Update of the national emission inventory (1990 – 2021) and projections (2021 – 2050) of ozone depleting substances and fluorinated greenhouse gases

PART B: Projections 2021 – 2050

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Vision on technology for a better world

ECONOTEC CONSULTANTS

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Public report

26/01/2023

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SUMMARY

In the present study the Belgian emission projections of fluorinated greenhouse gases covered by International and EU legislation (here referred to as CRF F-gases) were estimated for the years 2021-2050.

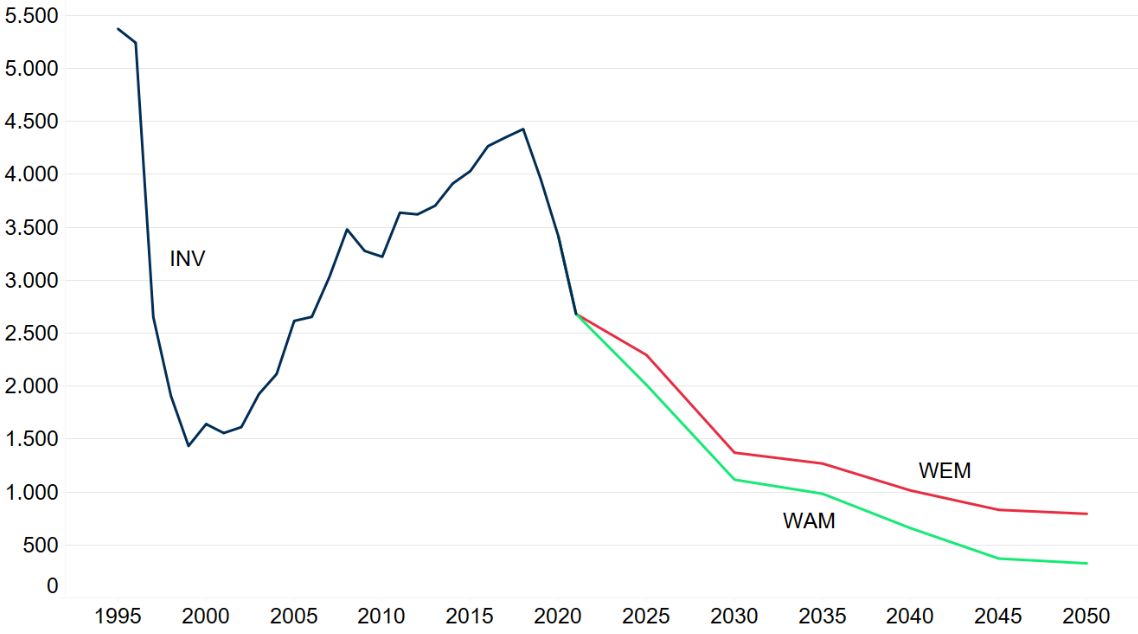
Emissions have been assessed for 5-year intervals by region, by emission source, by type of emission (manufacturing emissions, operating losses, disposal emissions) and by individual substances. In total, emissions from 10 CRF categories (2.B.9., 2.E.1, 2.E.4., 2.F.1., 2.F.2., 2.F.3., 2.F.4., 2.F.5., 2.G.1., and 2.G.2.) have been quantified for 21 CRF fluorinated greenhouse gases.

Emissions have been quantified for two scenarios:

- With existing measures (WEM): based on the existing EU, national and regional policies and measures.
- Wit additional measures (WAM): taking into account additional policies and measures, most importantly the proposal for an amended F-gas regulation, as published by the European Commission on the 5th April.

The emissions of the CRF F-gases (i.e. HFCs, PFCs, SF6 and NF3), expressed in kt CO_2-eq, are shown on Figure 0-1 and on Table 0-1 by category.

Figure 0-1. Projected emissions of CRF F-gases in Belgium in WEM and WAM scenario (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

Table 0-1. Projected emissions of CRF F-gases by source (in kt CO_2-eq).

WEM	2020	2021	2025	2030	2035	2040	2045	2050
Fluorochemical production	840,2	274,7	219,3	150,0	150,0	150,0	150,0	150,0
Commercial refrigeration	1.436,7	1.292,8	1.018,9	279,2	135,5	68,8	58,1	55,8
Stationary air-conditioning	533,9	566,0	609,9	693,6	745,1	564,0	396,3	360,3
Mobile air-conditioning	341,9	305,3	209,4	109,3	118,8	120,8	123,1	128,5
Transport refrigeration	22,3	17,9	18,0	7,5	4,4	1,3	0,3	0,2
Fire protection	10,7	9,6	5,4	1,2	0,0	0,0	0,0	0,0
Solvents	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Closed cell foam	44,1	46,1	30,7	26,9	24,3	22,1	20,2	18,6
Electrical equipment	11,3	8,2	10,6	12,7	10,5	10,6	10,8	12,2
Metered dose inhalers	43,8	43,9	43,6	39,3	37,2	33,5	29,7	25,7
Solvents	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Soundproof windows	73,9	71,3	83,4	8,6	0,0	0,0	0,0	0,0
Other	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total	**3.412,2**	**2.680,3**	**2.293,1**	**1.370,7**	**1.268,3**	**1.013,5**	**831,0**	**793,7**

WAM	2020	2021	2025	2030	2035	2040	2045	2050
Fluorochemical production	840,2	274,7	219,3	75,0	75,0	75,0	75,0	75,0
Commercial refrigeration	1.436,7	1.292,8	814,1	232,1	110,2	62,7	51,8	49,1
Stationary air-conditioning	533,9	566,0	533,6	565,9	571,8	307,0	41,3	7,1
Mobile air-conditioning	341,9	305,3	208,3	104,5	108,3	105,0	101,8	98,9
Transport refrigeration	22,3	17,9	18,0	7,4	4,3	1,0	0,1	0,1
Fire protection	10,7	9,6	5,4	1,2	0,0	0,0	0,0	0,0
Solvents	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Closed cell foam	44,1	46,1	30,7	26,9	24,3	22,1	20,2	18,6
Electrical equipment	11,3	8,2	10,6	12,6	9,5	9,3	9,1	8,9
Metered dose inhalers	43,8	43,9	43,6	39,3	37,2	33,5	29,7	25,7
Solvents	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Soundproof windows	73,9	71,3	83,4	8,6	0,0	0,0	0,0	0,0
Other	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total	**3.412,2**	**2.680,3**	**2.010,8**	**1.116,0**	**983,0**	**657,9**	**371,3**	**325,8**

Source: VITO, Econotec (own calculations, 2022).

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AR4	Fourth Assessment Report of the IPCC
AR5	Fifth Assessment Report of the IPCC
CFC	Chlorofluorocarbon
CRF	Common Reporting Format of the UNFCCC
CRF F-gas	compulsory gas for the UNFCCC reporting
FGR	F-gas regulation
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFE	Hydrofluoroether
HFO	Hydrofluoroolefin
IPCC	Intergovernmental Panel on Climate Change
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

1 INTRODUCTION

This section deals with the fluorinated greenhouse gas emission projections part. Article 18 of the Governance Regulation 2018/1999 [1] stipulates that by 15 March 2021, and every two years thereafter, Member States shall report to the Commission information on their national projections of anthropogenic greenhouse gas emissions by sources and removals by sinks, organised by gas or group of gases (hydrofluorocarbons and perfluorocarbons). This includes HFC, PFC, SF6 and NF3. National projections have to take into consideration any policies and measures adopted at Union level. Member States also have to make available to the public, in electronic form, their national projections including descriptions of the models and methodological approaches used, definitions and underlying assumptions.

This report presents the approach, the assumptions and the results obtained. The methodology follows the same approach as the emission inventory. Emissions have been quantified by region, by emission source, by individual substance and by year.

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

Included sectors

Table 1-1. CRF categories included in this report.

	Sector
2.B.	Chemical industry
2.B.9.	Fluorochemical production
2.E.	Electronics industry
2.E.1.	Integrated Circuit or Semiconductor
2.E.4.	Heat Transfer Fluid
2.F.	Product uses as substitutes for ODS
2.F.1.	Refrigeration and Air-conditioning Equipment
2.F.1.a.	Commercial refrigeration
2.F.1.b.	Household refrigeration
2.F.1.c.	Industrial refrigeration
2.F.1.d.	Transport refrigeration
2.F.1.e.	Mobile air-conditioning systems
2.F.1.f.	Stationary air-conditioning systems
2.F.2.	Foam Blowing Agents
2.F.3.	Fire Extinguishers
2.F.4.	Aerosols
2.F.4.a.	Metered-dose inhalers
2.F.4.b.	Other aerosols
2.F.5.	Solvents
2.G.	Other product manufacture and use
2.G.1.	Electrical Equipment
2.G.2.	SF6 and PFCs from Other Product Use
2.G.2.b.	Particle accelerators
2.G.2.c.	Soundproof windows
2.G.2.d.	Adiabatic properties: shoes
2.G.2.e.	SF6 and PFCs from other product use

Global Warming Potential values (GWP)

To be consistent with the inventory, values expressed in kt CO_2-eq have been converted from tonnes using the GWP values listed in Annex I and the Fifth Assessment Report of the IPCC. See Annex 2 for an overview of the GWP values used.

See Annex 2 for an overview of the used GWP values.

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.

Description of the projection scenarios

For the projections we consider two different scenarios:

- a scenario that includes all existing and adopted regional, national, and Union policies and measures (with existing measures or WEM), and;
- a scenario that includes all planned regional, national, and Union policies and measures with reasonable chance of being implemented (with additional measures or WAM).

As the time interval for the projections is up to 2050, the technological and political context is very difficult to predict for each subsector. At the moment of preparing the projections, the EU has released a proposal for an updated F-gas regulation, but this has not been adopted yet. The new F-gas regulation is intended to make the Union policy relating to fluorinated greenhouse gases consistent with the 2030 and 2050 ambition level. Both these ambition levels are enshrined in Union legislation. However, the proposal is still under discussion and the ambition level and main instrument, phase-down of HFCs placed on market, can still be adjusted. The amended F-gas regulation also appears ambitious with respect to the phase-out of certain gases for some applications (Daikin, pers. comm.) and some of the main assumptions and outcomes of the impact assessment have been criticised.

The implementation of the proposal for an amended F-gas regulation might be affected by other policies as well, both national and at Union level. The European REACH restriction proposal to ban PFAS substances could also have a substantial impact on this sector. This restriction proposal could include HFC and HFO refrigerants, some of which are important alternatives to high-GWP refrigerants needed to reduce GHG emissions in future. For the projections, it is assumed there is no restriction to place certain gases on the market under REACH.

There are also other barriers that could affect the further uptake of non-HFC refrigerants. A large number of HVAC technicians need to be re-trained to make this transition and there is a high demand for newly trained technicians.

This illustrates that the policy context is very uncertain and therefore that the WAM scenario results need to be interpreted taking these uncertainties into account.

- **WEM scenario**

The most important policies includes in the WEM scenario are listed in Table 1-1.

Table 1-2. Policies and measures included in the Belgian National Energy and Climate Plan.

Entity	Description
EU	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. This Regulation strengthened previous measures and introduced important changes. The total amount of the most important fluorinated greenhouse gases (HFCs) that can be sold in the EU from 2015 onwards were limited and phased-down in steps to one-fifth of 2014 sales in 2030. This is the main driver of the move towards more climate-friendly technologies. In addition the use of high GWP greenhouse gases in many new types of equipment were banned such as fridges in homes or supermarkets, air conditioning, foams and asthma sprays. The emissions from existing equipment were also limited by requiring checks, proper servicing and recovery of the gases at the end of the equipment's life.
EU	Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air conditioning systems in motor vehicles and amending Council Directive 70/156/EEC. This Directive prohibits the use of fluorinated greenhouse gases with a global warming potential of more than 150 times greater than carbon dioxide (CO_2) in new types of cars and vans introduced from 2011, and in all new cars and vans produced from 2017.
EU	Commission Implementing Regulation (EU) 2015/2067 of 17 November 2015 establishing, pursuant to Regulation (EU) No 517/2014 of the European Parliament and of the Council, minimum requirements and the conditions for mutual recognition for the certification of natural persons as regards stationary refrigeration, air conditioning and heat pump equipment, and refrigeration units of refrigerated trucks and trailers, containing fluorinated greenhouse gases and for the certification of companies as regards stationary refrigeration, air conditioning and heat pump equipment, containing fluorinated greenhouse gases.
Flanders	Green Deal Climate friendly refrigeration and cooling. In this green deal, the retail sector, installation- and servicing companies, suppliers and producers of equipment, sector federations and the Flemish government commit themselves to reduce the use of fluorinated greenhouse gases as refrigerant in supermarkets.
Flanders	Flemish action plan F-gases (2015-2020). The plan aimed to increase awareness of all stakeholders relating to leakages and maintenance of installations containing fluorinated greenhouse gases.Proposed initiatives to control the sale and use of F-gases and train technicians on natural or low-GWP alternatives. Aims to reduce emissions from fluorochemical production.
All regions	Each region has legislation in place on e.g. commercial and industrial refrigeration, handling of fluorinated greenhouse gases, and disposal of equipment containing fluorinated greenhouse gases. In Flanders this is Vlarem II, art. 5.16.3.3, in the Brussel Capital Region the " *Besluit van de*

	Brusselse Hoofdstedelijke Regering van 29 november 2018 betreffende de koelinstallaties" and in the Walloon Region "*l'Arrêté, déterminant les conditions intégrales et sectorielles relatives aux installations fixes de production de froid ou de chaleur mettant en oevre un cycle frigorifique*".

In the Flemish region, the Green Deal will speed up the transition to natural refrigerants and will make it easier for companies and industry to comply with the phase-down. It is however difficult to predict if that would lead to an effect that is larger than the phase-down. The Green Deal includes a large share of the sector in Flanders, but especially smaller retailers, installation companies are not included. As a conservative estimate we assume that the effect is similar. It is also assumed that there will be important spill-over effects to Wallonia and Brussels. Large companies in the distribution sector are national and actions taken will likely be rolled-out on a national level.

- **WAM scenario**

The WAM scenario. Most important policies and measures considered are included in Table 1-2.

Table 1-3. Policies and measures included in the Belgian National Energy and Climate Plan.

Entity	Description
UN	The Kigali Amendment to the Montreal Protocol is an international agreement to gradually reduce the consumption and production of HFCs. It is a legally binding agreement; ratified by Belgium in 2018.
EU	On 5 April a proposal for a regulation on fluorinated greenhouse gases, amending Directive (EU) 2019/1937 and repealing Regulation (EU) No 517/2014, was published by the European Commission. This proposal is now being negotiated by the co-legislators in the European Parliament and the Council. This amended legislation will increase the ambition level and align this with the EU's 2030 and 2050 climate mitigation objectives.
Walloon region	Voluntary sectoral agreements. The measure involves concluding a voluntary agreement with the food distribution sector on reducing its GHG emissions. Both the use of fluorinated gases and energy consumption will be covered. It will be designed from the outset to reflect the increasing restrictions on the use of HFC gases enshrined in Regulation (EU) No 517/2014. Voluntary HFC agreements can be used to outline trajectories for reducing HFC emissions (to be achieved by reducing leakage rates, …). The overall target of this voluntary agreement will be to reduce F-gas emissions by 90% by 2030, initially compared with 2005. The reference year for this calculation will be negotiable in order to avoid penalising businesses that have already recently invested in measures to reduce HFC emissions. At this stage, the target set in the voluntary agreement can be broken down into three secondary goals: • take action in relation to refrigerant gases in installations; • improve the energy efficiency of commercial food distribution premises; • develop renewable energy sources in order to achieve zero GHG emissions from any new commercial food distribution building from 2025.
Walloon region	Support for businesses wanting to replace equipment. Businesses wanting to install refrigeration equipment that uses alternative refrigerants are already currently eligible for investment aid. However the distribution sector, which is the main emitter of HFCs, is excluded. The method used to calculate aid is

	complex because the aim is to cover part of the additional investment cost compared with the reference technology (which must therefore be defined). The objective of the new measure will therefore be to: • encourage operators to switch to a non-HFC solution • simplify the current aid mechanism and introduce specific aid for the distribution sector • grant higher subsidies for replacing installations that contain large quantities of fluorinated greenhouse gases, expressed in t CO_2-eq • ensure that the F-gas is properly recovered during the replacement operation
Walloon region	Additional training on the use of alternative refrigerants/alternative technologies. The purpose of this measure is to prepare courses on new refrigerants/technologies (with a particular focus on safety-related aspects). 'Train-the-trainer' sessions will also be provided for training centres in Wallonia. As a first step, priority will be given to training courses relating to the use of CO_2; subsequent training courses will cover the following topics: • propane and fluorinated greenhouse gases that have a low global warming potential but that are inflammable; • ammonia. Training centres will also need to be provided with access to appropriate technical infrastructure so that technicians can be trained in these new technologies.
Brussels Capital Region	Additional and ambitious measures to combat F-gas losses, with closer monitoring of equipment and bodies. Against this background, the Brussels Government undertakes to: • significantly increase checks of HFC refrigerant gases by refrigeration engineers from 2020; • in 2020, introduce a financial incentive for new refrigeration equipment (including precision air-conditioning units and air-conditioning systems) using alternative refrigerants (refrigerants not listed in Annex I to Regulation (EU) No 517/2014 on fluorinated greenhouse gases).
Flanders	The Flemish Action Plan for reducing F-gas emissions 2015-2020 was launched during the Flemish climate conference of 19 April 2016. In addition to the actions set out in the existing plan, other measures will be taken to further reduce these F-gas emissions. The measures detailed below aim to help reduce F-gas emissions in the Flemish Region to a maximum of 0,6 Mt CO_2-eq by 2030. In 2020, it will be assessed whether a new specific Flemish action plan for the period 2021-2030 may offer added value in terms of consolidating the new initiatives/measures below, among others. The further measures/actions needed for this purpose are: • Reinforcing economic support instruments as part of a comprehensive strategy to support the conversion to natural refrigerants The switch to natural refrigerants requires major investment. We will therefore assess the environmental measures that are currently being supported by the 'prime écologique+' and that could be continued beyond 2020. We will also examine whether any other environmental measures that may make a positive contribution to reducing F-gas emissions (e.g. air-conditioning systems in large buildings and heat pumps with a low GWP value) could be supported as well. At the same time, we will ensure that available European funding is used as much as possible. In addition, to aid the switch to natural refrigerants, the creation of new training centres (and/or the conversion of existing centres) with the necessary facilities for teaching about natural refrigerants will be specifically supported. • Imposing additional responsibilities on specific target groups. In this respect, a Green Deal will be discussed with the distribution sector in 2020, so that by 2030 the use of conventional refrigerants in this

	sector has been reduced to the minimum and F-gas emissions are virtually zero. In the chemical sector as well, following consultation, specific agreements will be reached at company level (through the environmental permit or otherwise) with producers of fluorinated compounds, during the production of which F-gases are emitted, so that F-gas emissions by these producers are reduced as quickly as possible to a maximum of 0,15 Mt CO_2-eq. Finally, based on the results of the study into the waste issues of cooling applications that involve F-gases and the identification of potential sticking points (Afvalproblematiek van F-gasbevattende koeltoepassingen en identificeren van mogelijke knelpunten), measures will be taken together with the sectors directly concerned (refrigeration sector, RECUPEL, construction sector, etc.), which should lead to a considerable increase in the current degree of recovery of refrigerants in the waste stage.
Walloon region	Target for F-gas emissions. Fluorinated greenhouse gases account for 3% of Wallonia's total GHG emissions. Unit emissions from certain pieces of technical equipment can be very high. This is particularly true for cooling equipment in the retail sector, which can contain significant quantities of refrigerant gas with a global warming potential of almost 4,000 and high leakage rates. The overall target is to reduce fluorinated GHG emissions by 50% by 2030 compared with 2005 levels (in line with the Kigali Agreement).

Summarizing, the WAM scenario takes into account the proposal for an F-gas regulation, as published on 5 April 2022. For the longer term impact of this policy, it is also assumed that this scenario is consistent with the objective to become net climate neutral in 2050, as inscribed in the EU climate law. This has implications for certain sectors where a ban is not yet proposed in the new proposal, but where this could be foreseen to be consistent with the 2050 ambition level. The proposal for an amended F-gas regulation already goes a very long way in achieving that ambition: in 2050 there will be a 97,6% reduction of the quantities placed on the market compared to 2015.

Overall approach

The projections are based on the emission inventory for 2022 (emission year 2021), taken as reference year, and on the same methodology as the emission inventory. They also use assumptions consistent with those of the inventory.

The projections have been established simultaneously for Belgium and for each of the three regions, on a harmonised basis (regarding methodology and assumptions), in the same way as for the emission inventory. This means that when there is uncertainty on a particular parameter, as long as there is no evidence of a difference between regions on the value of that particular parameter, a common value has been chosen.

All calculations have been performed by extrapolating into the future the calculation models of the emission inventory, year by year, from 2021 up to 2050, which allows to consider changes in parameters occurring between the 5 yearly projection years, as well as the dynamic aspects of yearly stock changes.

The calculation method is specific to each sector. All sectors of the emission inventory have been considered, even the smallest ones, which ensures completeness of the projections compared to the inventory.

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 ‘Car airco’, ‘Trucks airco’, ‘Foams’, ‘Aerosols’, ‘SF6 in glass sector’, ‘Chemical industry’).
- The remaining emissions are regionalised using one of several (yearly) distribution keys: population, electricity consumption, and number of private cars.

The following regional distribution keys were used:

- population on 1st January (Statistics for 2005-2021; for 2022-2050, the latest projections of the Federal Plan Bureau & STATBEL);
- electricity consumption (SYNERGRID statistics for 2005-2021; for 2022-2050, the same percentage distribution has been assumed as for 2021);
- number of private cars on 1st August (STATBEL statistics for 2005-2021; for 2022-2050, the same percentage distribution has been assumed as for 2021).

Considering the long time frame and many uncertainties related to the shift to natural and low-GWP alternatives, it should be stressed that there are many uncertainties. The projections are not intended to be forecasts, they are based on numerous assumptions and should be considered as a possible future, given the existing and planned legislative context.

Table 1-4. Phase-down of fluorinated greenhouse gases placed on the market in the WEM and WAM projection scenario.

	WEM	WAM (in t)	WAM (in %)
Baseline 2008-2012	100%	-	-
Baseline 2015	-	176.700.479 t	100%
2020	63%	-	-
2021	45%	-	-
2022	45%	-	-
2023	45%	-	-
2024	31%	41.701.077 t	23,6%
2025	31%	41.701.077 t	23,6%
2026	31%	41.701.077 t	23,6%
2027	24%	17.688.360 t	10,0%
2028	24%	17.688.360 t	10,0%
2029	24%	17.688.360 t	10,0%
2030	21%	9.132.097 t	5,2%
2031	-	9.132.097 t	5,2%
2032	-	9.132.097 t	5,2%
2033	-	8.445.713 t	4,8%
2034	-	8.445.713 t	4,8%
2035	-	8.445.713 t	4,8%
2036	-	6.782.265 t	3,8%
2037	-	6.782.265 t	3,8%
2038	-	6.782.265 t	3,8%
2039	-	6.136.732 t	3,5%
2040	-	6.136.732 t	3,5%
2041	-	6.136.732 t	3,5%
2042	-	5.491.199 t	3,1%
2043	-	5.491.199 t	3,1%
2044	-	5.491.199 t	3,1%
2045	-	4.845.666 t	2,7%
2046	-	4.845.666 t	2,7%
2047	-	4.845.666 t	2,7%
2048	-	4.200.133 t	2,4%
2049	-	4.200.133 t	2,4%
2050	-	4.200.133 t	2,4%

Note: WEM = F-gas regulation, WAM = proposal for amended F-gas regulation

Tasks

The following tasks have been or will be carried out:

1. Data collection, among which:
   - enquiry among key stakeholders on important short-, mid- and long-term trends
   - collection of data and information on the projections of fluorinated greenhouse gases from Member States and EU Commission
2. Calculation of projected emissions:
   - Improvements of calculations based on the inventory
   - Calculation of projected emissions starting from 2021 to 2050, reporting on emissions in 5-year intervals
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 ReportNet 3.
4. Reporting:
   - Drafting of the initial report, the interim report, and the final report
   - Presentations in the steering group meetings
   - Contributing to the section in the projections report on fluorinated greenhouse gas emissions.

Table 1-5. Comparison of placing on the market prohibitions in the current and updated F-gas regulation.

Prohibition	F-gas regulation 517/2014	Proposal F-gas regulation
Footwear that contains fluorinated greenhouse gases.	4/7/2006	4/7/2006
Non-refillable containers for fluorinated greenhouse gases listed in Annex I, empty, partially or fully filled, used to service, maintain or fill refrigeration, air-conditioning or heat-pump equipment, fire protection systems or switchgear, or for use as solvents.	4/7/2007	4/7/2007
Non-confined direct evaporation systems that contain HFCs and PFCs as refrigerants.	4/7/2007	4/7/2007
Tyres that contain fluorinated greenhouse gases.	4/7/2007	4/7/2007
Fire protection equipment that contain PFCs	4/7/2007	4/7/2007
Windows for domestic use that contain fluorinated greenhouse gases.	4/7/2007	4/7/2007
Other windows that contain fluorinated greenhouse gases.	4/7/2008	4/7/2008
One-component foams, except when required to meet national safety standards, that contain fluorinated greenhouse gases listed in Annex I with GWP of 150 or more.	4/7/2008	4/7/2008
Aerosol generators marketed and intended for sale to the general public for entertainment and decorative purposes, as listed in point 40 of Annex XVII to Regulation (EC) No 1907/2006, and signal horns, that contain HFCs with GWP of 150 or more.	4/7/2009	4/7/2009
Domestic refrigerators and freezers that contain HFCs with GWP of 150 or more.	1/1/2015	1/1/2015
Fire protection equipment that contain HFC-23	1/1/2016	1/1/2016

Prohibition	F-gas regulation 517/2014	Proposal F-gas regulation
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.	1/1/2018	1/1/2018
Refrigerators and freezers for commercial use (self-contained equipment) that contain HFCs with GWP of 2 500 or more.	1/1/2020	1/1/2020
Refrigerators and freezers for commercial use (self-contained equipment) that contain HFCs with GWP of 150 or more.	1/1/2022	1/1/2022
Stationary refrigeration equipment that contains, or whose functioning relies upon, HFCs with GWP of 2 500 or more except equipment intended for application designed to cool products to temperatures below – 50 °C.	1/1/2020	1/1/2020
Plug-in room air-conditioning equipment (self-contained equipment) which is movable between rooms by the end user that contain HFCs with GWP of 150 or more.	1/1/2020	1/1/2020
Foams that contain HFCs with GWP of 150 or more, except when required to meet national safety standards: Extruded polystyrene (XPS).	1/1/2020	1/1/2020
Multipack centralized refrigeration systems for commercial use with a rated capacity of 40 kW or more that contain, or whose functioning relies upon, fluorinated greenhouse gases listed in Annex I with GWP of 150 or more, except in the primary refrigerant circuit of cascade systems where fluorinated greenhouse gases with a GWP of less than 1 500 may be used.	1/1/2022	1/1/2022
Foams that contain HFCs with GWP of 150 or more, except when required to meet national safety standards: Other foam.	1/1/2023	1/1/2023
Fire protection equipment that contain or rely on other fluorinated greenhouse gases listed in Annex I, except when required to meet safety standards	-	1/1/2024
Refrigerators and freezers for commercial use (self-contained equipment) that contain other fluorinated greenhouse gases with GWP of 150 or more.	-	1/1/2024
Stationary refrigeration equipment, that contains, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 2 500 or more except equipment intended for application designed to cool products to temperatures below -50 °C.	-	1/1/2024
Personal care products (i.e. mousse, creams, foams) containing fluorinated greenhouse gases.	-	1/1/2024
Equipment used for cooling the skin that contain, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 150 or more except when used for medical applications.	-	1/1/2024
Any self-contained refrigeration equipment that contains fluorinated greenhouse gases with GWP of 150 or more.	-	1/1/2025
Plug-in room and other self-contained air-conditioning and heat pump equipment that contain fluorinated greenhouse gases with GWP of 150 or more.	-	1/1/2025
Stationary split air-conditioning and split heat pump equipment: Single split systems containing less than 3 kg of fluorinated greenhouse gases listed in Annex I, that contain, or whose functioning relies upon, fluorinated greenhouse gases listed in Annex I with GWP of 750 or more.	1/1/2025	1/1/2025

Prohibition	F-gas regulation 517/2014	Proposal F-gas regulation
Medium voltage switchgear for primary and secondary distribution up to 24 kV, with insulating or breaking medium using, or whose functioning relies upon, gases with GWP of 10 or more, or with GWP of 2000 or more, unless evidence is provided that no suitable alternative is available based on technical grounds within the lower GWP ranges referred to above.	-	1/1/2026
Stationary split air-conditioning and split heat pump equipment: Split systems of a rated capacity of up to and including 12 kW containing, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 150 or more, except when required to meet safety standards.	-	1/1/2027
Stationary split air-conditioning and split heat pump equipment: Split systems of a rated capacity of more than 12 kW containing, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 750 or more, except when required to meet safety standards.	-	1/1/2027
High voltage switchgear from 52 and up to 145 kV and up to 50 kA short circuit current with insulating or breaking medium using, or whose functioning relies upon gases with GWP of 10 or more, or with GWP of more than 2000, unless evidence is provided that no suitable alternative is available based on technical grounds within the lower GWP ranges referred to above.	-	1/1/2028
Medium voltage switchgear for primary and secondary distribution from more than 24 kV and up to 52 kV, with insulating or breaking medium using, or whose functioning relies upon gases with GWP of 10 or more, or with GWP of more than 2000, unless evidence is provided that no suitable alternative is available based on technical grounds within the lower GWP ranges referred to above.	-	1/1/2030
High voltage switchgear of more than 145 kV or more than 50 kA short circuit current with insulating or breaking medium using, or whose functioning relies upon gases with GWP of 10 or more, or with GWP of more than 2000 unless evidence is provided that no suitable alternative is available based on technical grounds within the lower GWP ranges referred to above.	-	1/1/2031

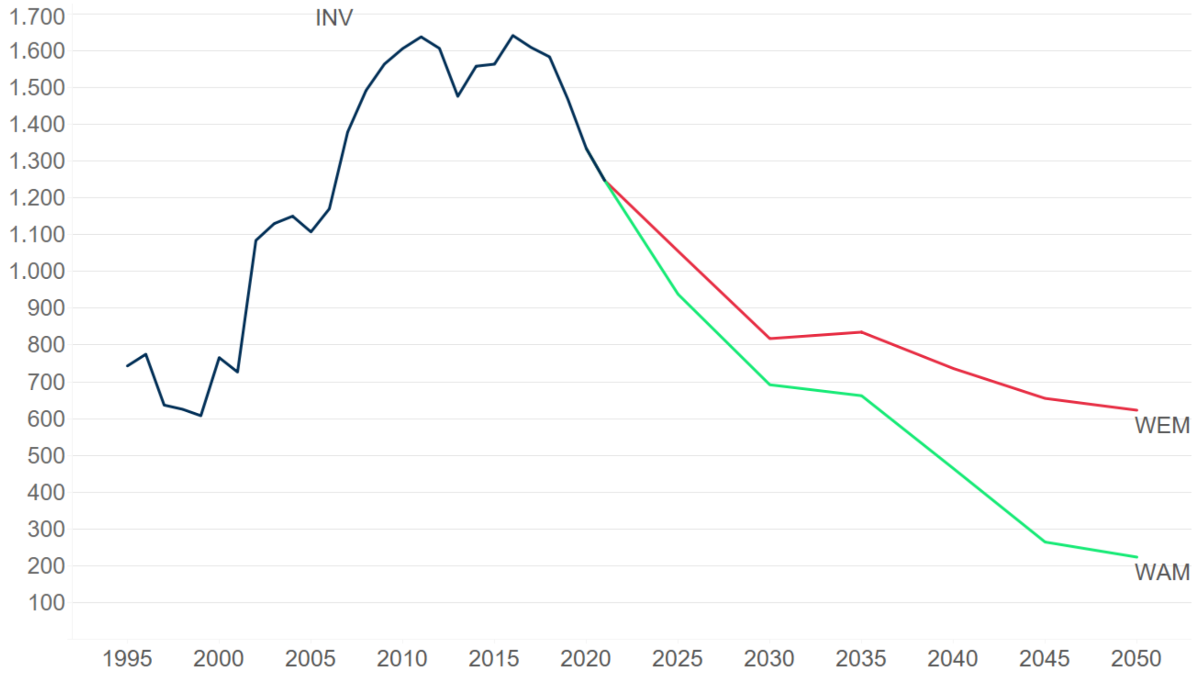
2 OVERALL RESULTS

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

2.1 Evolution of emissions by gas

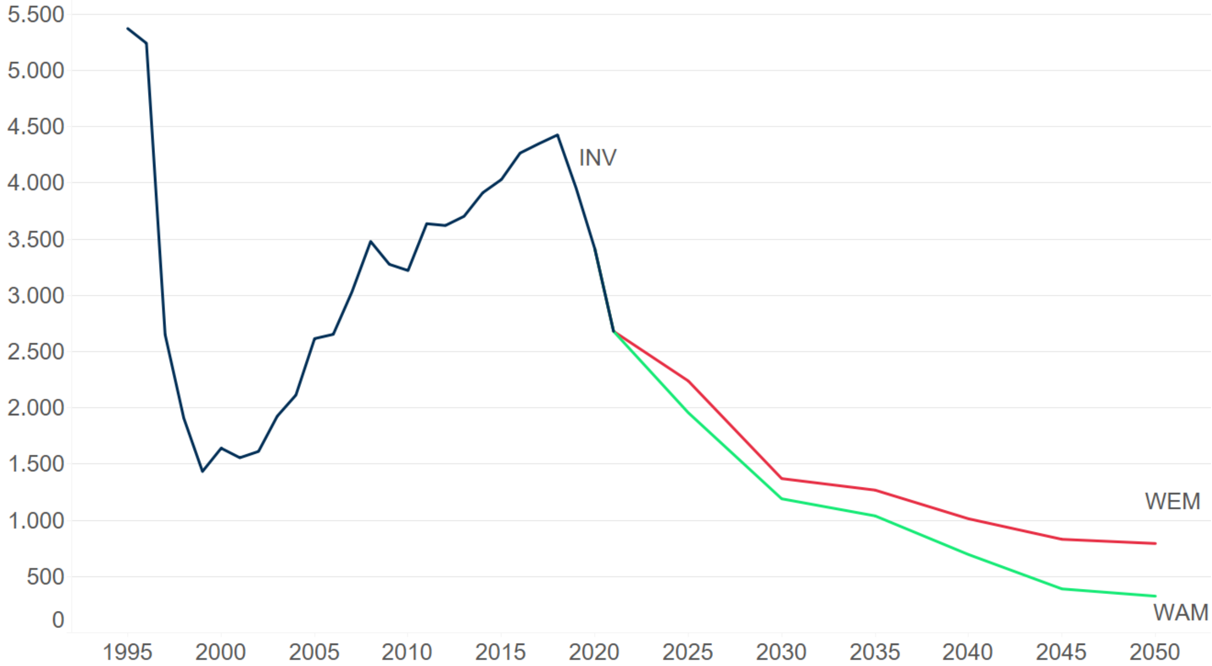
Figure 2.1 and Figure 2.2 show the evolution of emissions in tonnes and kt CO_2-eq in Belgium of the WEM and WAM scenario. In the WEM scenario, further emission reductions are achieved in the period 2021-2030. The WAM scenario clearly results in additional savings, although emissions in 2050 are still relevant.

Figure 2-1. Evolution of the CRF F-gas emissions in Belgium (in t).



Source: VITO, Econotec (own calculations, 2022).

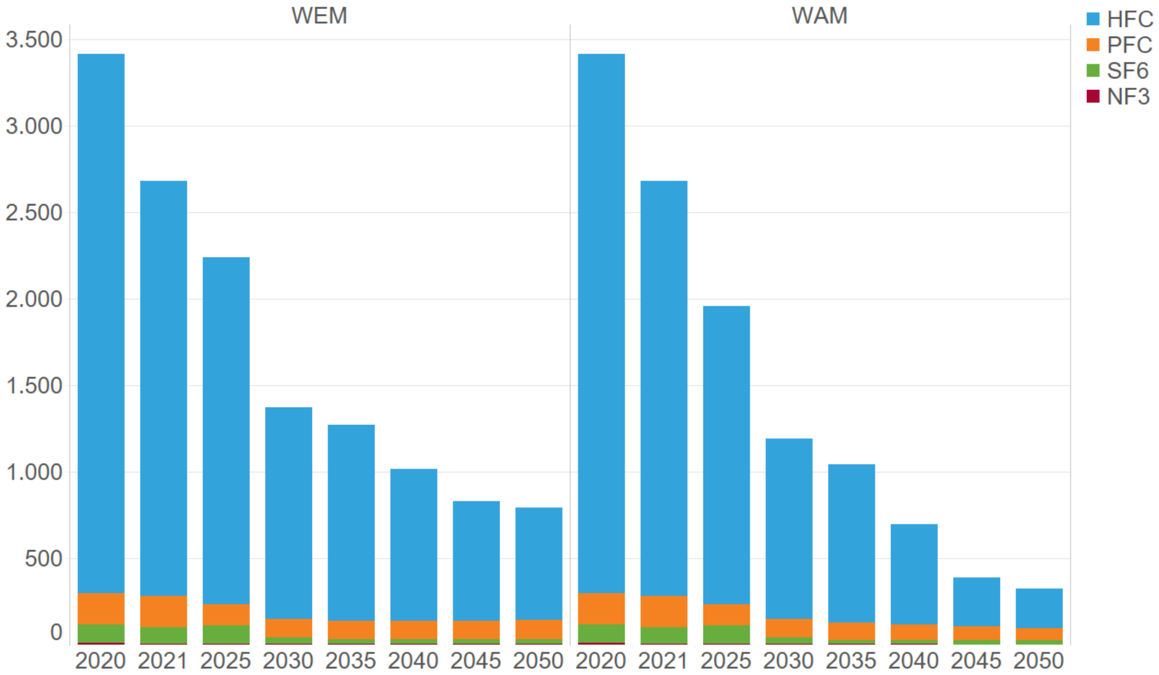
Figure 2-2. Evolution of the F-gas emissions in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

Figure 2-3 shows that the most important emission reductions are achieved in the HFC gases. This is not surprising considering the large share of HFCs in CRF gases. The difference between the WEM and WAM scenario are also almost exclusively achieved by these gases.

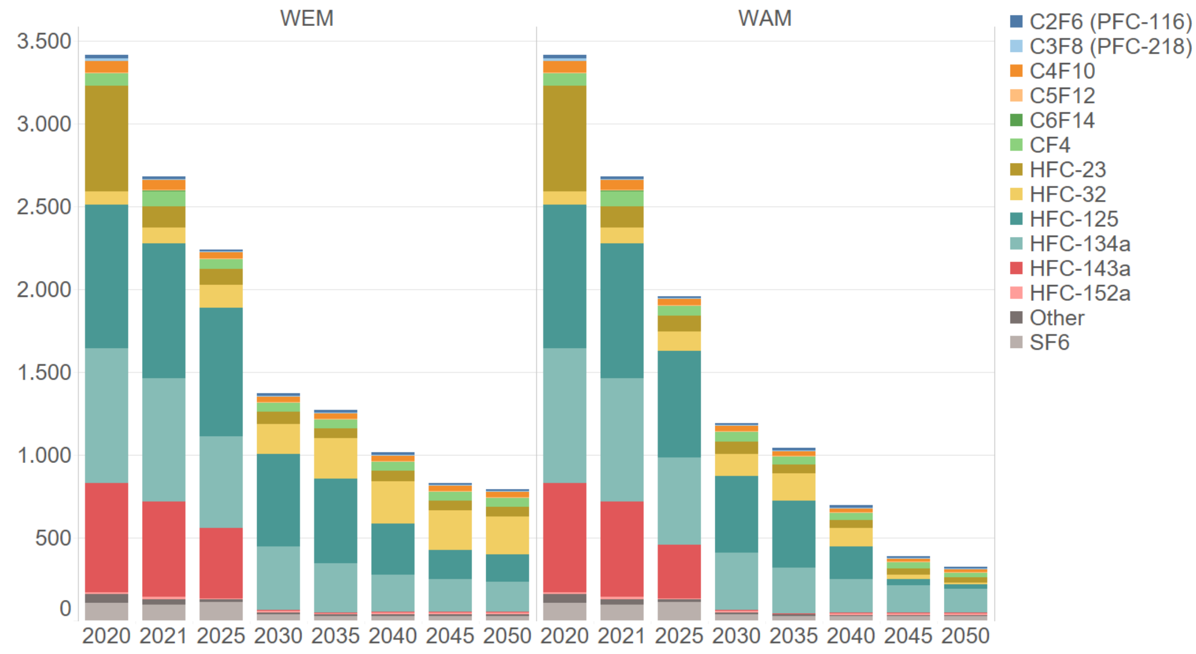
Figure 2-3. Evolution of the CRF F-gas emissions by type of gas in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

On Figure 2-4, the evolution of the 5 main HFC gases: HFC-23, HFC-32, HFC-R143a, HFC-134a and HFC-125 is shown. Emissions of HFC-23, HFC-125, HFC-134a and HFC-143a are projected to go down substantially in the coming decades. Emissions of HFC-32 could increase in the WEM scenario, mainly because that would be an alternative for higher GWP gases in stationary air-conditioning.

Figure 2-4. Evolution of the CRF F-gas emissions of the most important substances in Belgium (in kt CO_2-eq).

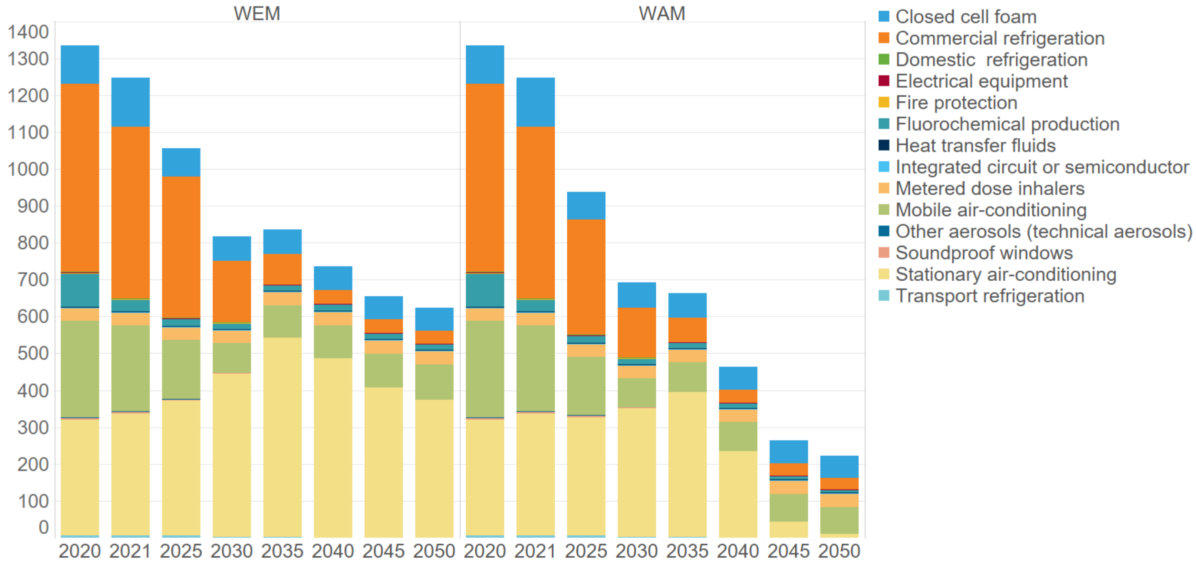


Source: VITO, Econotec (own calculations, 2022).

2.2 Evolution of emissions by source

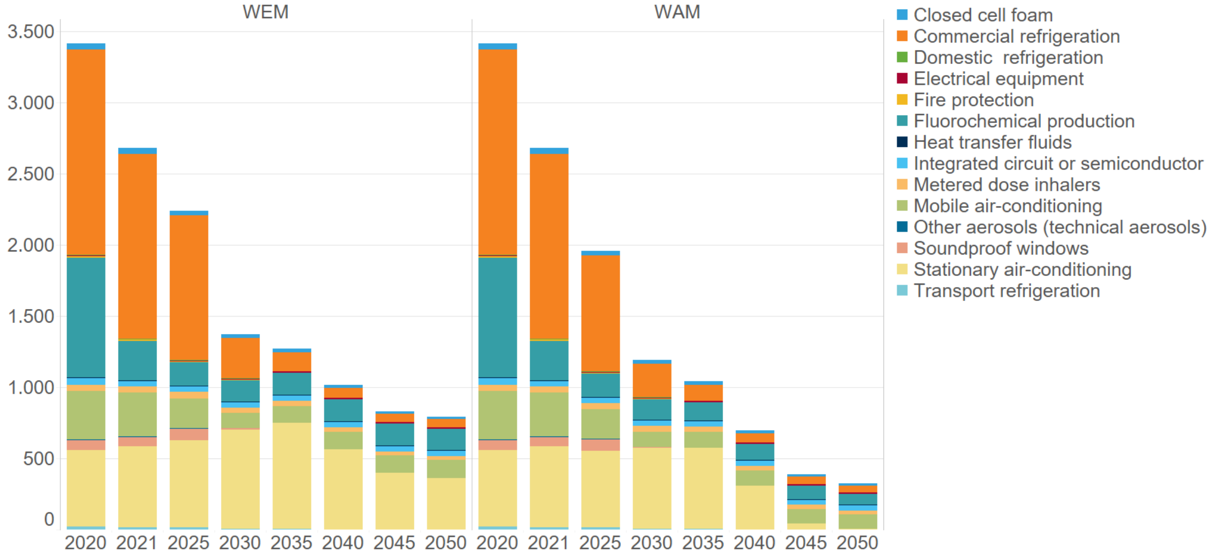
When considering all gases and quantities in tonnes (Figure 2-5), commercial and industrial refrigeration, and stationary and mobile air-conditioning are the main emission sources now and in future. Additional emission reductions in the WAM scenario are mainly achieved in stationary air-conditioning. The phase-down and additional restrictions for placing equipment with fluorinated greenhouse gases on the market in the proposal for an amended F-gas regulation are expected to have the biggest impact there.

Figure 2-5. Evolution of CRF F-gas emissions by source in Belgium (in t).



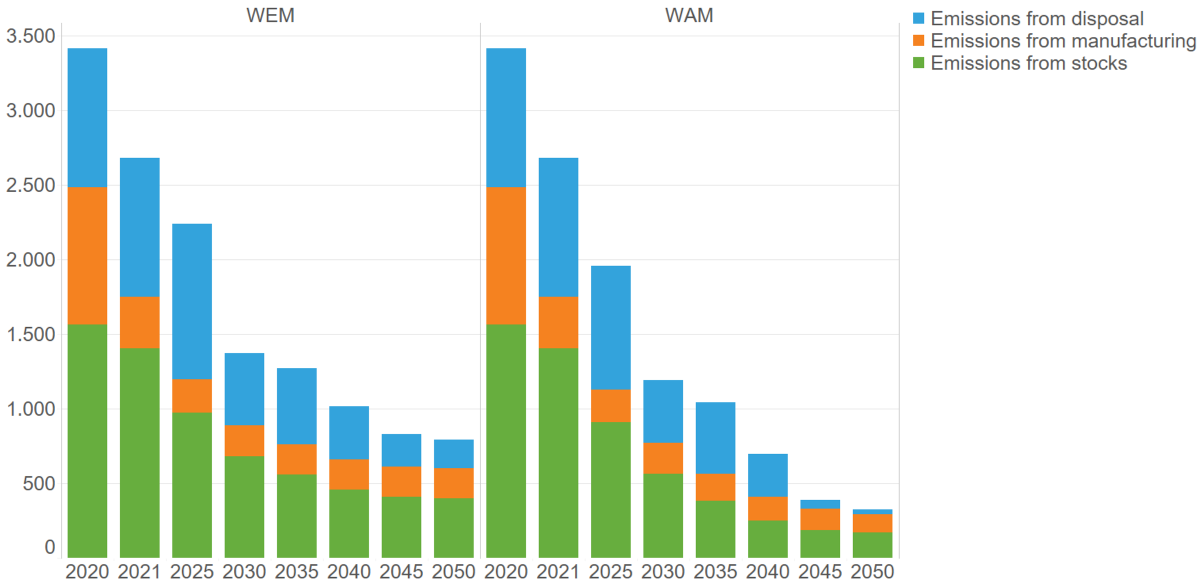
Source: VITO, Econotec (own calculations, 2022).

Figure 2-6. Evolution of CRF F-gas emissions per source in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

Figure 2-7. Evolution of CRF F-gas emissions from manufacturing, stock and disposal in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

2.3 Compliance of the WEM and WAM scenario with the phase-down

For the WEM and WAM scenario we estimated consumption (i.e. filled in new equipment and quantities used for recharging) and calculated the reduction in consumption. This reduction is compared against the phase-down of the F-gas regulation (WEM) and the proposal for an amended F-gas regulation (WAM). This is only an indicative comparison as the phase-down is applicable for the EU and therefore individual countries can have a consumption trend that is above or below this phase-down. In addition, the consumption data does not make a distinction between virgin and reclaimed gases. The EU phase-down only applies for virgin gas and therefore higher consumption data could result from the use of reclaimed gas. The amounts of reclaimed HFCs increased substantially after 2015, due to the new F-gas regulation and these HFCs are used to service existing equipment or are even used in new equipment.

Figure 2-8. Comparison of the phase-down (blue) and the WEM scenario (orange) consumption.

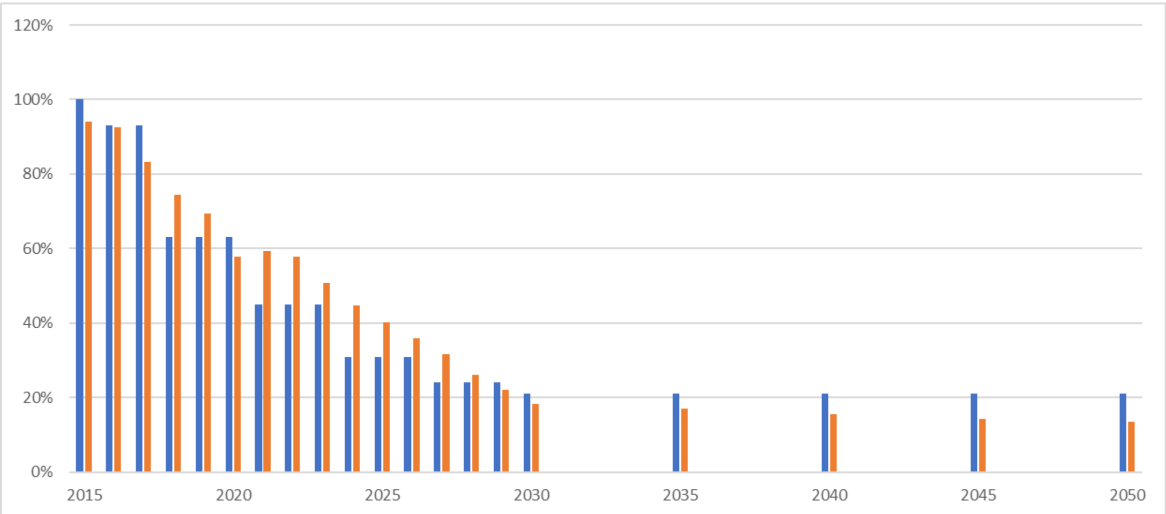
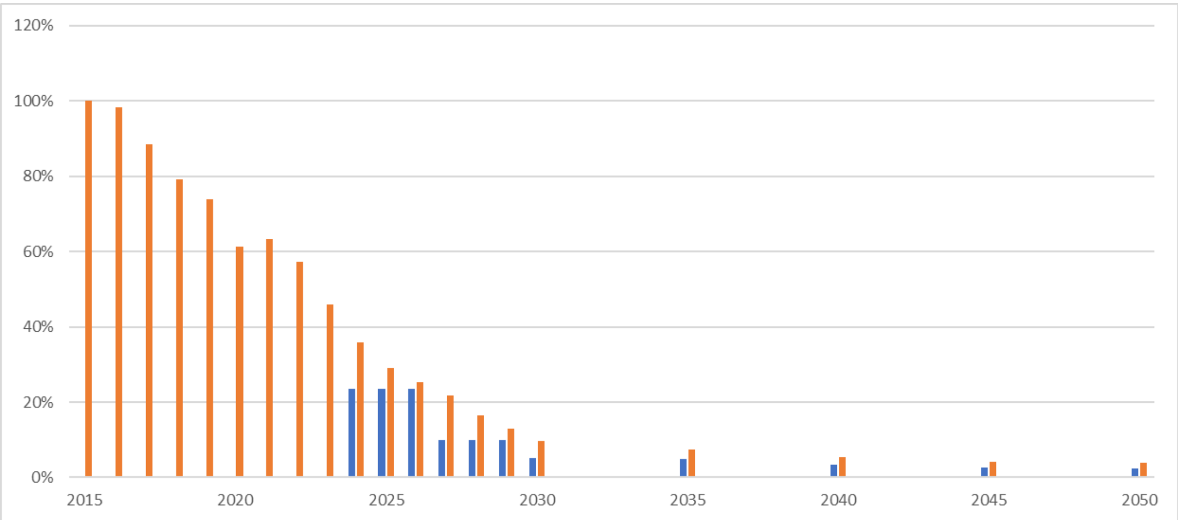


Figure 2-9. Comparison of the phase-down (blue) and the WAM scenario (orange) consumption.



3 EMISSION PROJECTIONS BY SECTOR

3.1 Fluorochemical production (2.B.9.)

Introduction

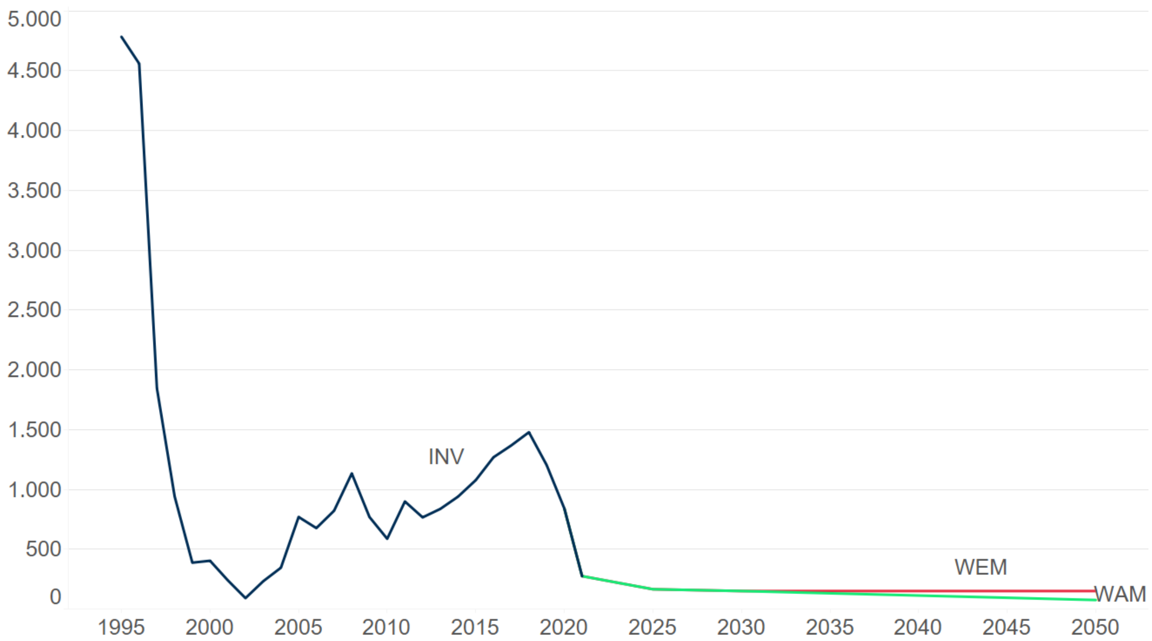
The emissions of this source are those of an electrochemical synthesis (electro-fluorination) plant, which emits PFCs and HFCs, as well as fluorinated greenhouse gases not covered by the Kyoto Protocol. This plant produces a broad range of fluorochemical products, which are used as basic chemicals as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

Methodology

Emissions have gone down considerable in 2021 compared to previous years due to the updated monitoring scheme and the mitigation measures taken by the fluorochemical plant imposed by the Flemish government. Following the agreement between the fluorochemical plant and the Flemish government, emissions have to decrease to 150 kt CO_2-eq by 2030 in the WEM and WAM scenario (VEKA, pers. comm.). After 2030 emissions remain the same in the WEM scenario. For the WAM scenario, it is assumed that emissions will decrease further to 75 kt CO_2-eq between 2030 and 2050 as the agreement also specifies that the plant has to take additional measures to reduce emissions further.

Results

Figure 3-1. Total emissions from fluorochemical production in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022)

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

Introduction

The semiconductor industry 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. 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.

The technical report accompanying the EU’s long-term strategy [2] showed that emission from semiconductor manufacturing could be reduced with a factor 10 compared to the baseline scenario.

The proposal for the amended F-gas regulation does not impose additional constraints on the use of F-gases by the semiconductor industry and therefore the WEM and WAM scenario is assumed to be the same.

Methodology

The methodology is based on consultation with the sector. Longer term trends are difficult to predict and both the existing as the planned policies and measures are not expected to have an impact on emissions. Despite short term decreases, due to planned investments in abatement technologies, emissions in this sector are assumed to be constant. One manufacturer is changing production processes, but the impact of this on emissions is difficult to predict at this point in time. At present no viable measures to reduce HFC demand in semiconductor industry for etching or cleaning of chemicals vapour deposition chambers are available [3]. Also Germany assumed emissions from semiconductor manufacturing to be constant for their 2021 projections [4].

Results

The resulting emissions are assumed to be constant throughout the 2022-2050 period. Total emissions, including heat transfer fluids, are 42,3 kt CO_2-eq (AR5) or 3,8 tonnes.

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

Introduction

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. The emission data from the semi-conductor industry are kept constant and results are included there.

3.4 Refrigeration and air-conditioning equipment (2.F.1.)

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

Introduction

As for the emission inventory 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 and commercial refrigeration and hermetically-sealed commercial refrigerators and freezers.

Methodology

- **On-site assembled systems for industrial and commercial refrigeration**

Disaggregation of the refrigerant bank

In the emission inventory, no distinction is made between industrial and commercial refrigeration, as the shares of these sub-sectors in the total consumption are not known.

For the projection, in order to be able to consider different assumptions by sub-sector (on refrigerant market shares, emission factors, evolutions of the fluid bank, impact of specific policies), the refrigerant bank by refrigerant was disaggregated between commercial refrigeration and industrial refrigeration.

As there is no data for Belgium, this disaggregation has been estimated based on the average disaggregation by substance observed for France, Germany and the UK in 2020 in the CRF reporting to UNFCCC[1]. A disaggregation by refrigerant mixture was obtained through a trial and error procedure as follows:

- Limiting the number of mixtures to a reduced set of 10 refrigerants (R134A, R404A, R407F, R422D, R448A, R449A, R452A, R455A, R507A, R513A) corresponding to 99,1% of the total bank end of 2021 in tonnes, and extrapolating the quantities in order to keep the same total;
- Applying the share of commercial refrigeration by substance to the bank by substance, to obtain an estimate of the bank of commercial refrigeration by substance;
- Making first assumptions on the share of commercial by mixture, starting by allocating the HFC-143a stock to R404A and R507A, in proportion of their presence in the bank at the end of 2021;
- Applying these shares to the total bank by mixture, to get an estimate of the commercial refrigerant bank by mixture, and calculating the corresponding bank by substance;
- Comparing this result to the initial disaggregation by substance and adapt the assumptions on share by mixture to approximate the latter, through a trial and error procedure.

For commercial refrigeration, the bank was again subdivided between supermarkets (centralised systems) and small commercial (condensing units) assuming a 2/3 share for supermarkets, based on [28]. The first category represents supermarkets (typical food sales area 700 m^2) and hypermarkets (typical food sales area 3000 m^2), while the second comprises

[1] Source: www.unfccc.org. 2022 submission.

both superettes[2] (typical food sales area 250 m2) and 'small specialized shops' (general food, bakeries, butcheries, fruits & vegetables, dairy products, service stations, bars, hotels and restaurants).

Provisions of EU regulation 517/2014 for the sector

As far as the refrigeration and air conditioning installations are concerned, the bans on placing on the market (Art. 11 and Annex III) concern among other things:

- from 1 January 2020, stationary refrigeration equipment running on HFCs with a GWP ≥ 2500, except for applications below -50°C;
- from 1 January 2022, multipack centralised refrigeration systems for commercial use with a capacity ≥ 40 kW with gases with a GWP ≥ 150, except in the primary refrigerant circuit of cascade systems with indirect medium temperature loop (see Annex I of (European Commission, 2017)), where a GWP of up to 1500 may be used;
- from 1 January 2025, single split air-conditioning systems with less than 3kg of fluorinated GHG that contain gases with GWP ≥ 750.

The restrictions on use (Art. 13) include a prohibition, from 1 January 2020, to use F-gases with a GWP ≥ 2500 to service or maintain refrigeration equipment with a charge size ≥ 40 t CO_2-eq. This does not apply to reclaimed or recycled F-gases until 1 January 2030.

Assumptions of the WEM scenario

Given the uncertainty and the lack of data, while many assumptions are required, a preference was given to assumptions that are simple, as much as possible referring to published data and rather conservative than 'optimistic' in terms of future emissions.

As in the inventory, lifetimes are assumed to be 15 years.

For the emission factors from the bank, we have extrapolated the exponential downward trend of the average emission factor of the inventory from 9,5% in 2021 to 7% in 2030 and 3,6% in 2050. This evolution is applied to the emission factors of the subsectors supermarkets/small commercial/industry, which are assumed to be in the proportions of 9/6/4,5 respectively, as in [28].

Refilling with refrigerant is assumed to occur with the same refrigerant as the emissions, at a level consistent with a 'percentage remaining in systems at disposal' of 70% at the end of the lifetime.

As in the inventory, we have assumed for all refrigerants and subsectors a manufacturing emission factor of 2% and a disposal emission factor of 75% (except for retrofitting where 50% is assumed) as in the inventory.

Annual activity growth rates are assumed to be 0,5% for commercial centralised systems, 1% for small commercial condensing units and 1% for industry.

From 2024, refrigerant shares assumed for new units are those of [28], shown on the table below. They were extended to 2020 and those of 2022-23 were obtained by interpolation.

[2] Minimarkets (e.g. Carrefour Express, Proxy Delhaize).

Table 3-1. Refrigerant shares assumed for new units 2024-2036.

	Supermarkets - centralised systems	Small commercial - condensing units	Industry
R134A	1,6%	9,3%	0,9%
R404A	0,0%	1,8%	0,9%
R407F	0,0%	0,0%	0,0%
R422D	0,0%	0,0%	0,0%
R448A	0,4%	0,6%	0,0%
R449A	1,7%	2,5%	0,0%
R452A	0,0%	0,0%	0,0%
R455A	0,0%	18,6%	0,0%
R507A	0,0%	0,0%	0,0%
R513A	14,4%	3,1%	5,4%
R1234ze+CO2	4,9%	0,0%	4,6%
R290 (propane)	0,0%	34,6%	0,0%
R717 (NH3)	0,0%	0,0%	65,6%
R744 (CO2)	46,8%	21,1%	22,6%
HC + CO2	30,2%	8,4%	0,0%
TOTAL	100,0%	100,0%	100,0%

Source: Öko-recherche, Ricardo, Öko-institut (2022) [5] .

As these shares refer to the total fluid bank, including natural refrigerants, the following F-gas fractions were assumed for the bank at the end of 2021:

- Supermarket centralised systems: 80%
- Small commercial condensing units: 100%
- Industry: 50%

Assumptions of the WAM scenario

The only difference with the WEM scenario is a lower disposal emission factor: 50% instead of 75%, except for retrofitting, where 20% is considered instead of 50%.

➢ **Hermetically-sealed commercial cooling**

Commercial refrigerators include also 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.

For the projections key characteristics of new hermetically sealed commercial refrigerators are assumed to remain the same. The only change is the refrigerants. The most frequently used refrigerants in the past were HFC-134a 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 current F-gas regulation already prohibited the use of HFCs with a GWP of 150 or since 1 January 2022, such as R404A and R134a. The amended F-gas regulation extends this to other fluorinated greenhouse gases with a GWP of 150 or more that are prohibited from 1 January 2024. In our calculations we assume that R404A and R134a will be replaced by non-fluorinated refrigerants such as R290 and R600a.

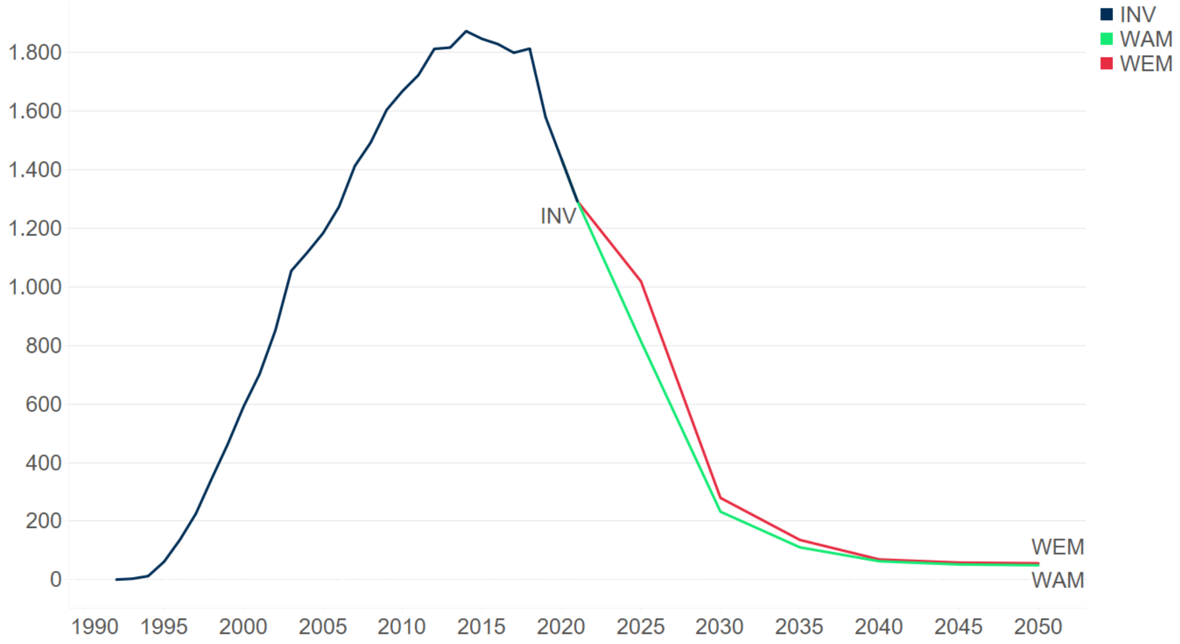
The annual emission factor for hermetically sealed commercial refrigerators and freezers is 1% (HFC-134a) and 0,25% (HFC-245fa), irrespective of the type (refrigerator, freezer, and combination) (see IPCCC methodology below).

Commercial refrigeration has an average lifetime of 10 years. With respect to disposal, commercial refrigeration is in some cases collected via the Recupel system. For calculating the disposal emissions, the same assumptions were used as for the inventory. No changes in recuperation efficiency of gases is assumed.

Results

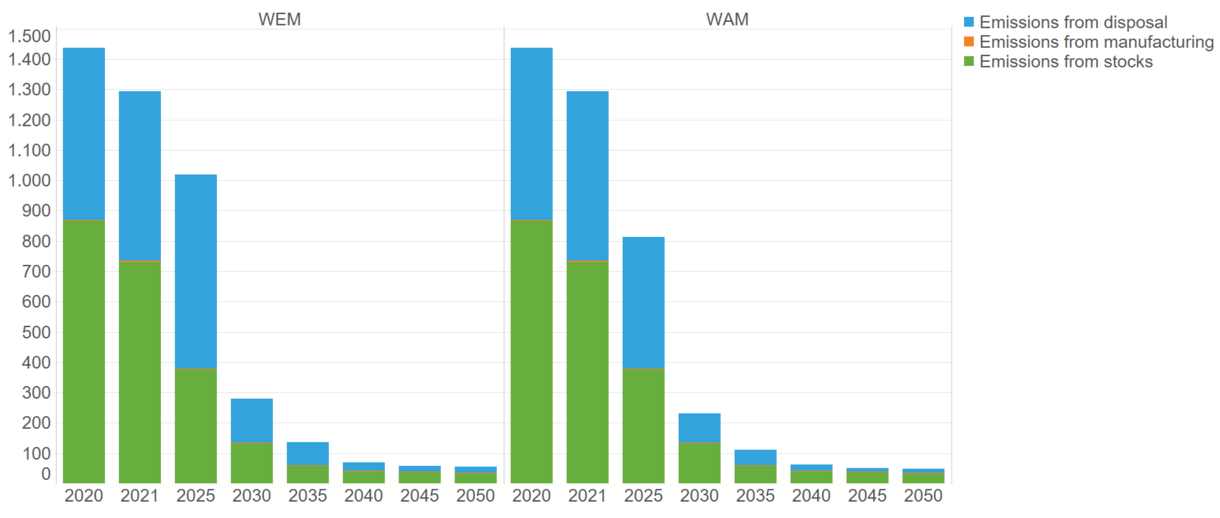
The emissions of CRF gases, expressed in CO_2-eq (Figure 3-2), have reached a peak in 2014. The difference between WEM and WAM scenario is most evident in 2025, with a difference of around 205 kt CO_2-eq.

Figure 3-2. Emissions of CRF gases from industrial and commercial refrigeration (in kt CO_2-eq).



Source: VITO, Econotec (survey, own calculations, 2022).

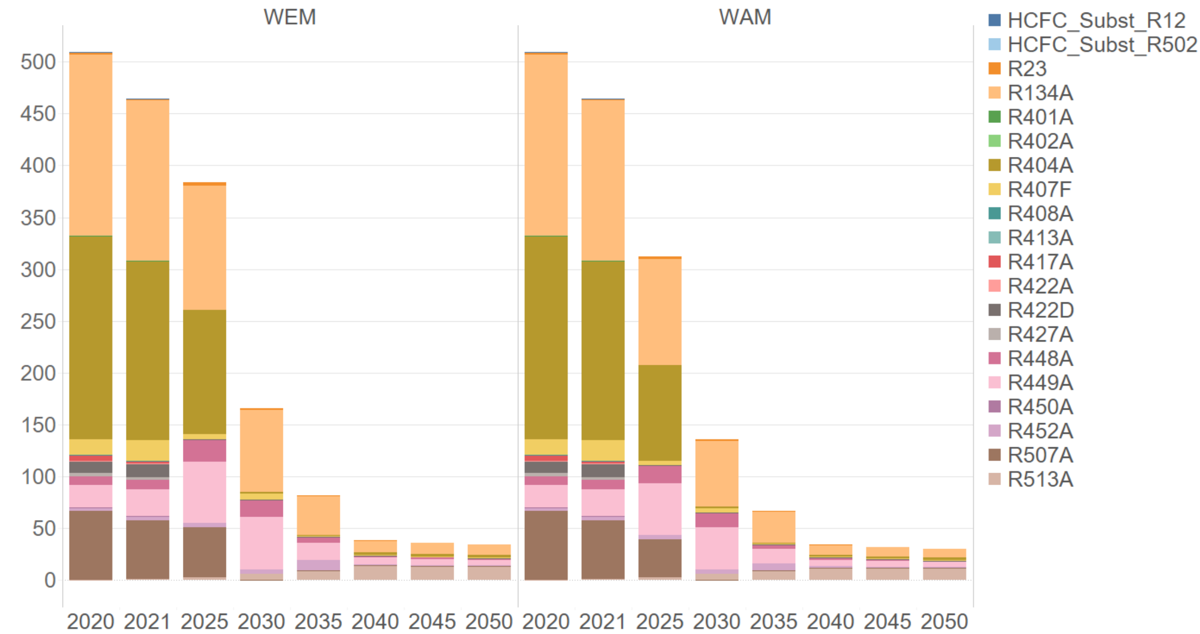
Figure 3-3. Emissions of CRF gases from industrial and commercial refrigeration by type (in kt CO_2-eq).



Source: VITO, Econotec (survey, own calculations, 2022).

Figure 3-4 shows the total emissions by relevant refrigerants, in terms of tonnes. Dominant are HFC-134a and R404A. R404A emissions will decrease relatively rapidly and by 2030 are assumed to be negligible.

Figure 3-4. Emissions from industrial and commercial refrigeration installations by refrigerant (in t).



Source: VITO, Econotec (survey, own calculations, 2022).

3.4.2 Domestic refrigeration (2.F.1.b.)

Introduction

This category consists of domestic refrigeration appliances such as refrigerators, freezers (chest or upright), and fridge freezers. Under the EU F-Gas Regulation [6], household refrigerators and freezers that use refrigerants with GWPs of 150 or higher are prohibited as of 2015 to be placed on the market.

Methodology

No new domestic refrigerators or freezers are placed on the Belgian and EU market since 2015, so emissions are only determined by operational emissions from older domestic refrigerators and freezers and disposal emissions. Emission factors during operation from existing equipment are kept constant. An average lifetime of 15 years is assumed, similar to the inventory. Concerning the disposal emissions, consultation showed that domestic refrigerators and freezers are still disposed and dismantled incorrectly (Coolrec, pers. comm.). This means 30% of refrigerators and freezers do not contain any refrigerants or are disposed incorrectly (with release of all refrigerants). HFC-134a is recuperated efficiently from refrigerators and freezers that are correctly disposed and dismantled and only 10% is assumed to be emitted, which is a conservative estimate.

Results

The emissions from this sector in 2025 amount to 0,8 kt CO_2-eq in the WEM and WAM scenario. By 2030 emissions are zero.

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

Introduction

Results are included under commercial refrigeration (2.F.1.a).

3.4.4 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 [7].

The amended F-gas regulation does not impose additional restrictions to the use of fluorinated greenhouse gases in refrigerated transport. There are small differences between WEM and WAM scenario, to account for the faster phase-down of placing HFCs on the market in the proposal for an amended F-gas regulation.

Methodology

Data on the fleet and new registrations of refrigerated trucks and trailers are obtained from the FPS Mobility for different weight categories (i.e. 2 - 5 ton, 5 - 9 ton, 9 - 22 ton, > 22 ton) for different years. For future years it is assumed that new registrations will grow proportionate to the projected population increase in both WEM and WAM scenario.

The most important assumption is the projected change in the refrigerants used in new refrigerated vans and trucks. This is based on the EU impact assessment [5], which assumes a difference between the baseline and proportionate action scenario. This is aligned with the assumptions used for the 2021 inventory year for the different weight categories.

Table 3-2. Assumed share of refrigerants in new refrigerated transport in Belgium.

	R134a	R404A	R452A	R513A	R744 and other
2 - 5 tonnes					
WEM – 2030	0.0%	0	5%	0%	95%
WEM – 2050	0	0	0	0	100%
WAM – 2030	0	0	0	0	100%
WAM – 2050	0	0	0	0	100%
5 - 9 tonnes					
WEM – 2030	0	0	5%	0%	95%
WEM – 2050	0	0	0	0	100%
WAM – 2030	0	0	0	0	100%
WAM – 2050	0	0	0	0	100%
9 - 22 tonnes					
WEM – 2030	0	0	5%	20%	75%
WEM – 2050	0	0	0	10%	90%
WAM – 2030	0	0	2.5%	10%	87.5%
WAM – 2050	0	0	0	5%	95%
>22 tonnes					
WEM – 2030	0	0	5%	20%	75%
WEM – 2050	0	0	0	10%	90%
WAM – 2030	0	0	2.5%	10%	87.5%
WAM – 2050	0	0	0	5%	95%

Source: VITO, Econotec (2022)[5].

Table 3-3. Share refrigerants in new refrigerated transport in the EU.

	R134a	R404A	R452A	R513A	R744 and other
Vans					
Baseline – 2030	1,1%	1,6%	3,1%	10,4%	83,8%
Baseline – 2050	0%	0%	0%	0%	100%
Proportionate action – 2030	1,1%	0,3%	0,4%	5%	93,2%
Proportionate action – 2050	0%	0,0%	0%	0%	100%
Trucks					
Baseline – 2030	0%	1,6%	2,8%	21,5%	74,1%
Baseline – 2050	0%	0,0%	0%	10%	90,0%
Proportionate action – 2030	0%	0,3%	1,5%	10%	88,2%
Proportionate action – 2050	0%	0,0%	0%	5%	95,0%

Source: Öko-recherche, Ricardo, Öko-institut (2022) [5].

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 operational emissions.

The stock 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 average quantities of fluorinated greenhouse gases used in each weight category are kept constant throughout the time series and are based on the inventory.

Operational emissions are calculated with an emission factor of 15% for both new and retrofitted systems. Leakage rates tend to be higher in transport refrigeration as compared to stationary applications due to the increased level of vibration in motion [3].

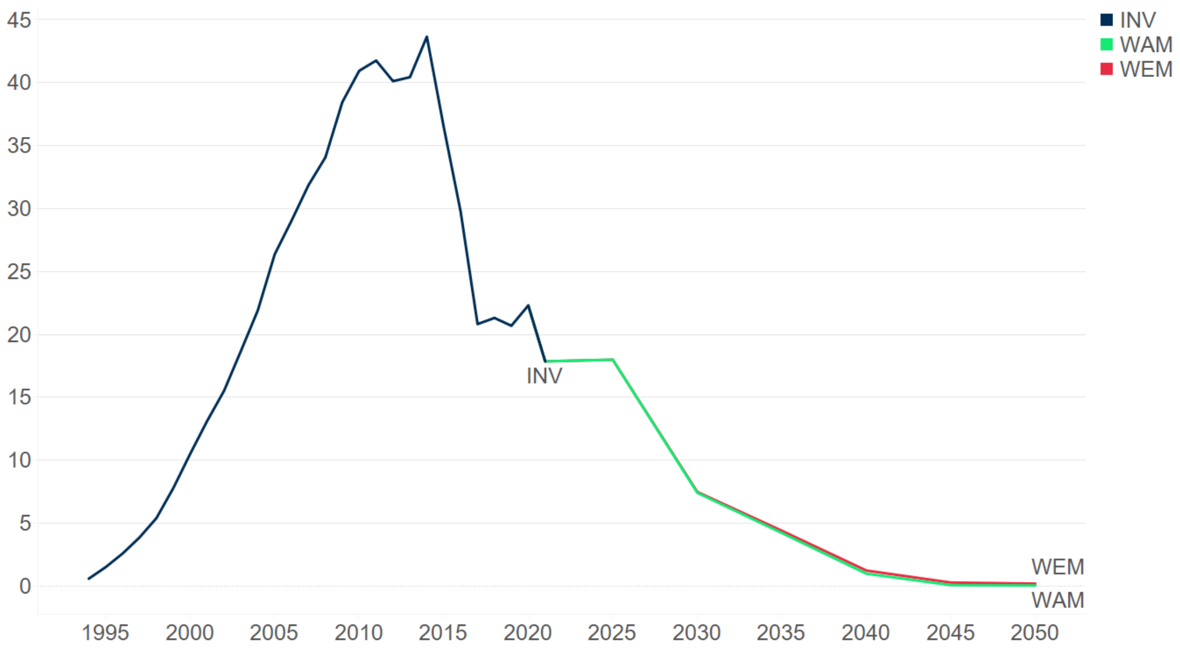
The disposal emission factor is 30% for all gases and all weight classes.

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 probably 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

Emission from refrigerated transport are expected to continue to decrease. There is a stagnation in emissions between 2021 and 2025 due to increasing disposal emissions, but this is temporary effect and emissions continue to decline afterwards.

Figure 3-5. Total emissions from transport refrigeration in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (survey, own calculations, 2022).

3.4.5 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, railway vehicles, and other vehicles. HFCs have been used in mobile air-conditioning systems since 1991. Due to the MAC directive the use of HFCs has already been phased-out in cars and small vans. In other transport modi this has not been the case, although some manufacturers have already made a transition to low-GWP alternatives in mobile air-conditioning systems.

Methodology

- **Cars**

Because the use of HFC-134 in the air-conditioning system of new cars is prohibited, emission projections are solely determined by the emissions during lifetime from the diminishing bank of HFC-134a in cars and emissions occurring at disposal and dismantling.

With respect to emissions during lifetime, the average lifetime of vehicles, the annual loss factor and refilling frequency are assumed to be the same as for the inventory.

Concerning disposal emissions an important factor will be the number of cars dismantled in Belgium and the recuperation of HFC-134a. Since 2005, the number of dismantled cars reported by Febelauto ranged between 103.000 to 171.000 cars, with substantial annual changes. This is lower than the number of cars that are expected to be at their end of life. For the projections (WEM and WAM) we have assumed a conservative estimate of an average annual number of 131.000 cars to be dismantled in Belgium with a recovery of 8,2 tonnes HFC-134a or HFO-1234yf per year. This results in an annual disposal emission factor ranging between 30% and 23%. The recovery of HFCs from cars is relatively low compared to the number of cars being dismantled.

Table 3-4. Assumptions WEM and WAM scenario cars.

	R134a	HFO-1234yf	R744
Baseline – 2030	0%	90.8%	9.2%
Baseline – 2050	0%	80.0%	20.0%
Proportionate action – 2030	0%	90.8%	9.2%
Proportionate action – 2050	0%	80.0%	20.0%

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- **Buses and coaches**

Consumption of HFC-134a for manufacturing is decreasing because of the shift to R407C (in electric buses) and purchases of prefilled air-conditioning systems. For projected manufacturing emission it is assumed that consumption will decrease further following trend in use of R-134a in buses.

The number of new registrations of buses and coaches grows proportionate to the increase in projected population size in Belgium.

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 and, since 2019 100% of buses are equipped with air-conditioning. A stock model approach is used to estimate the number of buses and coaches with air-conditioning in the entire fleet.

Operational 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.

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 in the German emission inventory.

For the projections, we assume that either HFC-134a, R407C or a non-fluorinated GHG is used (e.g. HFO-1234yf or CO2) for air-conditioning in buses and coaches. Buses and coaches are already equipped with CO2 air-conditioning systems, although still in small shares.

An important factor is the switch to electric buses and coaches. For example, Flanders operates public buses together with De Lijn and has opted for the principle of switching to alternative fuels based on electricity and hydrogen. From 2019, only zero-emission buses will be permitted in any new procurement by De Lijn. By 2025, there will only be emission-free buses in city centres. Even De Lijn's (private) subcontractors will be brought on board in this respect as much as possible. Due to the penetration of electric buses and coaches in Belgium, 50% of new vehicles are assumed to be equipped with R407C in 2030 and 25% still by HFC-134a in the WEM and WAM scenario. In 2035 the share of HFC-134A drops to zero percent, while the share of R407C remains at 50% up to 2050.

Table 3-5. Assumptions WEM and WAM scenario buses and coaches.

	R134a	R407C	HFO / R744
Buses			
WEM – 2030	25%	50%	25%
WEM – 2050	0%	50%	50%
WAM – 2030	25%	50%	25%
WAM – 2050	0%	50%	50%
Coaches			
WEM – 2030	20%	50%	30%
WEM – 2050	0%	50%	50%
WAM – 2030	20%	50%	30%
WAM – 2050	0%	50%	50%

- **Trucks**

Information on refrigerant use and emissions of manufacturing was obtained from the only Belgian manufacturer. The Belgian truck manufacturer is making the transition to HFO-1234yf. While HFC-134a was still used in 2021, quantities were already lower than for HFO-1234yf. From 2022 onwards it is assumed that emissions of HFC-134a are zero.

The number of newly registered trucks is allocated to three different weight categories. The growth of new registered trucks follows the average historic trend (2000 - 2021) as this tends to be higher than the growth proportionate to projected population increase.

For each weight category, different assumptions are taken with respect to percentages of new vehicles equipped with air-conditioning. It is assumed that share of vehicles equipped with air-conditioning will increase until 2030 when almost all new vehicels will have air-conditioning.

Operation emission factors are taken from Schwartz [8], 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). It is assumed that the share of vans equipped with HFO-1234yf is similar to that of passenger cars (100% HFO-1234yf from 2018 onwards). For small trucks[3] the share is assumed to be zero in 2021, although some manufacturers are using HFO in their new models. For other trucks the assumptions used are drawn from the EU impact assessment [5]. The share of HFO-1234yf however is expected to increase and the use of HFC-134a is expected to decrease. By 2030, 70% of medium-sized trucks[4] and 90% of large trucks[5] use HFC-134a in the WEM scenario after which HFC-134a will continue to be used up to 2050. In the WAM scenario 30% of medium-sized trucks and 50% of large trucks with an air-condition use HFC-134a. This reduces further after 2030, and is completely phased-out by 2050.

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.

Table 3-6. Assumptions WEM and WAM scenario trucks.

	R134a	HFO / R744
Trucks < 1,5 t		
WEM – 2030	0%	100%
WEM – 2050	0%	100%
WAM – 2030	0%	100%
WAM – 2050	0%	100%
Trucks 1,5 – 7,5 t		
WEM – 2030	70%	30%
WEM – 2050	60%	40%
WAM – 2030	30%	70%
WAM – 2050	0%	100%
Trucks > 7,5 t		
WEM – 2030	90%	10%
WEM – 2050	90%	10%
WAM – 2030	50%	50%
WAM – 2050	0%	100%

- **Rail**

Trams and metros with air-conditioning are excluded in this assessment. 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 2021 and the consumption of refrigerants for servicing trains. The stock is assumed to grow with same rate as projected population size.

3 Less than 1,5 tonne
4 Between 1,5 and 7,5 tonne
5 More than 7,5 tonne

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 emissions during lifetime, the emission factor is calculated based on quantities consumed by the NMBS/SNCB for servicing the air-conditioning systems (data from the NMBS/SNCB) and an average emission factor was used for the projections. Following the EU impact assessment, a switch to R513A is assumed as alternative to HFC-134a and R407C.

Table 3-7. Assumptions WEM and WAM scenario rail

	R134a	R407C	R513A
Train			
WEM – 2030	50%	0%	25%
WEM – 2050	0%	0%	30%
WAM – 2030	50%	0%	5%
WAM – 2050	0%	0%	0%
HST			
WEM – 2030	0%	50%	25%
WEM – 2050	0%	0%	30%
WAM – 2030	0%	50%	5%
WAM – 2050	0%	0%	0%

The disposal emissions are estimated at 15%, with the first trains with air-conditioning taken out of service from 2024.

- **Other vehicles**

Other vehicles include agricultural vehicles (tractors) and special vehicles (vehicles with a dimension and weight exceeding the established maximum limits, 44 tonnes), can also be equipped with air-conditioning.

The number of new registrations is based on the average number of new registrations in the period 2018-2022 and taking into account an annual growth that is the same as the projected population increase.

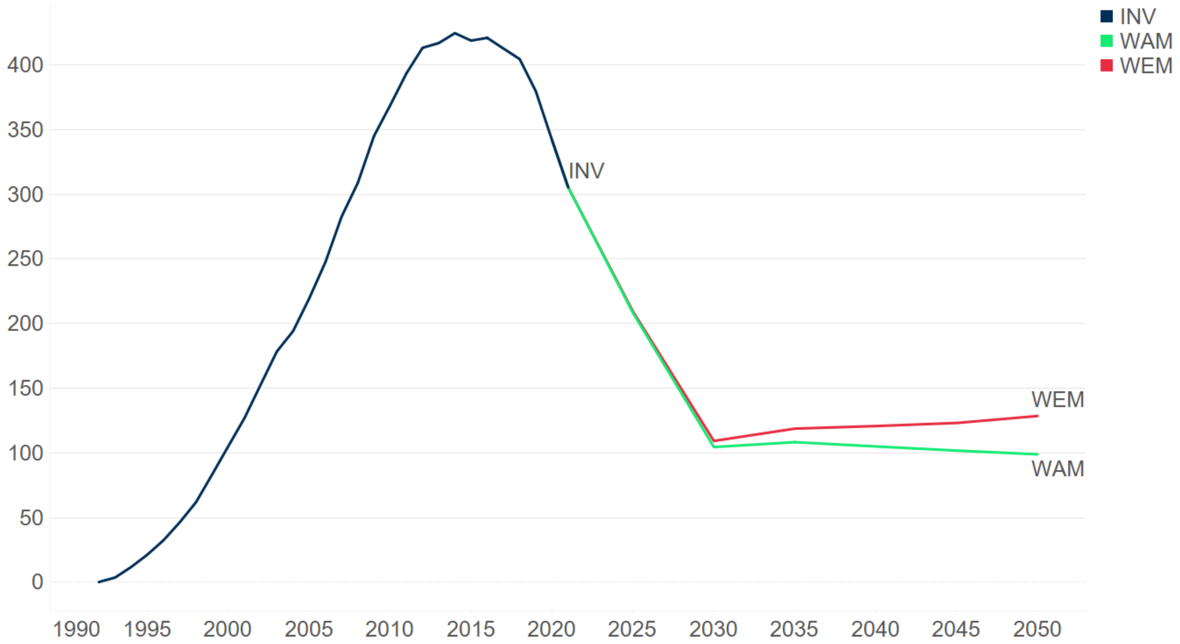
The average lifetime of tractors or other vehicles is 30 years and together with the new registrations is used to model the stock of equipment. A large share (95%) of vehicles is already assumed to be equipped with air-conditioning and this is kept constant throughout the 2022-2050 period. The share of air-conditioned tractors and other vehicles with HFC-134a and alternatives follows the same trend as in large trucks (see section Trucks). Emission loses during use are assumed to be 15% per year, with annual refilling.

The disposal emission factor is 30%.

Results

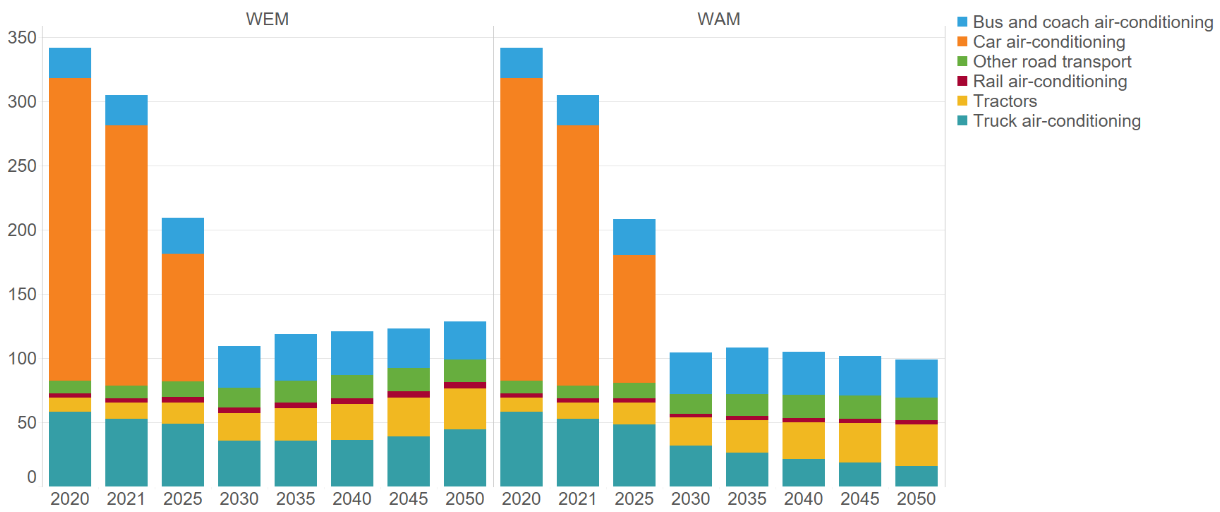
Emissions from mobile air-conditioning will decrease further in the period 2021-2030. This is mainly because of declining emission from cars. Emissions from air-conditioning from other vehicle types are expected to be more persistent, as use of alternative gases is not expected to be that important. As a consequence, emissions stagnate (WAM) or even slightly increase (WEM) after 2030.

Figure 3-6. Total emissions from mobile air-conditioning in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

Figure 3-7. Total emissions from mobile air-conditioning in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

3.4.6 Stationary air-conditioning (2.F.1.f.)

Introduction

This source category comprises plug-in movable air-conditioners, room air-conditioners (RAC), heat pumps, chillers, heat pump boilers and heat pump dryers. It is an important sector for the projections as the market for stationary air-conditioning and heat pumps is expected to grow as an important technology to decarbonise heating and cooling.

There are significant differences between WEM and WAM scenario, as the proposal for amended F-gas regulation imposes additional constraints on placing stationary air-conditioning equipment on the market.

Methodology

- **Movable air-conditioning**

The number of movable air-conditioning equipment sold every year is projected to be constant (the same as in 2021). As no new equipment with F-gases are sold, this has no impact on the projections. The average lifetime is assumed to be 15 years.

The average quantity of refrigerants in movable air-conditioning is 1 kg. While initially, air-conditioners used R407C and R410A, from 2020 all movable air-conditioning are equipped with R290 compliant with the EU F-gas regulation that prohibited the use of refrigerants with a GWP of 150 or more in moveable plug-in room air-conditioning. The amended F-gas regulation extends this prohibition to all plug-in room and other self-contained air-conditioning and heat pump equipment from 1 January 2025.

No manufacturing emissions are assumed. The lifetime emission factor is 2,5% per year, the same as the inventory [9]. This means that at the end of lifetime 0,7 kg of refrigerant remains in the equipment.

As for refrigerators, it is assumed that a substantial part of the equipment is disposed incorrectly and/or refrigerants are lost during transport, resulting in an assumed disposal emission factor of 70%. This is kept constant.

- **Heat pump tumble dryers**

Heat pump dryers have been on the EU market since 2004 and their penetration is increasing. Based on collected information, we estimated the scale of emissions from heat pump dryers in Belgium in 2022-2050.

It is assumed that 60% of households have a tumble dryer, based on the household budget survey of 2010. Annual sales of tumble dryers are estimated using an average lifetime of 15 years. It is estimated that each year around 200 000 tumble dryers are sold in Belgium. According to a 2019 Ecodesign study [10] 5,3 million tumble dryers are sold in the EU annually.

In more recent version, share of households with tumble dryer are not included. 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, which is kept constant for the entire projected period.

Dryers are equipped with either HFC-134a, R407C or R290, with quantities ranging between 220 and 430 g [11]. An average quantity of 300 g is assumed. The systems are hermetically sealed and for the German inventory in 2014 the operation emission factor is 0,3%, which we have used as well for the inventory and projections. This does not change in time.

The share of heat pump dryers equipped with HFC-134a, R407C or R290 is not known exactly. HFCs have been predominantly used in tumble dryers, but they have been increasingly replaced by alternatives. Companies are switching to alternatives, such as R450C[6] or propane. While there was concern that natural refrigerants alter the efficiency, more and more models are found on market that achieve an A+++ label [10]. Propane has been used since 2015 and is growing rapidly.

In the WEM scenario, we have assumed shares of 46% HFC-134a, 20% R407C and 35% R290 in 2021. The share of R290 is expected to continue to grow with 5%-points per year, until it completely replaces all equipment with HFC-134A (annual 3,5%-points decrease) and R407C (annual 1,5%-points decrease) in 2034.

In the WAM scenario, the amended F-gas regulation extends the prohibition of the use of refrigerants with a GWP value of 150 or more to plug-in room and other self-contained air-conditioning and heat pump equipment from 1 January 2025. This is assumed to apply for tumble dryers (as is considered in the impact assessment). This means a sharp decrease of F-gas containing tumble dryers sold in Belgium between 2023 (from 42% HFC-134a and 18% R407C) to the complete phase-out in 2025.

The disposal emission factor is 70% as for movable air-conditioning. At the moment, few tumble dyers with heat pump are dismantled correctly (Coolrec, pers. comm.).

- **Heat pump boilers**

Sales statistics are available from UBF-ACA and FRIXIS. In 2021 more than 8 000 were installed. For the projections we assume an annual growth rate of equipment placed on the market of 10% until 2030 (almost 20 000 new units placed on the market) and stable sales after 2030. This results in a total stock of heat pump boilers of 160 000 in 2030 (compared to 54 000 in 2021). After 2030, sales of new equipment is not as important as few (WEM) or no (WAM) new equipment will use HFCs.

We assume that boilers have an average lifetime of 15 years. This means that disposal and related emissions have not yet occurred, but start to be important from 2023 onwards.

Heat pump boilers mainly use HFC-134a as refrigerant. For simplification, 100% of heat pumps are assumed to be equipped with HFC-134a with a charge of 800 g in 2021.

In the WEM scenario, the use of HFC-134a in new equipment decreases steadily to 95% in 2022, 90% in 2023 and afterwards with 10%-points annually until no heat pump boilers with HFC-134a are sold in 2033.

In the WAM scenario, the prohibition of the use of refrigerants with a GWP value of 150 or more to plug-in room and other self-contained air-conditioning and heat pump equipment from 1 January 2025 of the amended F-gas regulation is taken into account. It is assumed that in three years the sales of heat pump boilers with HFC-134a will be replaced by non-HFC refrigerants.

[6] https://www.fluorocarbons.org/news/heat-pump-tumble-dryer-uses-lower-gwp-r-450a-to-replace-r-134a/

Heat pump boilers are hermetically-sealed systems and emissions during use are not high, so an emission factor of 2% is assumed (similar to the inventory). The disposal emission factor is assumed to be 70%.

- **Room air-conditioners and heat pumps**

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 2021. Projected consumption and emissions of R410A, R32 and HFC-134a for this plant are made consistent with the projected evolution of the gases placed on the market (e.g. if there is a 5%-points decrease of R410A placed on the market, the consumption for manufacturing of R410A also decreases with 5%-points). All manufacturing emissions are allocated to this sub-sector. The manufacturing emission factor is 1%.

Sales statistics from FRIXIS and UBF-ACA have used different classifications. For the inventory the sales statistics are split into two categories: room air-conditioners up to 7kW and room air-conditioners larger than 7 kW. This also includes heat pumps. A similar split is used for the projections. The sale of heat pumps and room air-conditioners is expected to increase as part of EU energy and climate ambitions. As for heat pump boilers an annual growth of sales of 10% is assumed until 2030. Up until 2030 this means a consistent growth compared to the period 2010-2021. In 2030, it is assumed that a total of 390 000 new installations are placed on the market, 290 000 up to 7 kW and 100 000 larger than 7 kW. The total stock of room air-conditioners and heat pumps is 2,9 million.

Assumptions on the characteristics of room air-conditioning were based on the French and German F-gas inventories. For the projections, the share of refrigerants is presented in Table 3-7. Assumptions are taken from the EU impact assessment [5] and the Umweltbundesamt report [12] and made consistent with the equipment types used in the projections.

Table 3-8. Assumptions WEM and WAM scenario for room air-conditioners.

	R410A	R32	R290 and HFO*
RAC < 7kW			
2021	43%	56%	0%
WEM – 2030	0%	40%	60%
WEM – 2050	0%	30%	70%
WAM – 2030	0%	5%	95%
WAM – 2050	0%	0%	100%
RAC > 7kW			
2021	46%	53%	0%
WEM – 2030	8%	32%	61%
WEM – 2050	5%	25%	70%
WAM – 2030	1%	2%	97%
WAM – 2050	0%	0%	100%

Note: For room air-conditioners and heat pumps it is expected that HFO blends could be increasing used, such as R454A, R454 and R454C. For our assessment this was allocated either to R32 or to the R290 and HFO category based on the share of R32 and HFOs in the blends and assumed use of these blends in future.

In the WEM scenario, R407C and R410A which have been used predominantly in the past will be replaced by R32 and non-HFC alternatives, such as R290 and HFOs. While the share of R32 will decrease, in 2050, 30% (equipment up to 7 kW) and 25% (equipment larger than 7 kW) of new installations will still use R32.

In the WAM scenario, driven by the proposal for the amended F-gas regulation, this transition will be much quicker and only few equipment will be placed on the market with R32 in 2030.

The lifetime emission factor is kept constant throughout the period 2021-2050 in both the WEM and WAM scenario, 4% and 5% for respectively equipment up to 7 kW and equipment larger than 7 kW.

The disposal emission factor is also kept constant at 70%.

- **Chillers**

The projected emissions from chillers are based on two different calculation methods. One bottom-up calculation and a top-down estimate based on the supply of R407C and R410A on the Belgian market.

R407C and R410A are predominantly used for stationary air-conditioning and chillers. Bottom-up calculations of the quantities used for filling and re-filling each year do not fully account for all R407C and R410A placed on the market. In the inventory, these remaining R407C and R410A quantities, and subsequent emissions, are allocated to the sector chillers. For the projections, these remaining top-down emissions will follow a similar trend as the bottom-up calculation with 2021 as reference year.

Changes in sales statistics of chillers are assumed to remain consistent with the growth in population size for the period 2021-2050. Recent annual sales statistics for chillers do not change much. An average lifetime of 15 years was assumed.

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 for all years, averages are used for all chillers. BSRIA[20] assumed that approximately 60% of chillers are up to 100 kW and 40% larger than 100 kW.

Data for the evolution of the share of refrigerants used was taken from the EU impact assessment. Based on 2018 detailed statistics on the characteristics of chillers placed on the Belgian market (FRIXIS, pers. comm.), the assumptions in the EU study were translated to match all chillers.

In the WEM scenario in 2030, it is assumed that 7% use R410A, 1% use HFC-134a, 35% use R32 and the remaining 57% use non-CRF gases, such as ammoniac. By 2050 the latter share has increased to 70% with a substantial share of new chillers with R32 remaining (25%).

In the WAM scenario, the transition to non-CRF happens faster and by 2030 17% of new chillers uses R32, 1% uses R407C and the remainder is non-CRF gases. By 2050 new chillers are exclusively equipped with non-CRF gases.

The disposal emissions are assumed to be 70% [13].

Table 3-9. Assumptions WEM and WAM scenario for chillers.

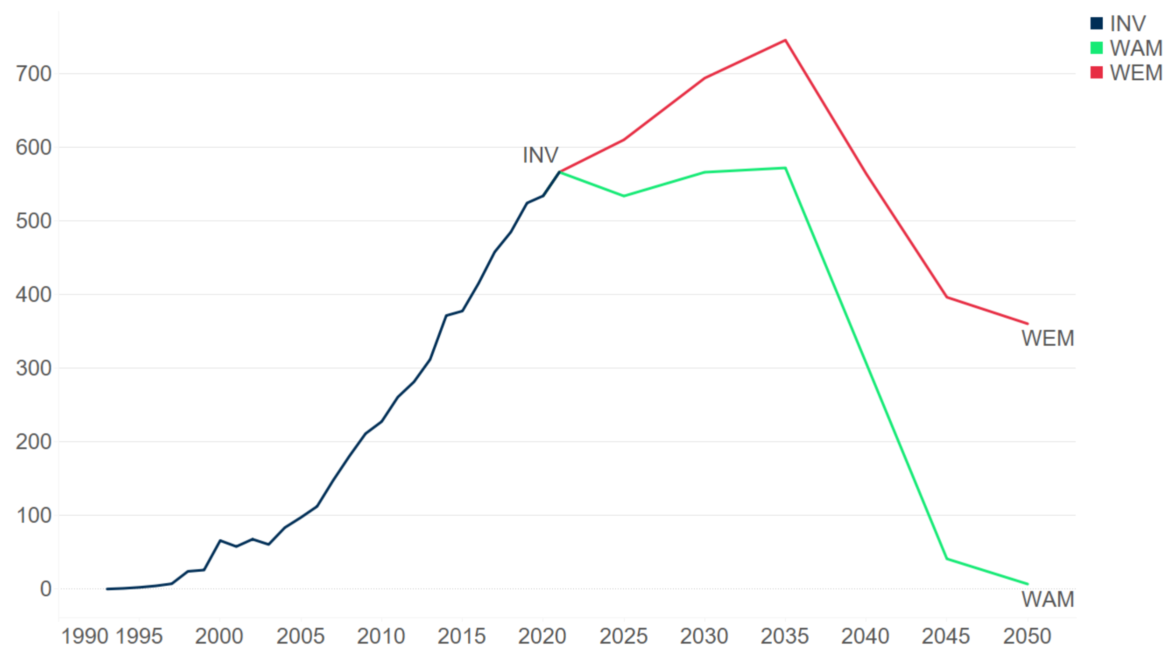
	R407C	R410A	HFC-134a	R32	Other*
2021	0%	67%	20%	0%	17%
WEM – 2030	0%	7%	1%	35%	53%
WEM – 2050	0%	5%	1%	25%	69%
WAM – 2030	0%	1%	0%	17%	82%
WAM – 2050	0%	0%	0%	0%	100%

Note: E.g. R717

Results

Emissions from stationary air-conditioning are projected to have a different trend than most other sectors. The increasing demand for heat pumps, heat pump boilers, and air-conditioning has as effect that emissions will continue to increase (WEM) or stagnate (WAM) up to 2035.

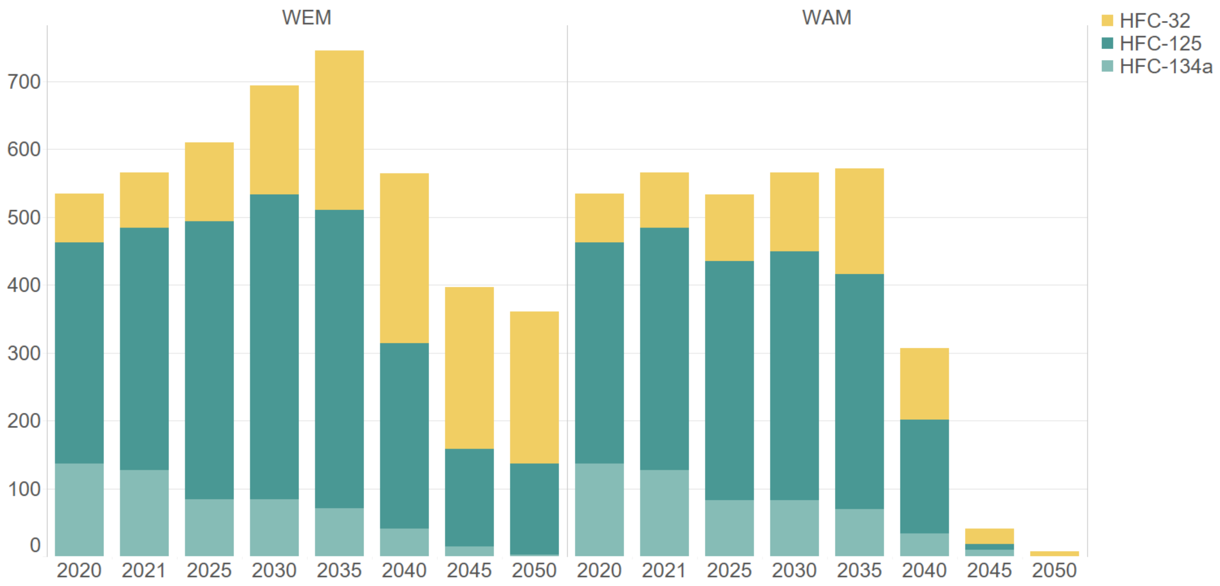
Figure 3-8. Total emissions from stationary air-conditioning in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

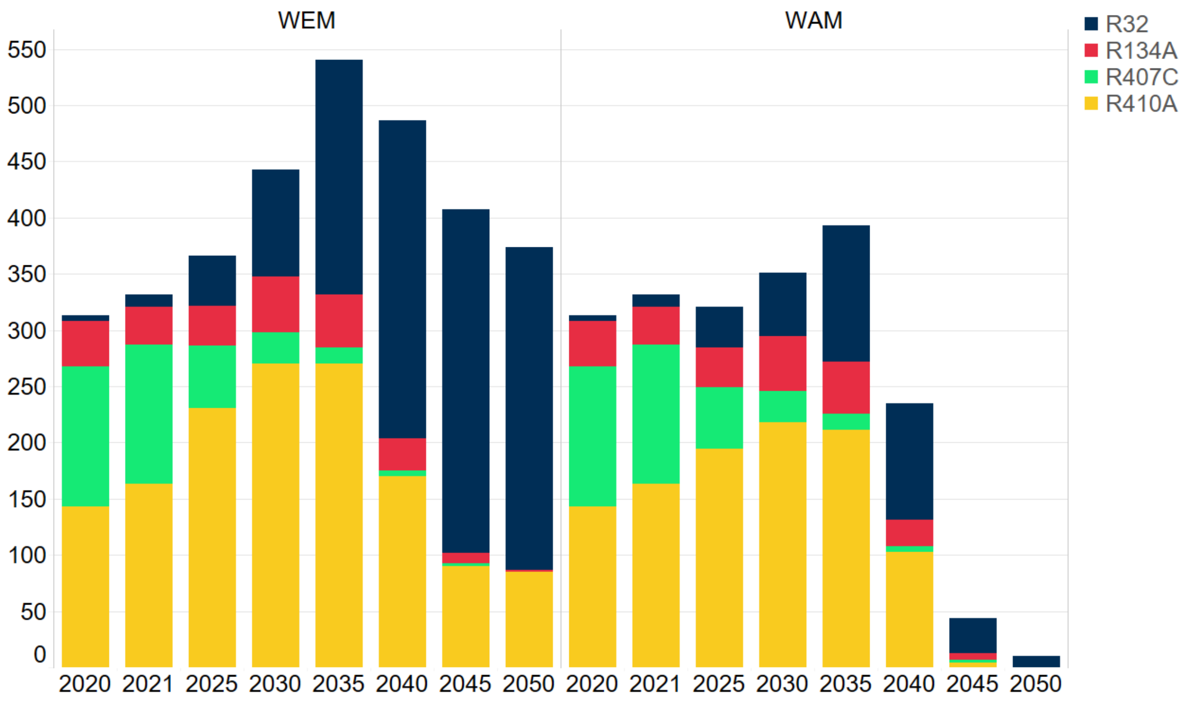
The most substantial difference between the WEM and WAM scenario is R32. R32 is a low-GWP refrigerant increasingly used in recent years in heat pumps and air-conditioning. Under the WEM scenario R32 continues to be an alternative, while in the WAM scenario R32 is also phased-out and replaced by non-CRF gases, following the proposal for amendment of the F-gas regulation.

Figure 3-9. Emissions from stationary air-conditioning by substance in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

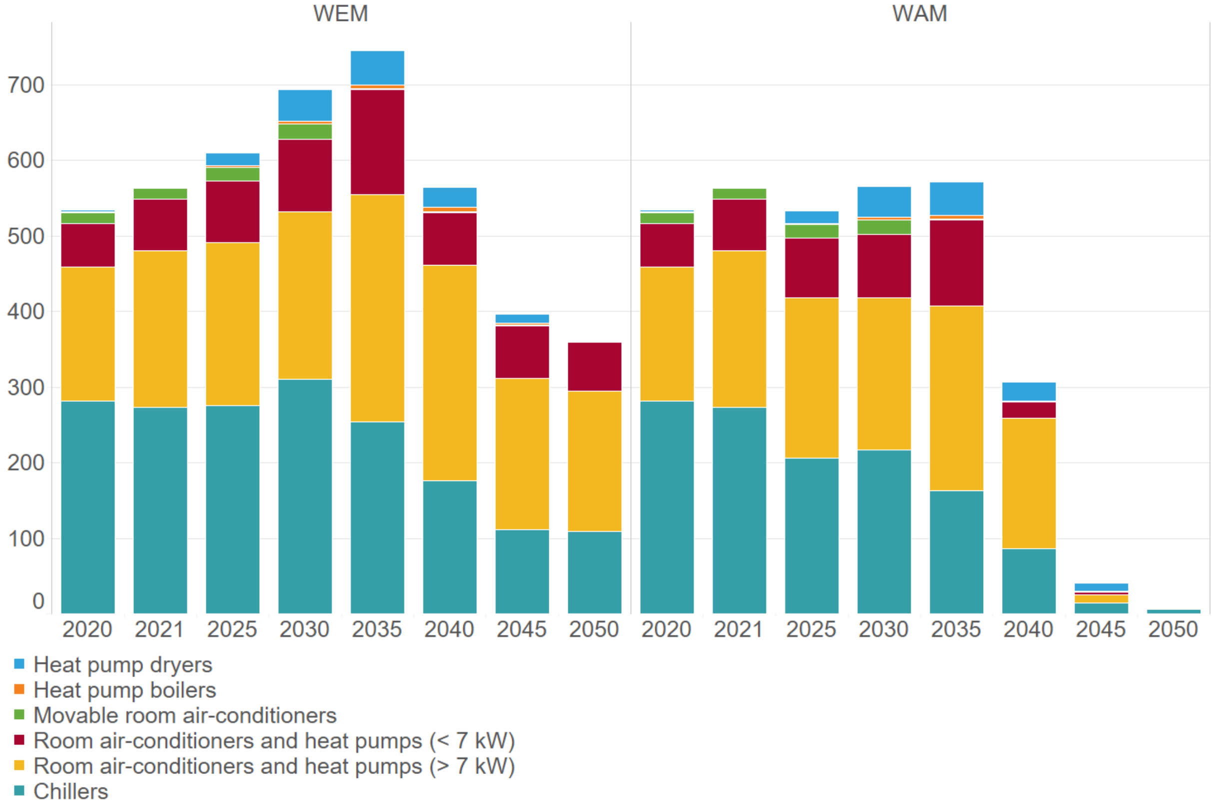
Figure 3-10. Emissions from stationary air-conditioning by refrigerants in Belgium (in t).



Source: VITO, Econotec (own calculations, 2022).

In the CRF category of stationary air-conditioning, the chillers and large room air-conditioners and heat pumps (of more than 7 kW) are the most important sources of emissions in future because of the higher quantities of refrigerants used per equipment. The difference between the WEM and WAM scenario is also mostly related to these two sources.

Figure 3-11. Emissions from stationary air-conditioning by source in Belgium (in t).



Source: VITO, Econotec (own calculations, 2022).

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

3.5.1 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

For the projections, the emissions from closed cell foams are calculated in the same way as for the emission inventory, from:

- the annual consumptions of fluorinated greenhouse 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,

where the emission factors have been kept constant, equal at their values in the emission inventory.

The end-of-year bank of fluorinated greenhouse 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 consumption of HFC-134a for manufacturing extruded polystyrene foam is prohibited since 1 January 2020. For manufacturing polyurethane foam, the consumption of HFC-134a, HFC-245fa, HFC-365mfc and HFC-227ea will be prohibited from 1 January 2023, and has already ceased (except for a switch-back to HFC grades in 2022 for 2-component spray foam forced by non-availability of equivalent HFO grades).

Future emissions are therefore only determined by passed consumptions.

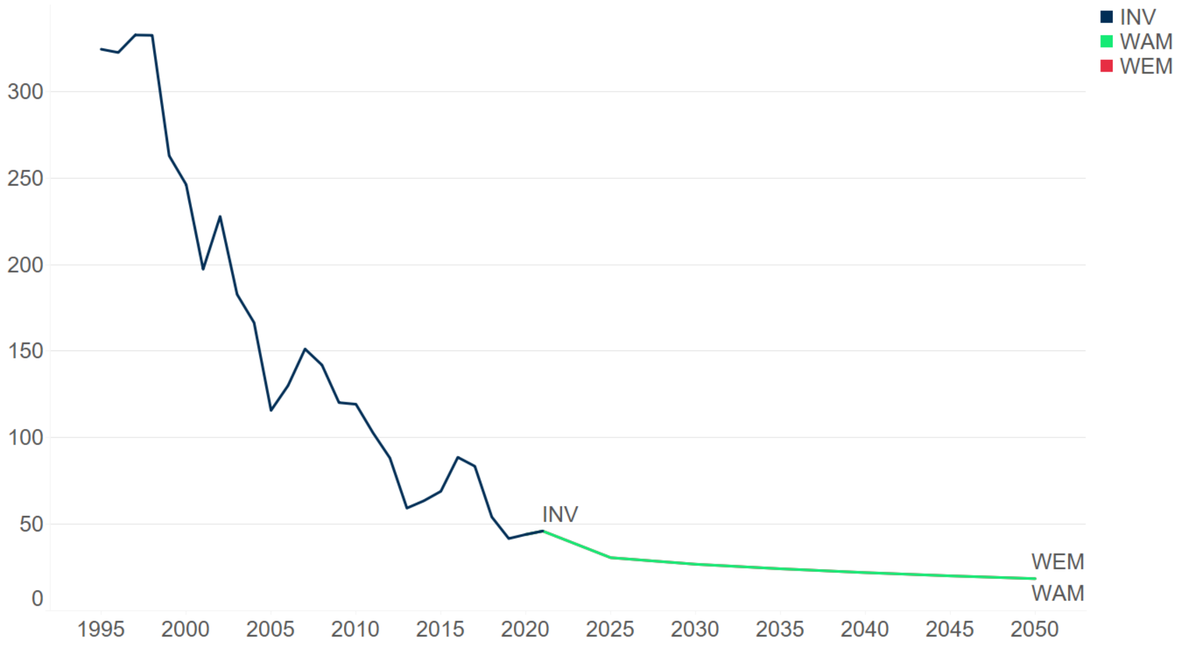
As refrigerators are not manufactured in Belgium, emissions from domestic refrigerator foams are evaluated in a similar way as emissions from refrigerator refrigerants, based on a model of the refrigerator stock. The foam of domestic refrigerators and freezers contains HFC-245fa. The emissions of Kyoto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

The recovery or destruction of fluorinated greenhouse 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.

No difference is made between the WEM and the WAM scenario.

Results

Figure 3-12 Total emissions from stationary air-conditioning in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

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

Introduction

Belgium produces One-Component-Foam (OCF) and canister foam.

Methodology

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. A future HFC consumption for manufacturing is not expected anymore for this kind of foam. For this product HFC-134a is totally replaced by HFO-1234ze since 2019.

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. They are low and have been kept constant at their latest value.

No difference is made between the WEM and the WAM scenario.

3.6 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. The main HFC used in fixed systems are HFC-227ea and HFC-125. However in recent years alternatives have been increasingly used and it is assumed that no new installation using HFC-227ea and HFC-125 have been installed in 2021 in Belgium.

Methodology

No new equipment containing HFC is installed in both the WEM and WAM scenario. In some cases, HFCs might be replaced by a non-CRF gas alternative before the end of life of an installation. For our assessment we have not taken this into account, considering the high level of uncertainty linked to the rate of these refurbishments.

Emission factors are kept the same from the emission inventory.

Table 3-10. Assumptions EU impact assessment fire protection.

	R227ea	R125	Low GWP
Baseline – 2030	0%	0%	100%
Baseline – 2050	0%	0%	100%
Proportionate action – 2030	0%	0%	100%
Proportionate action – 2050	0%	0%	100%

Source: Öko-recherche, Ricardo, Öko-institut (2022) [5]

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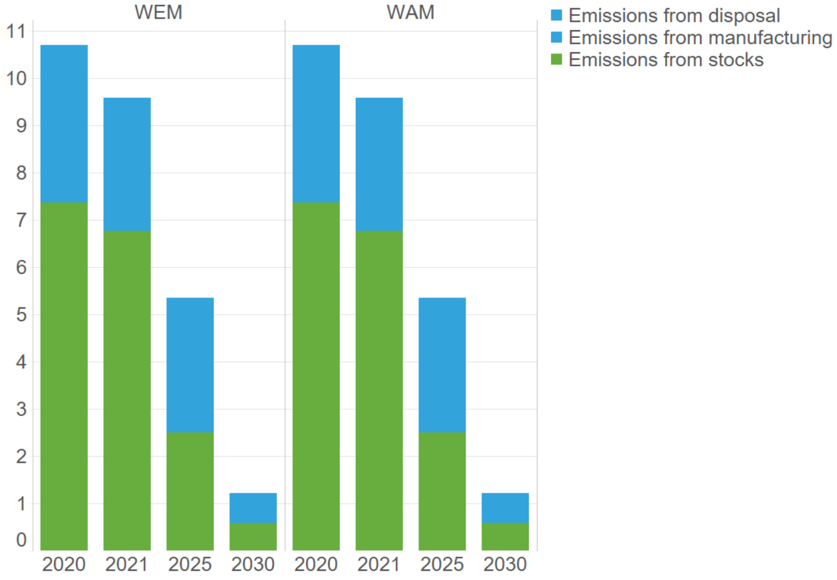
Results

The phase-out of HFCs results in rapidly decreasing emissions and after 2030 emissions will drop to zero. This is a conservative estimate as the early replacement of HFCs in existing installation will speed up the emission reduction in the WEM and WAM scenario.

Figure 3-13. Total emissions from fire protection in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

3.7 Aerosols (2.F.4.)

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

Introduction

As for the inventory, emissions are assumed to be equal to the quantity of F-gas contained in the products sold in Belgium.

Methodology

EU Regulation 517/2014 does not contain any specific provision for MDIs. The consumption of HFCs in metered dose inhalers is assumed to remain proportional to the population level. It is thereby assumed that the increase in the prevalence of asthma (number of persons suffering from asthma par 1000 persons) is compensated by a decrease in the spray quota (share of MDI vs. powder devices of nebulisers in the total of inhale therapy).

Pressurised MDIs used in Belgium contain essentially HFC-134a, a marginal portion still containing HFC-227ea. Currently no alternative propellant is available, but starting in late 2025, HFC-152a will be introduced on the market after an extensive period of testing [28].

For the WEM scenario, we have taken over the assumptions of the Baseline scenario considered for the EU in [28]:

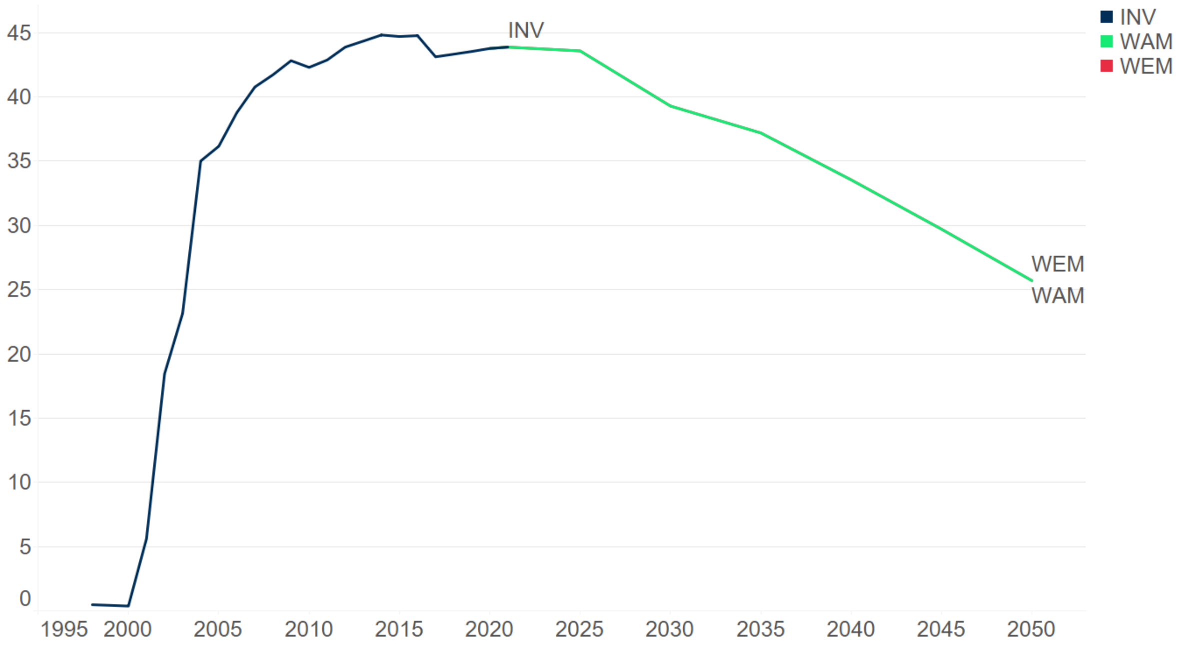
- the disappearance of HFC-227ea in new inhalers in 2022 (from 1,6% in 2021);
- 100% HFC-134a from 2022 to 2025;
- a linear decrease in the share of HFC-134a from 100% in 2025 to 48% in 2050.

Research is being conducted on the safety of HFO-1234ze, but to date it is not possible to properly assess the development on the market for this gas.

We have made no difference between the WEM and the WAM scenarios.

Results

Figure 3-14. Total emissions from MDI in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

3.7.2 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. 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. HFC-152a can still be used both according to the F-gas regulation and the proposal for amendment.

Methodology

Reporting is 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. For projections a conservative estimate is used of a constant manufacturing emission of 1,3 t HFC-152a, the average emissions of the latest 4 years.

Technical aerosols 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 Belgium. For the inventory, emissions from use are estimated based on per capita emissions of Germany.

The average emission factor in 2020 was 0,0313 g per person. This factor was used to estimate projected emissions.

Results

With the prohibition of the use of HFC-134a in technical aerosols, emissions are already low in 2021 and continue to be low (< 1 kt CO_2-eq.) in the projections.

3.8 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. 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. There are alternative technologies to using SF6 already commercially 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 [14].

ELIA (pers. comm.) plan to reduce emissions from SF6 switchgear as part of their act now programme. ELIA foresees a substantial increase in installed SF6 in new installations due to increased electrification and renewable energy. This growth is however reduced by EILA’s ambition to switch to alternatives before 2030. The amended F-gas regulation imposes restrictions to the use of SF6 in different switchgear applications.

Methodology

For SF6 used in switchgear for production, increase in wind energy is taken into account. In the WEM scenario, the quantity of SF6 in switchgear in wind turbines is assumed to increase from 4,9 t to 7,7 t in 2030, based on the Belgian NECP and plans for expanding on- and offshore wind energy. Quantities of SF6 for transport are expected to increase with on average 17,6 t SF6 per year until 2030. This takes into account the Act Now programme of ELIA to reduce the new SF6 volume with 50% compared to the business-as-usual scenario. For distribution an annual increase of 3 t new equipment (average last 3 years) is assumed. After 2030 it is assumed that only new installations with SF6 are installed to replace switchgear that is end of life.

In the WAM scenario, the prohibitions of using SF6 in medium- and high-voltage switchgear are taken into account.

Fugitive emission factors are kept constant and are 1,1%, 1% and 0,02% for respective production, transport and distribution. The disposal emission factor is assumed to be 1,5% for future, the same as for the inventory. Disposal is expected to start in 2025 for production and from 2034 for transport and distribution.

Table 3-11. Assumptions EU impact assessment electrical equipment.

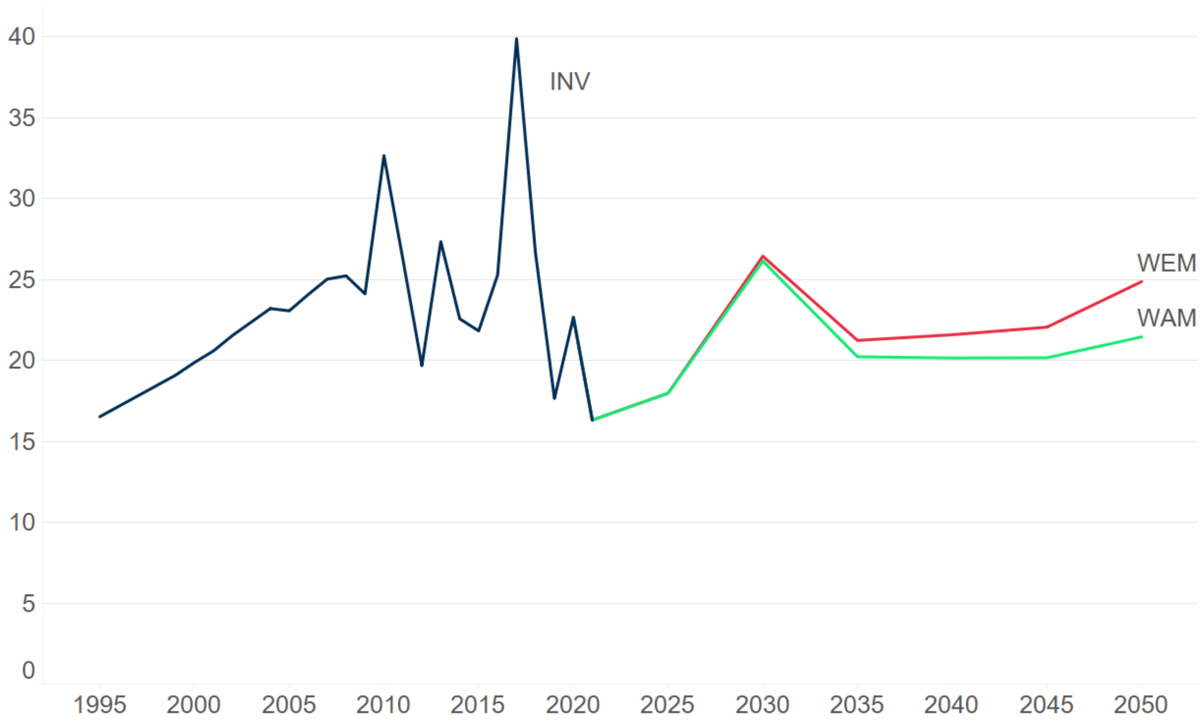
	SF6	Novec 5110	Air
Medium switchgear			
Baseline – 2030	100%		
Baseline – 2050	100%		
Proportionate action – 2030	61.4%	12.9%	25.8%
Proportionate action – 2050	5.0%	63.3%	31.7%
High voltage switchgear			
Baseline – 2030	100%		
Baseline – 2050	100%		
Proportionate action – 2030	61.4%	12.9%	25.8%
Proportionate action – 2050	5.0%	63.3%	31.7%

Source: Öko-recherche, Ricardo, Öko-institut (2022) [5]

Results

As a consequence of ELIA's act now programme, the difference between the WEM and WAM scenario is smaller than could be anticipated.

Figure 3-15. Total emissions from switchgear in Belgium (in kt CO_2-eq).



Source: VITO, Econotec (own calculations, 2022).

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

3.10 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. This was prohibited from July 2007 (domestic windows) and July 2008 (other windows).

Methodology

As use of SF6 is prohibited, the only emissions occurring are operational emissions (from the slowly decreasing bank of SF6 in glass) and disposal emissions. Existing and planned policies do not have an effect on assumptions relating to the annual loss factor from the bank (assumed to be 1%) and disposal emissions (100%).

Results

It is estimated that after 2030 there will be no further emissions from this emission source.

Figure 3-16. Total emissions from soundproof windows in Belgium (in kt CO_2-eq).

Source: VITO, Econotec (own calculations, 2022).

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

The use of SF6 in sport shoes stopped in 2003, and use of C3F8 stopped in 2006. With an average lifetime of 3 years, it is assumed that all shoes with SF6 or C3F8 have been disposed. Emissions in WEM and WAM projections are zero.

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ANNEX A EMISSION TABLES

A.1 Emissions of CRF F-gases by sector in kt CO_2-eq (AR5)

Table A-1. WEM emissions of CRF F-gases by CRF sector in Belgium (kt CO2-eq).

	2020	2021	2025	2030	2035	2040	2045	2050
Fluorochemical production	840,2	274,7	219,3	150,0	150,0	150,0	150,0	150,0
Commercial refrigeration	1.436,7	1.292,8	1.018,9	279,2	135,5	68,8	58,1	55,8
Stationary air-conditioning	533,9	566,0	609,9	693,6	745,1	564,0	396,3	360,3
Mobile air-conditioning	341,9	305,3	209,4	109,3	118,8	120,8	123,1	128,5
Transport refrigeration	22,3	17,9	18,0	7,5	4,4	1,3	0,3	0,2
Fire protection	10,7	9,6	5,4	1,2	0,0	0,0	0,0	0,0
Solvents	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Closed cell foam	44,1	46,1	30,7	26,9	24,3	22,1	20,2	18,6
Electrical equipment	11,3	8,2	10,6	12,7	10,5	10,6	10,8	12,2
Metered dose inhalers	43,8	43,9	43,6	39,3	37,2	33,5	29,7	25,7
Solvents	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Soundproof windows	73,9	71,3	83,4	8,6	0,0	0,0	0,0	0,0
Other	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total	**3.412,2**	**2.680,3**	**2.293,1**	**1.370,7**	**1.268,3**	**1.013,5**	**831,0**	**793,7**

Table A-2. WAM emissions of CRF F-gases by CRF sector in Belgium (kt CO2-eq).

	2020	2021	2025	2030	2035	2040	2045	2050
Fluorochemical production	840,2	274,7	219,3	75,0	75,0	75,0	75,0	75,0
Commercial refrigeration	1.436,7	1.292,8	814,1	232,1	110,2	62,7	51,8	49,1
Stationary air-conditioning	533,9	566,0	533,6	565,9	571,8	307,0	41,3	7,1
Mobile air-conditioning	341,9	305,3	208,3	104,5	108,3	105,0	101,8	98,9
Transport refrigeration	22,3	17,9	18,0	7,4	4,3	1,0	0,1	0,1
Fire protection	10,7	9,6	5,4	1,2	0,0	0,0	0,0	0,0
Solvents	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Closed cell foam	44,1	46,1	30,7	26,9	24,3	22,1	20,2	18,6
Electrical equipment	11,3	8,2	10,6	12,6	9,5	9,3	9,1	8,9
Metered dose inhalers	43,8	43,9	43,6	39,3	37,2	33,5	29,7	25,7
Solvents	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Soundproof windows	73,9	71,3	83,4	8,6	0,0	0,0	0,0	0,0
Other	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total	**3.412,2**	**2.680,3**	**2.010,8**	**1.116,0**	**983,0**	**657,9**	**371,3**	**325,8**

ANNEX B GWP AND ODP VALUES

Gas	Group		GWP (AR4)	GWP (AR5)	GWP (AR6)	GWP	ODP
HFC-125	HFC	CRF	3500	3170	3740	3170	
HFC-134	HFC	CRF	1100	1120	1260	1120	
HFC-134a	HFC	CRF	1430	1300	1530	1300	
HFC-143	HFC	CRF	353	328	364	328	
HFC-143a	HFC	CRF	4470	4800	5810	4800	
HFC-152	HFC	CRF	53	16	21,5	16	
HFC-152a	HFC	CRF	124	138	164	138	
HFC-161	HFC	CRF	12	4	4,84	4	
HFC-227ea	HFC	CRF	3220	3350	3600	3350	
HFC-23	HFC	CRF	14800	12400	14600	12400	
HFC-236cb	HFC	CRF	1340	1210	1350	1210	
HFC-236ea	HFC	CRF	1370	1330	1500	1330	
HFC-236fa	HFC	CRF	9810	8060	8690	8060	
HFC-245ca	HFC	CRF	693	716	787	716	
HFC-245fa	HFC	CRF	1030	858	962	858	
HFC-32	HFC	CRF	675	677	771	677	
HFC-365mfc	HFC	CRF	794	804	914	804	
HFC-41	HFC	CRF	92	116	135	116	
HFC-43-10-MEE	HFC	CRF	1640	1650	1650	1650	
NF3	NF3	CRF	17200	16100	17400	16100	
C10F18	PFC	CRF	7500	7190	7480	7190	
C2F6	PFC	CRF	12200	11100	12400	11100	
C3F8	PFC	CRF	8830	8900	9290	8900	
C4F10	PFC	CRF	8860	9200	10000	9200	
C5F12	PFC	CRF	9160	8550	9220	8550	
C6F14	PFC	CRF	9300	7910	8620	7910	
c-C3F6	PFC	CRF	17340	9200	9200	9200	
c-C4F8	PFC	CRF	10300	9540	9540	9540	
CF4	PFC	CRF	7390	6630	7380	6630	
SF6	SF6	CRF	22800	23500	25200	23500	
CFC-11	CFC	ODS	4750	4660	5560	2920	1
CFC-113	CFC	ODS	6130	5820	6520	4370	0,8
CFC-114	CFC	ODS	14400	8590	9430	8516	1
CFC-115	CFC	ODS	7370	7670	9600	9377	0,6
CFC-12	CFC	ODS	10900	10200	11200	9100	1
CFC-13	CFC	ODS	14000	13900	16200	13900	1
Halon 1211	Halons	ODS	1890	1750	1930	-17070	3
Halon 1301	Halons	ODS	7140	6290	7200	-37300	10
Halon 2402	Halons	ODS	1640	1470	2170	-29830	6
HCFC-123	HCFC	ODS	77	79	90,4	53	0,02
HCFC-124	HCFC	ODS	609	527	597	551	0,022
HCFC-141b	HCFC	ODS	725	782	860	599	0,11
HCFC-142b	HCFC	ODS	2310	1980	2300	2148	0,065
HCFC-22	HCFC	ODS	1810	1760	1960	1862	0,055
HCFC-31	HCFC	ODS	79,4	79,4	79,4	79,4	0,02
CCL4	Other ODS	ODS	1800	1730	2200	90	1,1
MB	Other ODS	ODS	5	2	2,43	-1248	0,6
HCFO-1233ZD	HCFO	Other	5	5	3,88	3,88	
HFO-1234mzz	HFO	Other	2	2	2,08	2,08	
HFO-1234yf	HFO	Other	4	4	0,501	0,501	
HFO-1234ze	HFO	Other	6	6	1,37	1,37	
(C2F5)OF	Other	Other	10000	10000	10000	10000	
ANDERE_OFCS	Other	Other	8985	8985	8985	8985	

Gas	Group		GWP (AR4)	GWP (AR5)	GWP (AR6)	GWP	ODP
C3F7NF2	Other	Other	10000	10000	10000	10000	
C7F17N	Other	Other	10000	10000	10000	10000	
C8F16O	Other	Other	10000	10000	10000	9400	
C8F19N	Other	Other	10000	10000	10000	10000	
CF3CF2CH3	Other	Other	4620	4620	4620	4620	
CF3CF2CHF2	Other	Other	2640	2640	2640	2640	
CF3CH2CF3	Other	Other	9810	8060	8060	8060	
CF3CHFOCF3	Other	Other	3220	3350	3350	3350	
CF3COF	Other	Other	2000	2000	2000	2000	
CF3SF5	Other	Other	17400	17400	17400	17400	
CH2=CF2	Other	Other	1	1	1	1	
CHF2CF2CF2CF3	Other	Other	2360	2360	2360	2360	
COF2	Other	Other	2	2	2	2	
Dimethylether	Other	Other					
HFP	Other	Other	0,05	0,05	0,05	0,05	
HFP_dimeer	Other	Other	1	1	1	1	
HFP_trimeer	Other	Other	1	1	1	1	
LBA	Other	Other	8985	8985	8985	8985	
OPEN_RINGEN	Other	Other	10357	10357	10357	10357	
PBSF	Other	Other	2000	2000	2000	2000	
PEM	Other	Other	10000	10000	10000	10000	
PFPMIE	Other	Other	10300	9710	10300	10300	
PFS	Other	Other	2000	2000	2000	2000	
PIPM	Other	Other	10960	10960	10960	10960	
PMM	Other	Other	9509	9509	9509	9509	
PNPM	Other	Other	10960	10960	10960	10960	
PTBA	Other	Other	9073	9073	9073	9073	
PTPA	Other	Other	8896	8896	8896	8896	
SF5CF3	Other	Other	17700	17400	18500	17400	
SO2F2	Other	Other	4090	4090	4090	4090	
C7F16	PFC	Other	7820	7820	8410	8410	
C8F18	PFC	Other	8000	8000	8260	8260	

Note: The GWP values used throughout the report is the column in yellow, which combines GWP AR5 values for CRF gases and GWP values based on latest available evidence for non-CRF gases.

GWP: Global Warming Potential, ODP: Ozone Depleting Potential, AR4: Fourth Assessment Report of the IPCC, AR5: Fifth Assessment Report of the IPCC, AR6: Sixth Assessment Report of the IPCC.

For ozone depleting substances, the GWP values used are net GWPs taking into account the indirect greenhouse effect of these substances, evaluated as the average of two extreme values (when relevant data are available).

ANNEX C REFRIGERANT MIX COMPOSITION

ASHRAE Number	GWP AR4 (*)	GWP AR5 (*)	GWP AR6 (*)	R22 HCFC	R124 HCFC	R142b HCFC	R23 HFC	R32 HFC	R125 HFC	R134a HFC	R143a HFC	R152a HFC	R227ea HFC	R116 PFC	R218 PFC	R1234yf HFO	R1234ze HFO	CF3I	R290 Propane	R600 Butane	R600a Isobutane	R601 Pentane	R601a Isopentane	R744 CO2
R401A	1258	1260	1263	53,0%	34,0%							13,0%												
R402A	2845	2647	2989	38,0%					60,0%										2,0%					
R403B	4541	4569	4721	56,0%											39,0%				5,0%					
R404A	3922	3943	4728						44,0%	4,0%	52,0%													
R407A	2107	1923	2262					20,0%	40,0%	40,0%														
R407C	1774	1624	1908					23,0%	25,0%	52,0%														
R407F	1825	1674	1965					30,0%	30,0%	40,0%														
R407H	1495	1378	1615					32,5%	15,0%	52,5%														
R408A	3222	3351	3856	47,0%					7,0%		46,0%													
R409A	1670	1670	1670	60,0%	25,0%	15,0%																		
R410A	2088	1924	2256					50,0%	50,0%															
R413A	2053	1945	2183							88,0%					9,0%						3,0%			
R417A	2346	2127	2508						46,6%	50,0%											3,4%			
R421B	3190	2890	3409						85,0%	15,0%														
R422A	3143	2847	3359						85,1%	11,5%											3,4%			
R422D	2729	2473	2917						65,1%	31,5%											3,4%			
R423A	2280	2274	2513							52,5%			47,5%											
R424A	2440	2212	2608						50,5%	47,0%										1,0%	0,9%		0,6%	
R426A	1508	1371	1614						5,1%	93,0%										1,3%			0,6%	
R427A	2138	2024	2397					15,0%	25,0%	50,0%	10,0%													
R428A	3607	3417	4061						77,5%		20,0%								0,6%	1,9%				
R434A	3245	3075	3654						63,2%	16,0%	18,0%										2,8%			
R437A	1805	1639	1930						19,5%	78,5%											1,4%	0,6%		
R438A	2265	2059	2425					8,5%	45,0%	44,2%										1,7%			0,6%	
R442A	1888	1754	2042					31,0%	31,0%	30,0%		3,0%	5,0%											
R448A	1387	1273	1494					26,0%	26,0%	21,0%						20,0%	7,0%							
R449A	1397	1282	1504					24,3%	24,7%	25,7%						25,3%								
R450A	605	547	643							42,0%							58,0%							
R452A	2140	1945	2292					11,0%	59,0%							30,0%								
R452B	698	676	779					67,0%	7,0%							26,0%								
R453A	1765	1636	1905					20,0%	20,0%	53,8%			5,0%							0,6%			0,6%	
R454A	239	237	270					35,0%								65,0%								
R454B	466	467	531					68,9%								31,1%								
R454C	148	146	166					21,5%								78,5%								
R455A	148,2	146	166					21,5%								75,5%								3,0%
R466A	733	696	808					49,0%	11,5%									39,5%						
R507A	3985	3985	4775						50,0%		50,0%													
R508A	13214	11607	13258				39,0%							61,0%										
R508B	13396	11698	13412				46,0%							54,0%										
R513A	631,4	572	673							44,0%						56,0%								
R513B	596	540	635							41,5%						58,5%								
R515A	390	402	432										12,0%			88,0%								
R515B	293	299	322										8,9%				91,1%							

(*) except for non-CRF components, for which AR6 values are used

ANNEX D LIST OF EMISSION SOURCES

Category used in calculation sheets	CRF Sector	
Chemical_industry_ducted	2.B.9.a	Fluorochemical production
Chemical_industry_non-ducted	2.B.9.b	Fluorochemical production
Heat_transfer_fluids	2.E.4.	Heat transfer fluids
Semiconductor	2.E.1.	Integrated circuit or semiconductor
Bus_Coach	2.F.1.e	Mobile air-conditioning
Cars	2.F.1.e	Mobile air-conditioning
Chillers	2.F.1.f	Stationary air-conditioning
Closed_foam	2.F.2.a	Closed cell foam
Commercial_refrigeration	2.F.1.a	Commercial refrigeration
Commercial_sealed	2.F.1.b	Domestic refrigeration
Domestic_refrigeration	2.F.1.b	Domestic refrigeration
Fire_extinguishers	2.F.3.	Fire protection
Foam_refrigeration	2.F.2.a	Closed cell foam
HP_boilers	2.F.1.f	Stationary air-conditioning
MDI	2.F.4.a	Metered dose inhalers
Movables	2.F.1.f	Stationary air-conditioning
Open_foam	2.F.2.a	Closed cell foam
Other_vehicles	2.F.1.e	Mobile air-conditioning
RAC_MIN_7	2.F.1.f	Stationary air-conditioning
RAC_PLUS_7	2.F.1.f	Stationary air-conditioning
Rail	2.F.1.e	Mobile air-conditioning
Refrigerated_transport	2.F.1.d	Transport refrigeration
Solvents	2.F.5.	Solvents
Technical_aerosols	2.F.4.b	Other aerosols (technical aerosols)
Tractors	2.F.1.e	Mobile air-conditioning
Trucks	2.F.1.e	Mobile air-conditioning
Tumble_dryers	2.F.1.f	Stationary air-conditioning
Chemical_industry_lab	2.G.2.e	SF6 and PFCs from other product use
Glass	2.G.2.c	Soundproof windows
Shoes	2.G.2.d	Adiabatic properties: shoes and tyres
Switchgear	2.G.1.	Electrical equipment
CCl4	X.X.X.x	CCl4
Methyl bromide	X.X.X.x	Methyl bromide

ANNEX E 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

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