.280,0	83,8	-117,7	-13,5	106,9	68,5	89,7
HFC	**0,0**	**0,0**	**7.462,5**	**5.962,9**	**8.612,1**	**6.877,9**	**7.298,1**	**0,0**	**0,0**	**5.776,7**	**3.475,4**	**2.428,4**	**2.564,8**	**3.789,1**	**0,0**	**0,0**	**1.685,8**	**2.487,5**	**6.183,7**	**4.313,1**	**3.509,0**
HFC 23	0,0	0,0	9,2	4,7	3,3	5,0	1,3	0,0	0,0	3,0	2,3	0,4	13,3	1,1	0,0	0,0	6,2	2,4	2,9	-8,3	0,2
HFC 32	0,0	0,0	2,4	67,9	240,3	294,1	1.374,9	0,0	0,0	126,5	19,0	54,4	45,2	514,7	0,0	0,0	-124,1	48,9	185,9	248,9	860,2
HFC 125, HFC 143a	0,0	0,0	0,0	0,0	21,4	11,8	8,4	0,0	0,0	174,7	1,3	6,3	54,9	111,5	0,0	0,0	-174,7	-1,3	15,1	-43,1	-103,1
HFC 134a	0,0	0,0	1.645,6	1.937,1	4.360,1	3.232,2	3.178,7	0,0	0,0	1.330,1	1.214,2	1.228,8	1.456,5	2.090,9	0,0	0,0	315,5	722,9	3.131,3	1.775,7	1.087,8
HFC 152a	0,0	0,0	151,3	189,2	343,4	314,0	275,4	0,0	0,0	11,0	25,7	1,7	0,8	0,6	0,0	0,0	140,3	163,5	341,7	313,2	274,8
HFC 404A	0,0	0,0	1.357,7	974,5	467,5	344,8	261,0	0,0	0,0	1.317,6	716,0	133,2	144,9	202,8	0,0	0,0	40,1	258,5	334,3	199,9	58,2
HFC 407C, HFC 407A, HFC 407F	0,0	0,0	555,0	372,1	525,1	541,5	417,4	0,0	0,0	583,4	402,7	371,7	263,6	274,8	0,0	0,0	-28,4	-30,6	153,4	277,9	142,6
HFC 410A	0,0	0,0	3.393,8	2.334,0	2.549,0	2.075,1	1.769,8	0,0	0,0	1.851,9	988,0	584,9	544,2	578,5	0,0	0,0	1.541,9	1.346,0	1.964,1	1.530,9	1.191,3
HFC 507A	0,0	0,0	347,5	83,4	102,0	59,4	11,2	0,0	0,0	378,5	106,2	47,0	41,4	14,2	0,0	0,0	-31,0	-22,8	55,0	18,0	-3,0
PFC	**0,0**	**0,0**	**187,8**	**246,7**	**115,3**	**93,5**	**341,3**	**0,0**	**0,0**	**39,6**	**33,4**	**15,9**	**8,8**	**16,9**	**0,0**	**0,0**	**148,2**	**213,3**	**99,4**	**84,7**	**324,4**
PFCs	0,0	0,0	187,8	246,7	115,3	93,5	341,3	0,0	0,0	39,6	33,4	15,9	8,8	16,9	0,0	0,0	148,2	213,3	99,4	84,7	324,4
HFO	**0,0**	**0,0**	**161,7**	**103,8**	**425,7**	**424,3**	**251,8**	**0,0**	**0,0**	**170,4**	**55,8**	**234,3**	**267,6**	**146,1**	**0,0**	**0,0**	**-8,7**	**48,0**	**191,4**	**156,7**	**105,7**
HFO 1234yf	0,0	0,0	90,7	23,5	82,2	101,7	47,7	0,0	0,0	126,8	8,9	12,3	41,9	13,4	0,0	0,0	-36,1	14,6	69,9	59,8	34,3
HFO 1234ze	0,0	0,0	71,0	80,3	343,5	322,6	204,1	0,0	0,0	43,6	46,9	222,0	225,7	132,7	0,0	0,0	27,4	33,4	121,5	96,9	71,4
Mixture	**0,0**	**4.948,9**	**117,7**	**75,5**	**42,0**	**45,5**	**23,3**	**0,0**	**4.280,0**	**53,0**	**36,5**	**15,5**	**4,2**	**5,5**	**0,0**	**668,9**	**64,7**	**39,0**	**26,5**	**41,3**	**17,8**
mixtures with CFC	0,0	104,6	47,2	27,8	35,4	44,7	22,8	0,0	4,1	0,6	0,6	0,1	0,1	0,1	0,0	100,5	46,6	27,2	35,3	44,6	22,7
mixtures with HCFC	0,0	0,0	70,5	47,7	6,6	0,8	0,5	0,0	46,0	52,4	35,9	15,4	4,1	5,4	0,0	-46,0	18,1	11,8	-8,8	-3,3	-4,9
mixtures with PFC/HFC	0,0	4.844,3	0,0	0,0	0,0	0,0	0,0	0,0	4.229,9	0,0	0,0	0,0	0,0	0,0	0,0	614,4	0,0	0,0	0,0	0,0	0,0
Total	**8.908,9**	**7.284,6**	**10.201,6**	**7.657,9**	**10.077,5**	**8.120,5**	**8.243,6**	**6.626,0**	**6.590,4**	**8.183,7**	**4.935,1**	**3.999,3**	**3.459,1**	**4.421,2**	**2.282,9**	**694,2**	**2.017,9**	**2.722,8**	**6.078,2**	**4.661,4**	**3.822,4**

Source : Eurostat

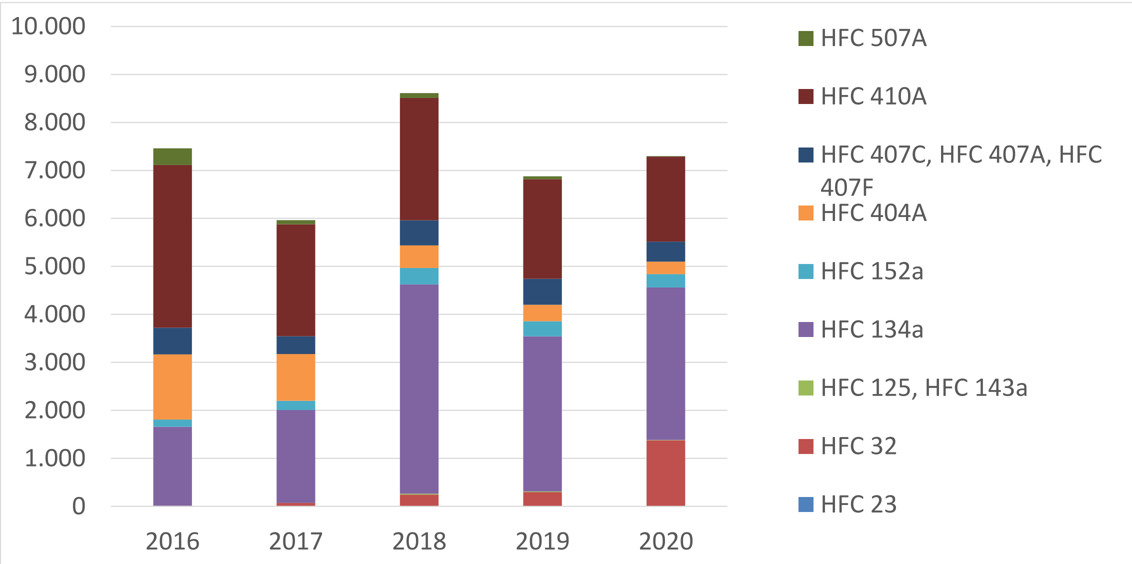
Net imports of HFCs sank by 19% in 2020 (Figure A4-1). HFC-134a accounts for 85% of this decrease, caused mainly by a reduction in imports. This is mainly explained by a rise of exports and a larger import of HFC 32 (Figure A4-3, Figure A4-2).

Figure A4-1. Net import of HFCs (t)



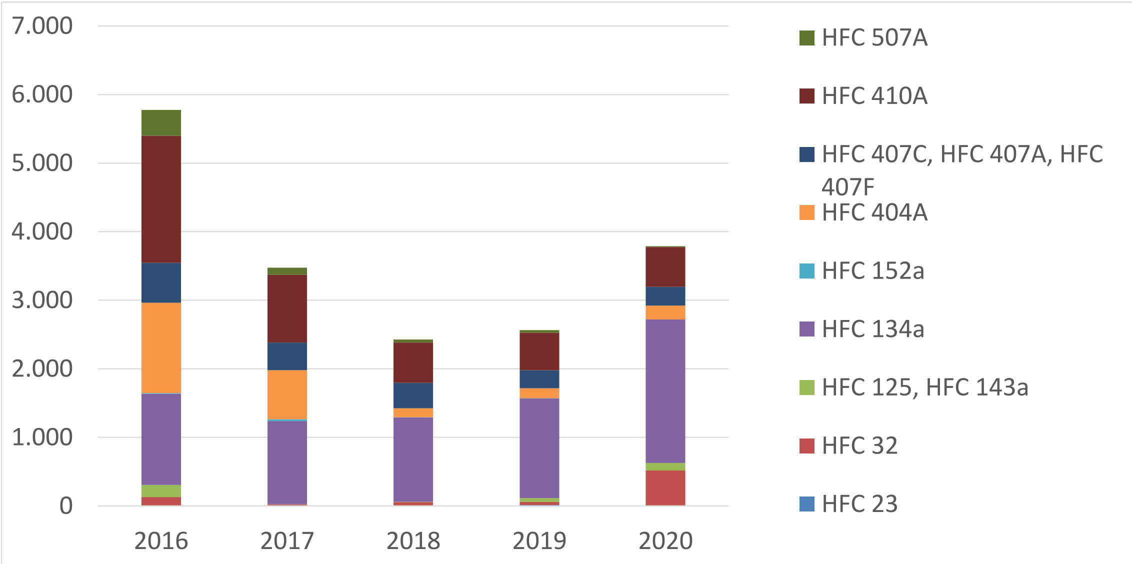
Source: Eurostat

Figure A4-2. Import of HFCs (t)



Source: Eurostat

Figure A4-3. Export of HFCs (t)

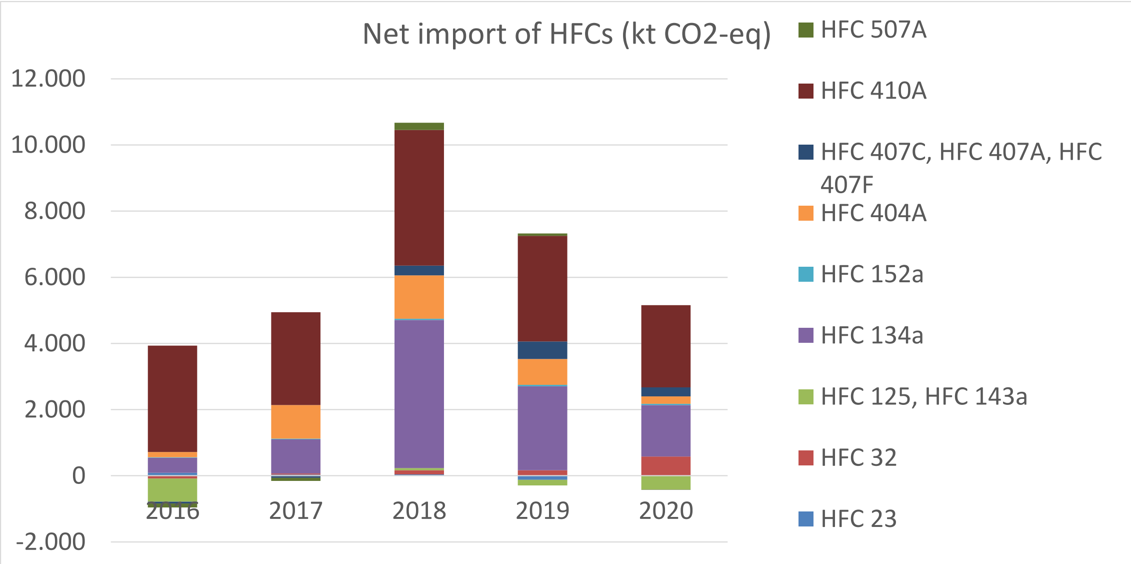


Source: Eurostat

The evolution in terms of CO_2-equivalents is practically the same[39], but the decrease in net imports is more pronounced.

39 A GWP value of 4000 has been assumed for 'HFC 125, HFC 143a' and 1900 for 'HFC 407C, HFC 407A, HFC 407F'.

Figure A4-4. Net import of HFCs (kt CO2-eq).



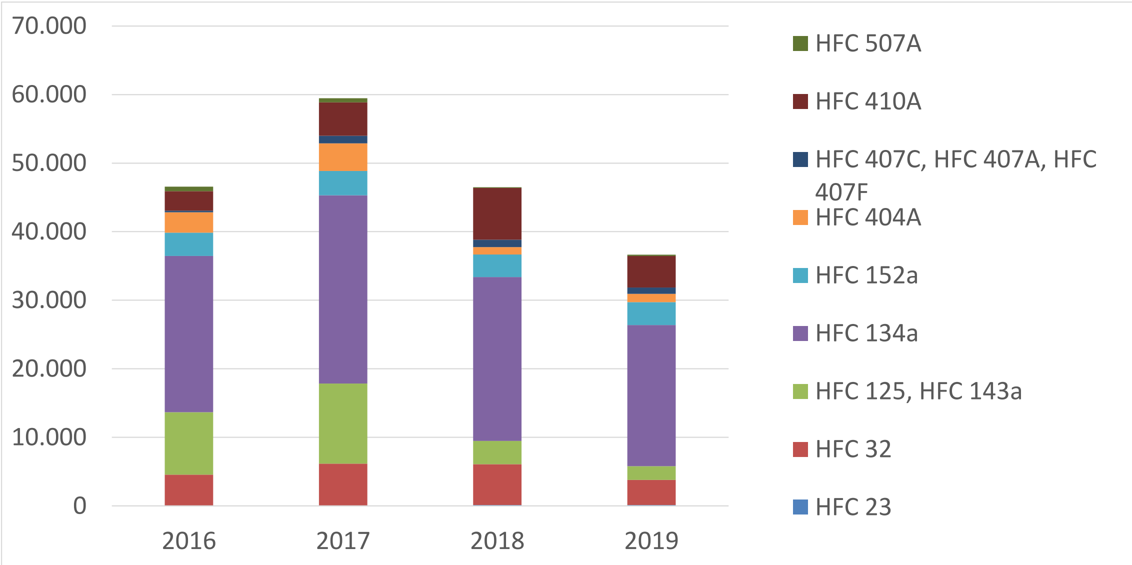
Source: Eurostat

The increase in 2018 is surprising, given the strong quota reduction at EU level in the framework of Art. 15 of EU Regulation 517/2014.

The evolution for Belgium differs significantly from the one observed for the EU, as can be seen on Figure A4-5 and Figure A4-6[40], for which there is a rise in 2017, but a strong decrease in 2018 and 2019, more pronounced in terms of CO_2-eq, total emissions having been cut by half between 2018 and 2019.

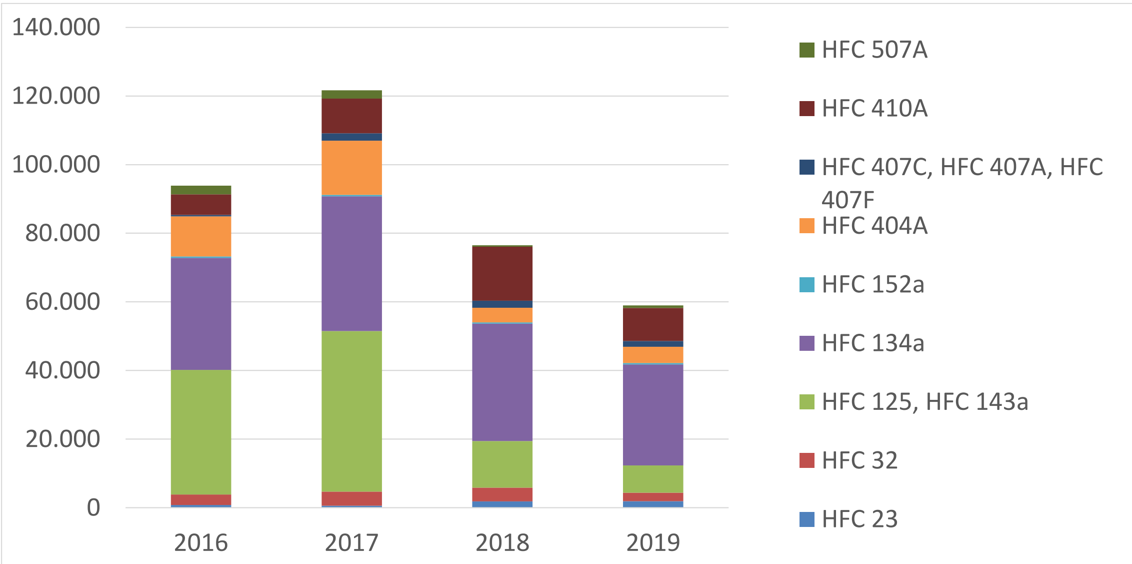
40 Figures for 2020 were not available yet at the time of preparation of this report.

Figure A4-5. Net import of HFCs in EU (t)



Source: Eurostat

Figure A4-6. Net import of HFCs in EU (kt CO_2-eq).



Source: Eurostat

ANNEX 5 LIST OF EMISSION SOURCES

Name of Worksheet	NFR Code	CRF source category
01. Dom. refrig. - Coolant	2 F 1 b	Domestic refrigeration
02. Dom. refrig. - Foam	2 F 2 a	Closed cell foam
03. Stationary airco	2 F 1 f	Stationary air-conditioning
04. Car airco	2 F 1 e	Mobile air-conditioning
05. Bus&Coach airco	2 F 1 e	Mobile air-conditioning
06. Trucks airco	2 F 1 e	Mobile air-conditioning
07. Refrigerated transport	2 F 1 d	Transport refrigeration
08. Passenger rail transport	2 F 1 e	Mobile air-conditioning
10. Ind.&comm. refrig.	2 F 1 a	Commercial refrigeration
11. Closed cell foam	2 F 2 a	Closed cell foam
12. PU cans	2 F 2 a	Closed cell foam
13. Aerosols MDI	2 F 4 a	Metered dose inhalers
14. Other aerosols	2 F 4 b	Other aerosols (technical aerosols)
15. CCl4	XXX	CCl4
16. Methylbr.	YYY	Methyl bromide
17. SF6 electr. Sector	2 G 1	Electrical equipment
18. SF6 in glass sector	2 G 2 c	Soundproof windows
19. Fire Extinguishers	2 F 3	Fire protection
20. Chemical Ind	2 B 9	Fluorochemical production
21. Semiconductors	2 E 1	Integrated circuit or semiconductor
22. Nike shoes	2 G 2 d	Adiabatic properties: shoes and tyres
23. Solvents	ZZZ	Solvents

ANNEX 6 COMMON REPORTING FORMAT (CRF) NOMENCLATURE

NFR Code	CRF source category	Aggregate source
2 B	Chemical industry	
2 B 9	Fluorochemical production	Chemical industry
2 B 9 a	By-product emissions	Chemical industry
2 B 9 a 2	Other (please specify - one row per substance)	Chemical industry
2 B 9 b	Fugitive emissions	Chemical industry
2 B 9 b 3	Other (please specify - one row per substance)	Chemical industry
10	Other	
2 E	Electronics industry	
2 E 1	Integrated circuit or semiconductor	Electronics industry
2 E 2	TFT flat panel display	Electronics industry
2 E 3	Photovoltaics	Electronics industry
2 E 4	Heat transfer fluid	Electronics industry
2 E 5	Other (as specified in table 2(II))	Electronics industry
2 F	Product uses as substitutes for ODS	
2 F 1	Refrigeration and air conditioning	
2 F 1 a	Commercial refrigeration	Refrigeration & air conditioning
2 F 1 b	Domestic refrigeration	Refrigeration & air conditioning
2 F 1 c	Industrial refrigeration	Refrigeration & air conditioning
2 F 1 d	Transport refrigeration	Refrigeration & air conditioning
2 F 1 e	Mobile air-conditioning	Refrigeration & air conditioning
2 F 1 f	Stationary air-conditioning	Refrigeration & air conditioning
2 F 2	Foam blowing agents	Foams
2 F 2 a	Closed cell foam	Foams
2 F 2 b	Open cell foam	Foams
2 F 3	Fire protection	Fire protection
2 F 4	Aerosols	
2 F 4 a	Metered dose inhalers	Aerosols
2 F 4 b	Other aerosols (technical aerosols)	Aerosols
2 F 5	Solvents	Other
2 F 6	Other applications (ODS substitutes)	Other
2 G	Other product manufacture and use	
2 G 1	Electrical equipment	Other
2 G 2	SF6 and PFCs from other product use	
2 G 2 a	Military applications	Other
2 G 2 b	Accelerators	Other
2 G 2 c	Soundproof windows	Other
2 G 2 d	Adiabatic properties: shoes and tyres	Other
2 G 2 e	Other (please specify - one row per substance)	Other
2 G 4	Other	Other
2 H	Other	Other