DANISH MINISTRY OF THE ENVIRONMENT

Environmental Protection Agency

Ozone depleting substances and the greenhouse gases HFCs, PFCs and SF6

Danish consumption and emissions 2003

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1 Summary

1.1 Ozone-depleting substances

ODP-weighted consumption for 2003 has been calculated at 17.36 ODP tonnes, a further reduction of 25.6 ODP tonnes compared to 2002, when consumption was 42.97 ODP tonnes.

The table below shows ODP-weighted consumption calculated on the basis of information on imports from importers and producers. The ODP values are listed in Appendix 1, Table 1.a.

Table 1.1 Overview of consumption and ODP-weighted consumption in 2002-2003, tonnes

Substance	Net consumption, 2002	ODP-weighted consumption, 2002	Net consumption, 2003	ODP-weighted consumption, 2003
CFCs [(1)]	0.95	0.76	0.1	0.08
Tetrachloro-methane	0.87	0.96	0.36	0.39
1,1,1-Trichloroethane	0.02	-	0.02	-
Halons	0	0	0	0
Methyl bromide	(only feedstock)	-	(only feedstock)	-
HCFCs HCFC-22 HCFC-123 HCFC-141b HCFC-142b	390 24.5 - 360 0	41.25 1.35 - 39.6 0	204.65 102.3 - 102.35 0	16.88 5.63 - 11.26 0
Total		42.97		17.36

(1) In the calculation of the ODP-weighted consumption of CFCs, CFC-113 is the only substance which has been reported and which is included in the calculation basis.

Danish consumption of methyl bromide has only been used as feedstock for other chemical production. Therefore it is not included as an emission.

CFCs, tetrachloromethane, and trichloroethane are used exclusively for laboratory purposes.

HCFCs are used as refrigerants or for foam production (system foam). The areas of application of HCFCs in 2003 are shown in Table 1.2.

Table 1.2 Consumption of HCFCs by application area in 2003, tonnes.

Application area	HCFC-22	HCFC-123	HCFC-141b	HCFC-142b
System foam (for panels, insulation, etc.)	0	0	102.35	0
Refrigerants, R22	96.7	0	0	0
Refrigerants, HFC mixtures	5.6			
Total	102.3	0	102.35	0

HCFC-22 is used as a refrigerant, and HCFC-141b is used in foam production.

Figure 1.1 shows the development of ODP-weighted consumption.

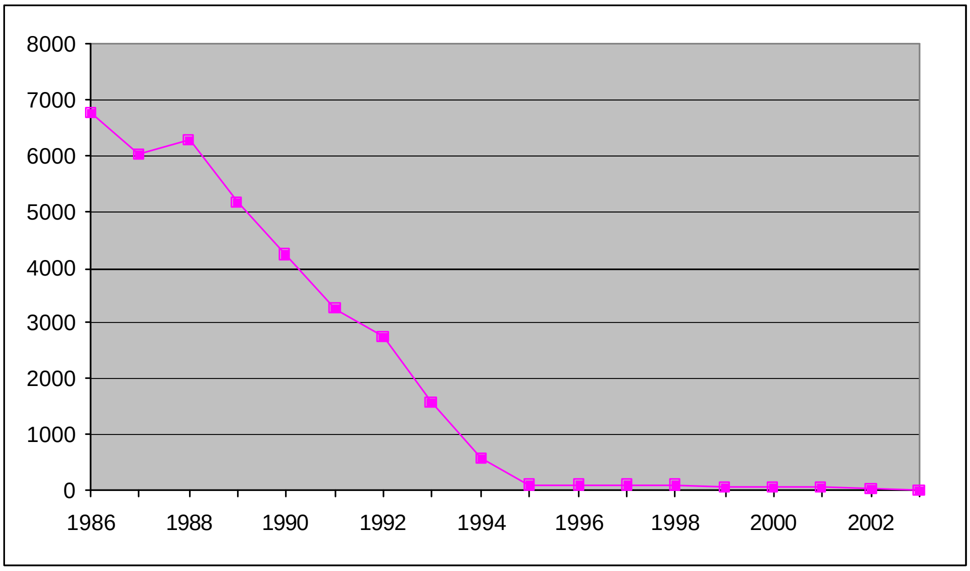

Figure 1.1 The development of ODP-weighted consumption 1986-2003, tonnes.

The specific consumption figures for individual substances and groups of substances and the ODP contribution calculated for the period 1986-2003 appear in Table 3.1 in Chapter 3.

1.2 Greenhouse gases

The GWP-weighted actual emissions of HFCs, PFCs, and SF_6 in 2003 were 745.6 thousand tonnes CO_2 equivalents. The corresponding emissions were 715.0 thousand tonnes CO_2 equivalents in 2002, as reported in /13/. However, an update has been made and the figure for 2002 has now been recalculated as 718.8 thousand tonnes, which corresponds to a total increase of 26.8 thousand tonnes CO_2 equivalents.[1]

Emissions of HFCs, PFCs, and SF_6 in 2002 contributed about 1 per cent of the total Danish GWP contribution /19/.

In Table 1.3 below, consumption, actual emissions and stock in products are summarised after making adjustments for any imports and exports of stock in products.

Source	Substance	Consump-tion and imports, DK	Stock	Actual emis-sions	GWP contribution	GWP contribution in total
Refrigerants for commercial stationary refrigerators and A/C systems	HFC-134a	84.7	726.6	72.7	94555	
	HFC-404a	134.5	857.9	82.6	269353	
	HFC-401a	0.2	25.4	3.2	57	
	HFC-402a	1.7	32.3	3.7	6144	
	HFC-407a	96.8	281.7	22.2	33783	
	HFC-507a	9.2	57.1	5.5	16963	
	Other HFCs	13.0	100.9	10.0	17217	
	PFCs	0.5	22.7	2.5	17591	
	All substances					**455662**
Household fridges/freezers						
Refrigerants	HFC-134a	94.1	764.9	9.2	11899	
	HFC-404a	4.3	71.8	0.8	2582	
Insulation foam	HFC-134	0.0	1380.8	78.1	101522	
	HFC-152	0.0	2.5	0.1	16	
	All substances					**116019**
Refrigerants for mobile A/C systems	HFC-134a	32.1	203.8	63.7	82860	**82860**
Refrigerated vans and lorries	HFC-134a	0.5	6.9	1.3	1744	
	HFC-404a	6.2	31.5	5.5	18083	
	HFC-402a	0.0	2.3	0.5	821	
	All substances					**20648**
Shoe soles	HFC-134a	3.5	0.3	1.7	2270	**2270**
Soft foam and aerosol sprays etc.	HFC-134a	26.3		26.4	34320	
	HFC-152a	3.3		3.3	212	
	All substances					**34532**
System foam	HFC-134a	0.0		0.0	0	
	HFC-152a	0.0		0.0	0	
	HFC-365	18.0		0.0	0	
	All substances					**0**
Liquid cleaners	PFCs	0.0		0.3	1750	**1750**
Double glazing	SF6	0.0	37.6	0.4	9440	**9440**

[1] Due to new knowledge about the consumption of SF_6, an update was made of the historical data, which means that 2002 emissions have been corrected upwards by 3.8 thousand tonnes CO_2 equivalents.

High-voltage power switches	SF6	1.9	63.5	0.4	10102	**10102**
Laboratories	SF6	0.4		0.4	9680	**9680**
Training shoes	SF6	0.0	0.5	0.1	2629	**2629**
Total	HFCs	528.3	4546.6	390.5	694401	
	PFCs	0.5	22.7	2.5	19341	
	SF6	2.3	101.5	1.3	31850	
GWP contribution	Total				**745592**	

Table 1.3 Consumption, actual emissions, stock, adjusted for imports/exports as well as GWP contribution from greenhouse gases 2003, tonnes.

In Figure 1.2 below, total GWP contributions from HFCs, PFCs, and SF_6 are shown in relation to individual sources. The figure shows the sources responsible for the greatest individual contributions in 2003.

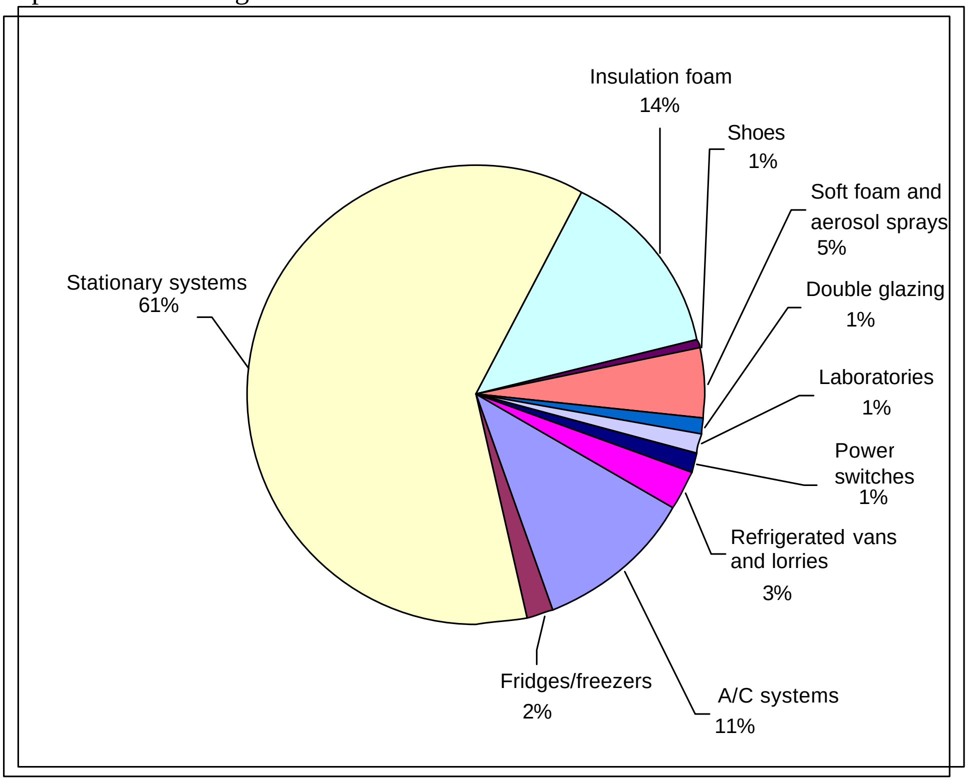

Figure 1.2 The relative distribution in 2003 of GWP contribution, analysed by source

The figure shows that emissions from refrigerants used in commercial stationary refrigerators account for the largest GWP contribution. These refrigerators make up 61% of the overall actual contribution in 2003. The contribution is primarily from HFCs, and a small part is from PFCs.

The second-largest GWP contribution, accounting for 14 per cent, comes from ongoing releases of HFCs from insulating foam in fridges and freezers.

Five per cent of the GWP contribution stems from HFC emissions released during the production of soft foam and from the use of HFC-based aerosol sprays.

The three most substantial sources of SF_6 emissions in 2003 were power switches, laboratories, and double glazing. These contributed more or less equally, and together account for about 3 per cent of the total GWP contribution.

HFCs comprise around 93.1 per cent of the overall GWP contribution in 2003. Emissions of SF_6 make up 4.3 per cent and emissions of PFC contribute 2.6 per cent to the total contribution.

The relative distribution is shown in Figure 1.3 below.

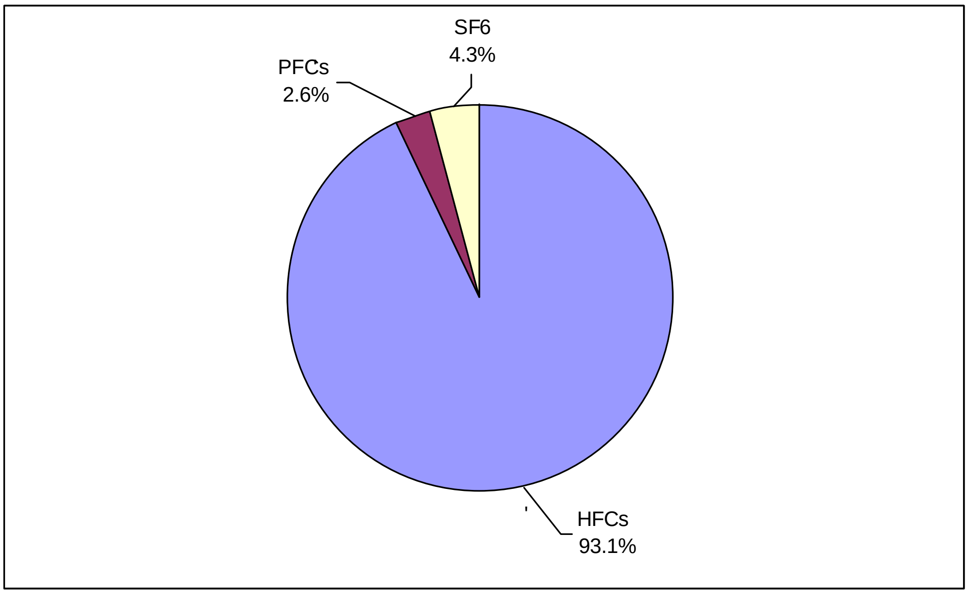

Figure 1.3 The relative distribution of the GWP contribution from HFCs, PFCs, and SF_6, 2003.

1.2.1 HFCs

In 2003, the total consumption of HFCs was 528.3 tonnes. This represents a significant reduction compared to 2002, when total consumption was around 713.2 tonnes. The consumption of HFC-134a has almost halved since 2002, because by and large the chemical is no longer used in foam production. The consumption of HFC-404A as a refrigerant in refrigerators has also been reduced, however to a lesser extent. HFC consumption is only continuing to increase with regards to HFC-407c. HFC-407c is frequently applied in new refrigerators, where previously the refrigerant HFC-22 was used.

The total GWP contribution from HFCs was 694.4 thousand tonnes CO_2 equivalents, which is an increase of 23.2 thousand tonnes compared to 2002.

1.2.2 Sulphur hexafluoride (SF_6)

The consumption of sulphur hexafluoride was 2.3 tonnes in 2003, which represents an increase compared to 2002, when consumption was 1.4 tonnes.

Actual emissions have been calculated at 1.3 tonnes, equivalent to a GWP contribution of 31.9 thousand tonnes CO_2 equivalents. In 2002, emissions were about 25.5 thousand tonnes CO_2 equivalents.

1.2.3 Perfluorinated hydrocarbons (PFCs)

In 2003, the consumption of perfluorinated hydrocarbons (perfluoropropane), which are used exclusively in the refrigerant R413a, was 0.5 tonnes. The actual GWP-weighted emission is 19.3 thousand tonnes CO_2 equivalents, which is a reduction from 2002.

1.2.4 Trends in total GWP contribution from potent greenhouse gases

Figure 1.4 shows the trend in Danish GWP contributions 1992-2003 from HFCs, PFCs, and SF_6. The differences arising from the present calculations of the total GWP value compared with earlier calculation methods are illustrated in the figure.

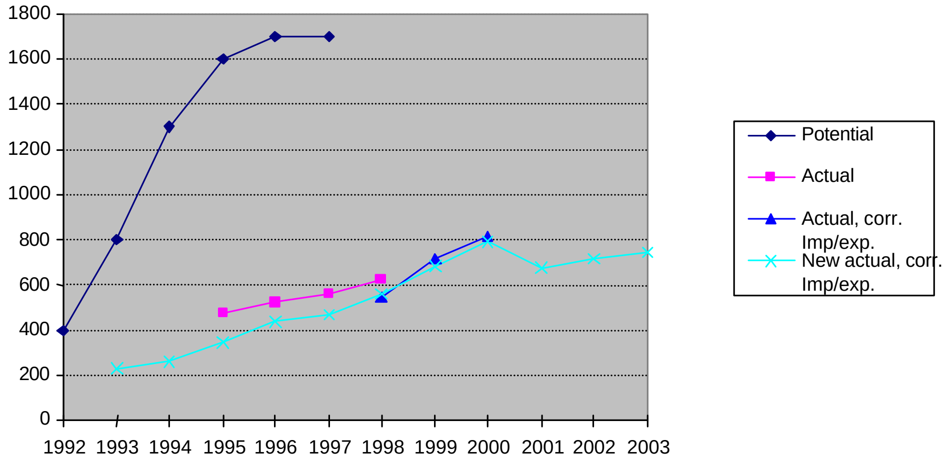

Figure 1.4 Trends in GWP-weighted potential, actual and adjusted actual emissions 1992-2003, '000 tonnes CO_2 equivalents.

The figure shows that, in 2003, there was again an increase in the total GWP contribution.

The development in the GWP contribution 1992-2003 can also be seen in Table 1.4 below.

Table 1.4 Total GWP-contribution from HFCs, PFCs, SF_6, '000 tonnes CO_2 equivalents, determined according to the four different methods of calculation applied during this period

	Potential	Actual	Actual, adjusted imp/exp.	New actual, adjusted imp/exp.
1992	400			
1993	800			230
1994	1300			263
1995	1600	480		344
1996	1700	520		435
1997	1700	560		472
1998		625	577	564
1999			700	683
2000			818	793
2001				699
2002				719
2003				745

2 Introduction

On behalf of the Danish Environmental Protection Agency (Danish EPA), the consulting firm PlanMiljø carried out an evaluation of Danish consumption and emissions of ozone-depleting substances and the industrial greenhouse gases, or so-called F-gases, HFCs, PFCs, and SF_6 for 2003 The evaluation was carried out in continuation of previous evaluations /13/ and references in these.

The evaluation includes a calculation of actual emissions of HFCs, PFCs, and SF_6. In this calculation of actual emissions, the release from stock of greenhouse gases in products has been taken into account, and adjustments have been made for imports and exports of the greenhouse gases in products. Appendix 5 describes the specific emission factors, etc.

The evaluation was partly prepared to enable Denmark to fulfil its international obligations to provide information within this area, and partly to follow the trend in consumption of ozone-depleting substances as well as the consumption and emissions of HFCs, PFCs, and SF_6. An example of reporting of Danish emissions is given in reference /18/ and, most recently, in reference /19/.

The ozone-depleting substances regulated by the Montreal Protocol are depleting the earth's protective ozone layer at a much greater rate than natural processes reproduce ozone. This is disturbing the natural balance and leading to an increase in dangerous ultraviolet radiation. The depletion is dependent on the different ozone-depleting potentials of the specific substances: their ODP values (Ozone-Depleting Potential).

Greenhouse gases cause an increase in the ability of the atmosphere to retain surplus heat radiated from the earth. Consequently the temperature of the earth's surface is rising and this leads to climate changes. There are several ozone-depleting substances that also have a strong greenhouse effect.

The potential effect of different greenhouse gases varies from substance to substance. This potential is expressed by a GWP value (Global Warming Potential). The so-called F-gases that do not have an ozone-depleting effect, but which have high GWP values (HFCs, PFCs and SF_6) are regulated by the Kyoto Protocol under the Climate Change Convention.

The Danish EPA has published a booklet on the ozone layer and the greenhouse effect /5/, and in cooperation with the other Nordic countries, the Danish EPA has published a booklet on the protection of the ozone layer - Nordic Perspective /6/. The Danish EPA has also published a report on substituting the greenhouse gases HFCs, PFCs and SF_6 /10/.

2.1 Monitoring Group

The project was overseen by a monitoring group. The monitoring group reviewed the evaluation results. The monitoring group consisted of:

- Frank Jensen, Danish EPA
- Mikkel Aamand Sørensen, Danish EPA
- Erik Lyck, National Environmental Research Institute, Denmark (NERI)
- G. Teddy Hansen, AKB Denmark (Authorized Refrigeration Installers Association)
- Marianne Kodahl, Confederation of Danish Industries (DI)
- Tøger Flagsted, Statisitics Denmark
- Tomas Sander Poulsen, PlanMiljø

2.2 Objective

The objective of this project was to map the 2003 consumption of newly produced industrial ozone-depleting substances and the consumption and actual emissions of HFCs, PFCs, and SF_6. The evaluation was made partly in accordance with the IPCC guidelines (Intergovernmental Panel on Climate Change) /4/, and partly following the method employed in previous evaluations.

In Appendix 1, Tables 1.a and 1.b show the ozone-depleting substances regulated by the Montreal Protocol, their chemical formulas and ODP values (Ozone-Depleting Potential), and the potent industrial greenhouse gases covered by the Kyoto Protocol under the Climate Change Convention, including their chemical formulas and GWP values (Global Warming Potential).

2.3 Scope and definition

Ozone-depleting substances

This evaluation covers the net consumption of ozone-depleting substances. The term “net consumption” is understood as the amount of imported goods in bulk or drums, less any re-export of substances as raw materials.

Ozone-depleting substances contained in finished products that are imported and exported are not included in the evaluation. This delimitation is in full compliance with international guidelines.

The evaluation does not account for the consumption of ozone-depleting substances used as raw material in the production of other substances, such as tetrachloromethane, and which are not subsequently emitted to the atmosphere.

The information on consumption has been gathered from importers, suppliers and enterprise end-users (usually purchasing departments), and Statistics Denmark. This method of data gathering means that the information gathered is about the quantities of substances traded. Purchase and sales figures are used as an expression of consumption. This approach is considered to be suitable and adequate for the present purpose, since experience from previous projects shows that a levelling out occurs with time and that the substances sold/purchased are consumed within a relatively small time horizon.

None of the substances covered here are produced in Denmark. Furthermore, ozone-depleting substances are treated at chemical waste processing plants in Denmark. Treatment and destruction data was gathered for the evaluation, but in line with all previous evaluations it has not been accounted for in the consumption figures.

Greenhouse gases

The evaluation of the actual emissions of HFCs, PFCs and SF_6 was carried out in continuation of previous evaluations, which have become increasingly more comprehensive and accurate in step with the development of internationally approved guidelines (IPCC Guidelines) and the provision of increasingly detailed data.

The evaluation of the actual emissions includes quantification and calculation of any imports and exports of HFCs, PFCs, and SF_6 in products, and it includes substances in stock. This is in accordance with the latest and most accurate method of calculation (Tier 2) among the options provided for in the IPCC Guidelines /4/.

2.4 Methods

Consumption and emissions

The evaluation of the consumption and the calculation of emissions and stock was carried out on the basis of information from six sources:

- Importers, agency enterprises, wholesalers, and suppliers
- Consuming enterprises, and trade and industry associations
- Recycling enterprises and chemical waste recycling plants
- Statistics Denmark
- KMO, the Danish Refrigeration Installers' Environmental Scheme
- Previous evaluations of HFCs, PFCs and SF_6 /2, 11, 13, 16/.

Information for the present evaluation was first gathered by means of a questionnaire survey. The responses to the questionnaires were supplemented where necessary with information gathered by telephone.

The results of the project are primarily based on the information received from enterprise and importer respondents etc., as well as reports and statistics from KMO, etc.

The information gathered from importers and suppliers was compared with information from consumer enterprises in order to monitor any discrepancies between purchase and sales information and application of the substances. In some cases, the use of individual substances was estimated on the basis of two sources, since the majority of the consuming enterprises were known. In cases where not all enterprise end-users had specified the application area for substances, the consumption of individual substances was estimated on the basis of the information provided by importers, suppliers, and any trade and industry-related associations, such as KMO.

There may be inconsistencies between the information provided by suppliers and enterprise end-users. This is partly due to imports from other EU countries, changes in inventories of substances, or a lack of correlation between the quantities sold and the quantities consumed. It is also due in part to a certain amount of uncertainty in the method of calculation used by enterprises. However, sales and consumption information has been harmonised.

The estimated average degree of uncertainty in the report's consumption figures (quantities sold and bought) is about 10-15 per cent, and slightly greater for data regarding application areas. The degree of uncertainty in the calculation of actual emissions is estimated at 20-25 per cent, depending on import/export information for the specific products.

The evaluation was conducted using two different methods /4/:

- Potential emissions (ozone-depleting substances)
- Actual emissions (HFCs, PFCs, and SF_6)

The ozone-depleting substances are not included in the calculations of emissions of greenhouse gases, since ozone-depleting substances are regulated by the Montreal Protocol. When evaluating emissions of ozone-depleting substances, net consumption is considered equivalent to *potential emissions*. Thus:

Potential emissions = imports + production - exports - destruction/treatment.

The evaluation of greenhouse gas emissions is based on a calculation of *actual emissions*. Actual emissions are emissions in the relevant year, accounting for the time lapse between consumption and emissions. Actual emissions include Danish emissions from production, from products during their lifetimes, and from the disposal of products. Actual emissions for the specific areas of application are determined on the grounds of the following analyses:

Tier 2 Top-down analysis
In the Tier 2 Top-down analysis, emissions are determined on the basis of information on consumption in the various areas of application and calculated or estimated emissions in the area of application (emission factors).

Tier 2 Bottom-up analysis.
In the Bottom-up analysis, the estimated emissions for a specific application area are based on information from producers using substances in production and in products; information on imports and exports of products; information on the technological developments within the application areas; information on the average amount of greenhouse gases contained in products; and information on the lifetime of products and actual emissions during their use and disposal.

Tier 2 bottom-up analyses were carried out within selected areas over a number of years. The analyses quantified the stock and, in some cases, Danish emission factors. Detailed analyses were carried out for commercial refrigerators, mobile A/C systems, fridges, freezers, and SF_6 power switches. Analyses were evaluated in separate reports /2, 11, 16/.

Bottom-up comprises:

- Screening of the market for products in which greenhouse gases are used.
- Defining the average content of greenhouse gases per product unit.
- Defining the lifetime and the disposal emissions of products.
- Identifying technological characteristics and trends of significance for emissions of greenhouse gases.
- Calculating imports and exports on the basis of defined key figures, Statistics Denmark's foreign trade statistics, and information from relevant industries.

Results from this analysis have been expanded in the present evaluation of actual emissions.

As far as possible, the consumption and emissions of greenhouse gases have been evaluated individually, even though consumption of certain HFCs has been very limited. This was done to ensure transparency in the calculation of the GWP value. However, it was necessary to operate with a category for "Other HFCs", as not all importers and suppliers have detailed records of sales of individual substances.

Uncertainty varies from substance to substance. Uncertainty is greatest for HFC-134a due to its widespread application in products that are imported and exported. The greatest uncertainty in the analysis of substances by application areas is assessed to concern the breakdown of consumption of HFC-404a and HFC-134a between commercial stationary refrigerators and mobile A/C systems. This breakdown is significant for the short-term (about 5 years) emissions calculations, but will balance out in the long term. This is because the breakdown is only significant for the rate at which emissions are released.

Appendix 5 shows an overview of all application areas included with descriptions of the bases of calculation.

2.5 Explanation of terminology

The following terms and abbreviations are used throughout this report:

- *Enterprise end-user:* A producer that uses ozone-depleting substances or potent greenhouse gases in connection with production processes in the enterprise.

- *Emission factor:* The factor used in the calculation of emissions from a product or a production process.

- *Consumption:* Consumption includes the quantities of substances reported in Denmark in the year in question via imports from wholesalers and information from Danish producers.

- *Importer:* Enterprises in Denmark that sell the relevant substances on the Danish market.

- *KMO:* The Danish Refrigeration Installers' Environmental Scheme

- *Stock:* The amount of substance contained in products in use in Denmark.

3 Ozone-depleting substances

All known importers of ODSs responded to the questionnaire survey. The responses provide information on imports/exports, sales/purchases, and areas of application for relevant substances (including both mixed and pure substances). All ODSs reported by the importers are newly produced ODSs.

The information from importers was supplemented with statistical information from Statistics Denmark for 2003. Statistical data was used to cross-check imports/exports information from importers. The statistics do not distinguish between new and re-used substances, and thus imports could, in principle, consist of both new and re-used substances.

The foreign trade statistics for 2003 assign the following ozone-depleting substances to the following separate positions:

- CFC-11 (position no. 2903.41.00)
- CFC-12 (position no. 2903.42.00)
- CFC-113 (position no. 2903.43.00)
- CFC-115 (position no. 2903.44.90)
- Tetrachloromethane (carbon tetrachloride) (position no. 2903.14.00)
- 1,1,1-trichloroethane (methyl chloroform) (position no. 2903.19.00)

The foreign trade statistics also include some substance group positions that can indicate trends in imports and exports of HCFCs (and HFCs and PFCs), but due to the broad definitions of the substance groups, it is not possible to utilise the position numbers in the evaluation since this relates to individual substances.

3.1 Imports and exports

The following sections describe imports and sales of individual ozone-depleting substances.

3.1.1 CFCs

On the basis of information from importers, sales of new CFCs in 2003 were 0.1 tonnes. In 2002, sales were 0.95 tonnes. The reduction is due to new techniques, so that CFC-113 is no longer used for analysis purposes by the off-shore industry.

One importer reports having sold 0.1 tonnes of CFC-113 for laboratory purposes.

Statistics Denmark registered imports of 0.037 tonnes of CFC-113, 1.791 tonnes of CFC-11, and 25.716 tonnes of CFC-12 in 2003. Imports of CFC-11 and CFC-12 are prohibited and therefore enterprises' calculations are being re-examined for correctness.

3.1.2 Tetrachloromethane

Three importers reported having imported and sold a total of 0.36 tonnes of tetrachloromethane for laboratory purposes in 2003. In 2002, imports and sales were 0.87 tonnes.

Statistics Denmark registered imports of 0.11 tonnes in 2003.

3.1.3 1,1,1-Trichloroethane

Two importers imported and sold about 0.025 tonnes of 1,1,1-trichloroethane in 2003.

Statistics Denmark registered imports of 3.861 tonnes in 2003.

3.1.4 Halons

Halons have been phased out and there were no reports of imports of halons in 2003.

3.1.5 Methyl bromide

Methyl bromide was only imported for feedstock in 2003.

3.1.6 HCFCs

Five enterprises imported HCFCs in 2003.

Consumption of HCFC-22 has gone up, whereas consumption of HCFC-141b has gone down. There has been no consumption of HCFC-142b.

In 2003, imports of HCFC-22 (new and regenerated) were about 211.8 tonnes, of which 5.6 tonnes came from HFC mixtures. Re-exports were about 115 tonnes, ie. net imports of HCFC-22 in 2003 were about 102.3 tonnes, of which 96.7 tonnes were imported as pure HCFC-22.

Imports of HCFC-141b were 102.4 tonnes in 2003. In 2002, imports totalled 360 tonnes.

There were no imports of HCFC-142b in 2003, and Danish consumption of this substance has been phased out.

Table 3.1 Developments in consumption and potential emissions, tonnes (ODP-weighted tonnes are shown in italics).

Substance	1989	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CFC-11	2,300 *2,300*	1,30 *1,30*	593 *593*	54 *54*	0	0	0	0	0	0	0	0 -	0 -
CFC-12	825 *825*	612 *612*	495 *495*	243 *243*	0	0	0	0	0	0	0	0 -	0 -
CFC-113	327 *261.6*	253 *202.4*	162 *129.6*	70 *56*	3 *2.4*	5 *4*	2 *1.6*	1.4 *1.12*	3.3 *2.64*	4.8 *3.84*	2.6 *2.08*	0.95 *0.76*	0.1 *0.08*
CFC-115	68 *40.8*	56 *33.6*	50 *30*	26 *15.6*	0	0	0	0	0	0			-
All CFCs	3.520	2.228	1.300	393	3	5	2	1.4	3.3	4.8	2.6	0.95	0.1
ODP-weighted consumption	*3,427.*	*2,155*	1247.6	*368.6*	*2.4*	*4*	*1.6*	*1.12*	*2.64*	*3.84*	*2.08*	*0.76*	*0.08*
Tetrachloromethane	2	3	<1	0.7	1.7	1.5	2.0	0.7	1.3	0.6	1.25	0.87	0.36
ODP-weighted consumption	*2.2*	*3.3*	*1*	*0.77*	*1.87*	*1.65*	*2.2*	*0.77*	*1.43*	*0.66*	*1.26*	*0.96*	*0.4*
1,1,1-Trichloroethane	396	1,01	940	569	104	0	0.9	0.2	0.03	0	0.05	0.002	0.025
ODP-weighted consumption	*39.6*	*101.5*	*94*	*56.9*	*10.4*	*0*	*0.09*	*0.02*	*0.003*	*0*	*0.005*	-	*0.002 5*
Halon 1302	105 *1050*	45 *450*	14 *140*	5 *50*	0	0	0	0	0	0	0	0	0
Halon 1211	15 *45*	4 *12*	1 *3*	0	0	0	0	0	0	0	0	0	0
Halon 2402	0	0	0	0.7 *4.2*	0	0	0	0	0	0	0	0	0
All halons	120	44	15	6	0	0	0	0	0	0	0	0	0
ODP-weighted consumption	*1095*	*462*	*143*	*54.2*	0	0	0	0	0	0	0	0	0
Methyl bromide[1)]	51	31	17	12	9	8	5	0	0	0	Only feed-stock	Only feed-stock	Only feed-stock
ODP-weighted consumption	*30.6*	*18.6*	*10.2*	*7.2*	*5.4*	*4.8*	*3*	*0*	*0*	*0*	-	-	-
HCFC-22 (pure)	455 *25*	1,00 *55.3*	813 *44.7*	750 *41.2*	748 *41.1*	610 *33.5*	600 *33*	534 *29.4*	566 *31.1*	347 *19.1*	249.1 *13.7*	24.5 *1.35*	96.7 *5.3*
HCFC-123	0	0	*0*	*0*	*0*	*0*	*0*	*0*	0	*0*	18 *0.36*	0 -	0 -
HCFC-141b	0	90 *9.9*	340 *37.4*	510 *56.1*	410 *45.1*	440 *48.4*	585 *64.3*	621 *68.3*	447.1 *49.2*	538.8 *59.3*	609 *66.99*	360 *39.6*	102.3 *11.3*
HCFC-142b	0	130 *8.45*	326 *21.2*	145 *9.4*	195 *12.7*	160 *10.4*	17 *1.1*	17 *1.1*	15.8 *1*	15.8 *1*	0 *0*	0 -	0 -
Other HCFCs	0	0	0	0	5 *n.s*	<5 *n.s*	20 *n.s*	0	0	0	0	0 -	0 -
HCFC-22 from HFC mixture											13.8 *0.76*	5.5 *0.3*	5.6 *0.3*
HFCs	455	1.203	1.479	1.410	1.302	1.215	1.222	1.172	1.029	901.6	889.9	390	204.7
ODP-weighted consumption	*25*	*73.65*	*103.3*	*106.7*	*98.9*	*92.3*	*98.4*	*98.8*	*81.3*	*79.4*	*81.45*	*41.25*	*16.9*
Total ODP-weighted consumption	*5,150*	*2,758*	*1,593*	*590*	*121*	*108*	*111*	*101.5*	*85.3*	*83.9*	*85.2*	*42.97*	*17.4*

1) Information from the Danish EPA environmental statistics.
n.i. = not informed
n.s. = no specified information available for individual substances

Table 3.2 shows an overview of the Danish consumption of HCFCs by application area, based on information from importers and producers.

Table 3.2 HCFC consumption analysed by application area for 2003, based on information from importers and producers, tonnes.

Application area	HCFC-22	HCFC-141b	HCFC-142b
System foam (for panels, insulation, etc.)	0	102	0
Refrigerants	102.3	0	0
Total	102.3	102	0

3.1.7 Treatment and destruction

Denmark has two treatment facilities for processing ODSs - Kommune Kemi (KK) and Århus Genindvinding. All ODSs to be treated are sent to these plants.

The KK plant does not operate a registration system for individual substances because it receives and treats all substances in mixed tanks. Consequently, it is not possible to quantify the amounts of substances collected for treatment based on what the plant receives. Therefore, information from the importers that receive and send on used ODSs for treatment at the KK plant has been used instead.

The Århus Genindvinding plant can document specific annual quantities of individual substances processed at the plant.

The ODSs treated in 2003 appear in the table below.

Table 3.3 Treated ODSs in 2003, tonnes

ODS	Quantity, tonnes
HCFC-22	5.8
CFC-12	10.1
CFC-11	12

Some of the HCFC-22 originates from HFC mixtures (HFC-401a, HFC-402a, HFC-408a, HFC-409a) that are sent by Danish importers to the Kommune Kemi treatment plant for processing, either as mixtures of pure refrigerants or in mixed cylinders.

4 Greenhouse gases

4.1 Import of substances

An overall picture of the trends in imports of greenhouse gases is given in Table 4.1, based on information from importers for the years 1987, 1989, 1992, 1994-2003.

4.1.1 HFCs

HFCs were imported by ten enterprises in 2003. Five of these were Danish suppliers and five were end-users, importing directly from other EU countries.

Total imports (minus re-exports) of all HFCs, according to importers, fell from 713.2 tonnes in 2002 to 528.3 tonnes in 2003.

Imports of HFC-134a fell from 401.6 tonnes in 2002 to 241.2 tonnes in 2003. Imports of HFC-152a fell from 11.9 tonnes in 2002 to 3.3 tonnes in 2003. The marked reduction is due to the fact that HFC134a/HFC-152a have now been phased out as foam blowing agents in insulation foam used in the production of fridges/freezers.

Imports of HFC-404a fell from 188.7 tonnes in 2002 to 145 tonnes in 2003. Imports of HFC-407c increased from 89.1 tonnes in 2002 to 96.8 tonnes in 2003. HFC-407c is a substitute refrigerant for HCFC-22 in refrigerators, and the increase is therefore a natural consequence of the required phase-out of R-22 installations.

Imports of other HFCs (HFC-408a, HFC-409a, HFC-410a) measured 25 tonnes in 2003 compared with 7.5 tonnes in 2002. In 2003, HFC-365, a newer foam blowing agent, was also imported and used. Imports of HFC-507a fell to 9.2 tonnes in 2003. In 2002, imports were 14.4 tonnes.

2003 saw few imports of HFC-401a and HFC-402a, namely 0.2 and 1.7 tonnes respectively.

4.1.2 Sulphur hexafluoride

Four importers reported having imported and sold 2.25 tonnes of sulphur hexafluoride in 2003. In 2003, sulphur hexafluoride was used in power switches and for laboratory purposes (primarily plasma erosion).

Use of SF_6 in the metal industry was phased out in 2000 and in the glazing industry in 2001.

4.1.3 Perfluorinated hydrocarbons

Two importers reported having imported and sold mixture products containing the perfluoro compound C_3F_8, which is present in the refrigerant R413 used in commercial refrigerators. Converted, imports of this substance correspond to about 0.5 tonnes.

Table 4.1 Developments in imports of greenhouse gases, tonnes.

Substance	1987	1989	1992	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
HFC-134a	0	0	20	524	565	740	700	884	644.6	711.1	472.8	401.6	241.2
HFC-152a	0	0	4	51	47	32	15	14	35.8	16.4	11.1	11.9	3.3
HFC-401a	-	-	-	-	-	-	-	15	15	9.5	4.1	0	0.2
HFC-402a	-	-	-	-	-	-	-	10	10	4.2	0.8	0	1.7
HFC-404a	0	0	0	36	119	110	110	146	193.7	193.1	126.2	188.7	145
HFC-407a	-	-	-	-	-	-	-	17	40	44.7	40.3	89.1	96.8
HFC-507a	-	-	-	-	-	-	-	10	10	23.85	2.2	14.4	9.2
HFC-365	-	-	-	-	-	-	-	-	-	-	-	-	18
Other HFCs	0	0	0	1	14	20	65	15 [1)]	29.2[1)]	24.14[1)]	18.4[1)]	7.5[2)]	13[2]
All HFCs	0	0	24	612	745	902	890	1112	978.3	1026.9	676	713.2	528.3
Sulphur hexafluoride	n.i.	n.i.	15	21	17	11	13	9	12.1	9	4.7	1.4	2.2
Perfluorinated hydrocarbons	0	0	0	0	1.5	3	8	6	7.9	6.9	3.7	1.95	0.5

1) The category "other" includes HFC-408a, -409a, -410a and HFC-365, HFC-23 and HFC-227ea, (in the emission calculation a worst-case scenario is used on the basis of the GWP value for HFC-410a). There were, however, no imports in 2003.

n.i. = not informed

n.e. = not evaluated

2) The category "other" includes HFC -408a, -409a, 410a (in the emission calculation a worst-case scenario is used on the basis of the GWP value for HFC-410a).

4.2 Consumption by area of application

The evaluation of consumption by application area is estimated on the basis of information from importers and producers, and on sales reports to the Danish Refrigeration Installers' Environmental Scheme (KMO). Table 4.2 shows consumption by application area.

Table 4.2 Consumption of HFC analysed by application area in 2003, tonnes.

Application area	HFC-134a	HFC-152a	HFC-401a	HFC-402a	HFC-404a	HFC-407a	HFC 507a	HFC-365	Other HFCs
Insulation foam (fridges, freezers etc.)	0	0	0	0	0	0	0	0	0
Refrigerant (household and commercial fridges, freezers etc.)	94.1	0	0	0	4.3	0	0	0	0
Refrigerant (commercial stationary refrigerators and A/C systems) [1]	84.7	0	0.2	1.7	134.5	96.8	9.2	0	13
Refrigerated vans and lorries	0.5	0	0	0	6.2	0	0	0	0
Refrigerants in mobile A/C systems [2]	32.1	0	0	0		0	0	0	0
Other (including aerosol sprays and soft foam)	29.8	3.3	0	0	0	0	0	18	0
Total	241.2	3.3	0.2	1.7	145	96.8	9.2	18	13

1) Estimate based on the residual amount of HFC-134a, for which there is no available application data from the producers. The residual amount is distributed between commercial and mobile refrigerators on the basis of the importers' estimates.

There are no other known application areas for HFCs in Denmark than the ones appearing in Table 4.2.

4.2.1 Consumption of HFC as a refrigerant

In recent years, the general trend in Danish consumption of HFCs as refrigerants points toward increased use of HFCs in commercial refrigerators. However, consumption fell by about 55 tonnes in 2003 compared to 2002, when there was an especially high level of consumption, probably due to the fact that HFC taxes were introduced towards the end of 2002. The general increase in HFC refrigerants in commercial systems is a natural consequence of the phase-out of refrigerators based on R-22 (HCFC). The production of new R-22 systems was prohibited in 2000 and substitution with R-22 in existing systems was prohibited in 2002.

For individual refrigerants used in commercial refrigerators, there has been an increase in recent years in the consumption of HFC-407c and in the category "Other refrigerants" (HFC-408a, HFC-409a and HFC-410a). In 2003, the consumption of HFC-407c in commercial refrigerators was greater than the consumption of HFC-134a. The most commonly used refrigerant in commercial refrigerators is still HFC-404a.

The consumption of HFC-134a as a refrigerant in fridges/freezers was less in 2003 than in previous years. This is primarily attributable to the fact that one producer moved this part of its production abroad. In other words, the fall is not considered to be an indication of a general fall in production by the Danish refrigeration industry.

The consumption of refrigerants in vans and lorries is stable and the consumption of refrigerants for mobile A/C systems seems to have increased again slightly this year.

Consumption by application area is based on information from producers and importers and on data from KMO, which receives reports of the sales of substances from refrigerator installers and automobile garages, etc. (only when drawing-off is more than 1 kg).

The consumption of refrigerants for household fridges and freezers is calculated on the basis of information from enterprise end-users.

The consumption figures for refrigerants in commercial and stationary A/C systems, and mobile A/C systems and refrigerators are estimated using data from KMO and information from importers as well as statistics on car imports.

Table 4.3 shows the relative consumption by weight of refrigerants according to application area.

Table 4.3 Consumption of refrigerants, by type of product, 2003, tonnes.

Substance HFC	Fridges /freezers	Commercial refrigerators and A/C systems	Mobile A/C systems	Refrigerated vans and lorries	Total	In per cent
-134a	94.1	84.7	32.1	0.5	211.4	44%
-401a	-	0.2	-	-	0.2	0%
-402a	-	1.7	-	-	1.7	0%
-404a	4.3	134.5	-	6.2	145.0	31%
-407c	-	96.8	-	-	96.8	20%
-507a	-	9.2	-	-	9.2	2%
Others	-	13	-	-	13.0	3%
Total	98.4	340.0	32.1	6.7	477.2	100%
	21%	71%	7%	1%	100	

4.2.2 Consumption of HFC for foam production and as propellant

In 2003, there was again a significant reduction in the general consumption of HFC-134a for foam production. In 2003, no Danish producers of refrigeration equipment used HFCs as a foaming agent in the production of insulation foam. This phase-out is the direct consequence of a statutory order on phase-out of potent industrial greenhouse gases, as well as the fact that there are competitive alternative technologies available on the market.

The overall consumption of HFC-134a and HFC-152a as foaming agents for soft foam and as propellants fell in 2003 compared to 2002.

In 2003, the use of HFCs as propellants in aerosols for special purposes was about the same as in 2002. In total, the consumption of HFC-134a amounted to 29.8 tonnes in 2003, compared to 49.8 tonnes in 2002.

The use HFCs as foaming agents in soft foam declined by about 18 tonnes, which is almost a 50-per-cent reduction compared to 2002.

Furthermore, in 2003 a consumption of 18 tonnes of HFC-365 in the production of system foam was reported. The application was in products that were exported. It has been reported that this consumption does not give rise to emissions during production, and therefore consumption for this use is not included in the following emission calculations, since emissions equal 0.

As was the case in previous years, there have been no reports of consumption of HFCs for chemical production, fire extinguishing equipment, or other application areas apart from those mentioned.

4.2.3 Consumption of SF_6

The overall consumption of SF_6 in 2003 was 2.3 tonnes. Consumption of SF_6 was used for power switches in high-voltage plants and for laboratory purposes.

Table 4.4 Consumption of SF_6 by application area, tonnes

Application area	DK consumption, tonnes
Double-glazed windows	-
Power switches in high-voltage plants	1.9
Laboratory purposes	0.4
Total	2.3

4.2.4 Consumption of PFCs

Total consumption of perfluoropropane (C_3F_8) for refrigeration purposes amounted to about 0.5 tonnes in 2003. There were no reports of other applications of PFCs in Denmark in 2003.

4.3 Emissions of HFCs, PFCs and SF_6

This section describes the actual emissions of the greenhouse gases HFCs, PFCs, and SF_6 for 2003. The calculations are based on the reports on consumption of these substances analysed by application areas (section 4.2). For relevant product groups, adjustments have been made for imports and exports of the substances in products.

Appendix 5 shows the leakage rates employed, calculation method, IPPC Tier method etc., in relation to individual substance and application area. It also shows the extent to which the IPCC default values and specific default values for Denmark have been used /4, 16/.

4.3.1 Actual emissions of potent greenhouse gases in 2003 and projected emissions

The GWP-weighted actual emissions of HFCs, PFCs, and SF_6 in 2003 totalled about 745,600 tonnes CO_2 equivalents. The corresponding emissions were 718,800 tonnes CO_2 equivalents in 2002, which corresponds to a calculated total increase of about 26,800 tonnes CO_2 equivalents.

The total GWP contribution divided between HFCs, PFCs, and SF_6 is shown in the table below.

Table 4.5 GWP contribution by substance group, tonnes

Substance group	Consumption, tonnes 2002	Consumption, tonnes 2003	GWP contribution, tonnes 2002	GWP contribution, tonnes 2003
HFCs	713.2	528.3	671,200	694,400
PFCs	1.9	0.5	22,200	19,300
SF_6	1.4	2.3	25,500	31,900
Total			718,800	745,600

Although HFC consumption was significantly smaller in 2003, GWP contribution was still greater than in 2002. This is due to emissions from the stock in commercial refrigerators based on HFC-134a, HFC-404a and HFC-407c.

4.3.2 Emissions of HFCs from refrigerants

A distinction is made between:

- Fridges and freezers for household use and retailers etc.
- Commercial refrigerators (in industry and shops) and stationary air conditioning systems
- Mobile air conditioning systems (in cars, lorries, buses, trains etc.)
- Refrigerated vans and lorries

Actual emissions from these sources occur in connection with:

- *filling* of refrigerants (0.5 per cent to 2 per cent of consumption depending on application area).
- *continual release* during the operational lifetime. An assumed average value which also accounts for release occurring as a result of accident and damage (10 per cent to 33 per cent of consumption per year, depending on application area).

Release resulting from *disposal* does not count as emissions in Denmark since Danish legislation ensures that management and treatment of refrigerants prevent such emissions. The release is defined in order to write down stock (the quantity of refrigerants contained in a product).

Appendix 5 shows the specific emission factors used in the calculations.

Commercial refrigerators and stationary A/C systems

Commercial refrigerators, used e.g. by supermarket chains or by industry, and stationary A/C systems, also used by retailers and industry, as well as by offices, constitute the largest source of emissions. The most commonly used refrigerants in this product group are HFC-404a, HFC-407c, and HFC-134a, of which the former is most frequent and the latter least frequent.

In addition, use of the refrigerants HFC-408a, HFC-409a, HFC-410a, and HFC-507c is less common, and HFC-401a and HFC-402a are used only to a very modest extent.

It is not relevant to adjust for imports and exports of HFCs in stationary commercial refrigerators and A/C systems since filling takes place at the site of operation, following installation.

Table 4.6 shows actual emissions of specific HFCs. Total emissions of all HFCs have been converted to CO_2 equivalents in order to take into account the different GWP values of the substances.

The calculation of the GWP contribution from the category "Other HFCs" (HFC-408a, HFC-409a, and HFC-410a) is based on a worst-case scenario in which the GWP value is calculated on the basis of HFC-410a (50 per cent HFC-32, 50 per cent HFC-125), which has the highest GWP value of the three substances. The GWP value for HFC-410a is 1,725.

Table 4.6 Actual emissions and GWP contribution from commercial refrigerators 2003 and 2010, tonnes

	Substance	Consumption, DK	Stock	Actual emissions	GWP contribution 2003	GWP contribution 2010
Commercial refrigerators and stationary A/C systems	HFC-134a	84.7	726.6	72.7	94555	89604
	HFC-404a	134.5	857.9	82.6	269353	317830
	HFC-401a	0.2	25.4	3.2	57	0
	HFC-402a	1.7	32.3	3.7	6144	3965
	HFC-407c	96.8	281.7	22.2	33783	70029
	HFC-507a	9.2	57.1	5.5	16963	20310
	Other HFCs 1)	13.0	100.9	10.0	17217	18490
	All substances				**438071**	**520229**

1) The category "Other HFCs" includes HFC-408a, -409a and -410a (the calculation of emissions is based on a worst-case scenario on the basis of the GWP value of HFC-410a).

2) The projected future scenario takes into account the effect of a new statutory order on phasing-out HFCs etc. and the effect of the taxes implemented. Furthermore, assumptions about the substitution of HCFC-22 systems by HFC-134a and HFC-404a are included in the calculations.

In the projection of emissions in 2010, which takes account of the specific phase-out dates set out in the 2003 Statutory Order from the Ministry of the Environment on certain ozone-depleting substances (prohibition and restrictions on use), the GWP contribution from commercial refrigerators in 2010 is estimated at about 520,000 tonnes.

This is a significant reduction compared to the projected scenario in /13/, which was carried out with historical data for 2002 when the 2010 GWP contribution was estimated at 581,000 tonnes. The reduction in the projected scenario is due to the method used, where the consumption of refrigerants observed in one year is assumed to be the same in the following years. In 2003, there was a reduction in consumption of both HFC-404a and HFC-134a.

If the projected figure for 2003 made in 2002 is compared to the actual emissions observed in 2003, we see a difference of less than 3,000 tonnes, which corresponds to an uncertainty of less than 1 per cent.

Fridges/freezers

Actual emissions from refrigerants in fridges and freezers are determined on the basis of consumption adjusted for imports and exports of HFCs. The calculation assumes that the refrigerant is removed and treated upon disposal so that no emission occurs (see Appendix 5).

When adjusting for imports and exports, the estimates of imports/exports in Environmental Project no. 523 are used /2/. In this case, exports are assumed to comprise 50 per cent of consumption. The calculation is made on the basis of Statistics Denmark's foreign trade statistics /3/ of average figures for the amount of HFC-134a in a standard fridge/freezer manufactured in 1999. The statistical background data for this is given in Appendix 2. This evaluation has not assessed whether the figures are up-to-date.

In addition, the effect of taxes on the reduction in consumption is taken into account in the projection of consumption of HFC-134a in fridges. These taxes are assumed to lead to a gradual reduction in consumption. This is assumed not to be the case for HFC-404a-based household fridges/freezers since these are special products.

Table 4.7 shows actual emissions from fridges/freezers in 2003 and 2010.

Table 4.7 Emissions of refrigerants from fridges/freezers 2003 and 2010, tonnes

	HFC-134a		HFC-404a	
	2003	2010	2003	2010
Consumption	94.1	85.0	4.29	4.29
Emissions during production	1.9	1.7	0.09	0.09
Exports	47.1	42.5	0	0
Stock	764.9	944.8	71.84	93.51
Emissions from stock	7.3	9.4	0.71	2.67
Emissions during destruction	0.0	0.0	0	0
Actual emissions	9.2	11.1	0.79	1.09
GWP contribution, ‘000 tonnes CO_2 equivalents	11.9	14.4	2.58	3.54

Total emissions of HFC refrigerants from fridges/freezers in 2003 were 14,500 tonnes CO_2 equivalents. In the projections of actual emissions, a small increase is expected, giving about 18,000 tonnes CO_2 equivalents in 2010.

Mobile A/C

Emissions from mobile A/C systems are released during filling and from continual loss of HFC-134a, and are also due to accident and damage.

The calculation has been adjusted for imports and re-exports of HFC-134a, which is the only HFC imported in A/C systems in cars and lorries. In Denmark, the consumption of HFC-134a for mobile A/C systems is used solely for refilling. Initial filling is carried out by car manufacturers in the country of production.

The assumptions used in the calculation of consumption and stock in mobile A/C systems appear from the table below. The assumptions have been adjusted according to individual statistical categories for types of transport and they represent estimated values based on information from car importers and refrigerator service enterprises /16/.

Table 4.8 Assumptions used in the calculation of stock in mobile A/C systems, 2003

	Proportion with A/C, %	Filling, kg HFC-134a	Percentage of all vehicles that undergo A/C maintenance
Cars	10 %	0.75	50 %
Busses	20 %	9	20 %
Vans	10 %	0.8	50 %
Trucks	50 %	1.5	40 %

D.A.F. (The Danish Automobile Dealers Association) publishes annual statistics of the number of vehicles in Denmark /17/. These data form the basis for the calculation below of HFC-134a stock in Danish vehicles. Calculations also include a calculation of the proportion of A/C systems installed in vehicles, which are still undergoing servicing, and which are therefore still being refilled with refrigerants in connection with leakage and other repairs. This calculation forms the basis for determining the amount of HFC-134a refrigerants refilled in vehicles in Denmark in 2003. Refilled stock = Danish consumption.

The results are shown in the table below.

Table 4.9. Determination of Danish stock in mobile A/C systems in 2003 analysed by vehicle type, tonnes

	2003	Stock, kg, tonnes	Maintenance filling, tonnes	Average filling per year, tonnes HFC-134a
Private cars	1897911	142.3	71.2	23,.
Busses	8973	16.2	3.2	1.1
Vans	364456	14.6	7.3	2.4
Lorries	48657	36.5	14.6	4.9
TOTAL		**209.6**	**96.3**	**32.1**

The total stock of HFC-134a in mobile A/C systems in Denmark in 2003 was calculated to be about 209.6 tonnes. Stock is expected to increase further in the coming years since there is a continuing trend that more vehicles and new vehicles have A/C systems. In 2003, the volume of HFC-134a filled onto mobile air conditioning systems was 32.1 tonnes, which is 0.3 tonne more than in 2002. This volume of refrigerants was used solely for refilling in connection with the maintenance of existing systems /16/.

The table below shows a projection of calculated actual emissions from mobile A/C systems in Denmark. The table has been prepared on the basis of a steady-state assumption where imports and consumption for refilling in 2010 are assumed to be the same as in 2003.

Table 4.10. The calculated actual emissions of HFC-134a from mobile A/C systems in 2003 and 2010, tonnes

	2003	2010
Imports via vehicles	27.8	27.8
Consumption for refilling	32.1	32.1
Total stock increase	59.9	59.9
Emissions during filling	1.4	1.4
Operation emissions from stock	62.3	58.7
Total release from stock	63.7	60.2
Stock	203.8	195.5
Actual emissions	63.7	60.2
GWP contribution, '000 tonnes CO_2 equivalents	82.9	78.2

Refrigerated vans and lorries

There are an estimated 5,500-6,000 refrigerated vans and lorries in Denmark /16/. These require an average filling of about 8 kg, equivalent to 44-49 tonnes refrigerants, either HFC-134a, HFC-404a or HCFC-22.

Actual emissions from refrigerated vans and lorries in 2003 are stated in the table below.

Table 4.11. The calculated actual emissions of HFC-134a and HFC-404a from refrigerated vans and lorries in 2003 and 2010, tonnes

	HFC-134a		HFC-404a	
	2003	2010	2003	2010
Consumption	0.45	0.45	6.2	6.2
Emissions during filling	0.02	0.02	0.3	0.3
Contribution to stock	0.43	0.43	5.9	5.9
Emissions from stock	1.32	0.67	5.2	5.7
Stock	6.87	3.71	31.5	33.9
Actual emissions	1.34	0.69	5.5	6.0
GWP contribution, '000 tonnes CO_2 equivalents	1.74	0.90	18.1	19.7

In addition there were emissions of about 0.5 tonnes from HFC-402a in stock, corresponding to 800 tonnes CO_2 equivalents. There was no registered consumption of HFC-402a for refrigerated vans and lorries in 2003. It is assumed that the substance has been phased out, which is why the actual emissions in 2010 are set to only about 200 tonnes CO_2 equivalents.

Thus, the total actual emissions from refrigerated vans and lorries were just below 20,600 tonnes CO_2 equivalents in 2003.

4.3.3 Emissions of HFCs from foam plastic products and propellants

Two calculation principles have been applied in the calculation of emissions of HFCs used in foam plastic products, depending on the type of product:

1) Hard PUR foam plastics (closed cell)

2) Soft PUR foam plastics (open cell)

3) Polyether foam (closed cell)

The following basis of calculation has been used in the emissions calculation for foam plastic products.

Table 4.12 Factors in the calculation of emissions from foam plastic products

	Hard PUR foam	Soft PUR foam	Polyether foam
Release during production	10%	100%	15%
Annual loss	4.5%	-	4.5%
Lifetime	15	-	1-10 (3 years)

Insulation foam

Hard foam plastic produced with HFC-134a is used primarily in insulating foam for fridges/freezers. Calculations of emissions from insulating foam in fridges/freezers have been adjusted for imports and exports of fridges/freezers.

Consumption of HFC-134a for foaming of insulation foam used in fridges/freezers was phased out in 2003. Actual emissions are therefore solely from stock and there are no longer any exports.

Actual emissions of HFC-134a from insulating foam are summarised in Table 4.13

Table 4.13 Emissions of HFCs from insulating foam, tonnes

	2003	2010
Consumption, HFC-134a	0.0	0.0
Emissions during production	0.0	0.0
Exports	0.0	0.0
Stock	1380.8	756.4
Emissions from stock	78.1	66.6
Actual emissions	78.1	66.6
GWP contribution, '000 tonnes of CO_2 equivalents	101.5	86.6

In the projections for 2010, it is estimated that the stock will be reduced as a result of the phase-out of HFC-134a as a foaming agent. Previous years' projections estimated a phase-out by 2006. However, the fact that this foaming agent had already been phased out by 2003 has meant a further reduction of about 11,000 tonnes of CO_2 equivalents by 2010, compared to previous projected scenarios.

Polyether foam

The consumption of polyether-based foam was reported to be about 3.5 tonnes, and the actual emissions are estimated at 1.7 tonnes, corresponding to about 2,300 tonnes CO_2 equivalents. The calculation is based on the assumption that no emissions are released upon disposal since the gases are destroyed by incineration.

Calculations from 1998 are used for import adjustments. In the calculation, it is estimated that 5 per cent of all shoes with plastic, rubber, or leather soles contain polyether. In 1998 about 12.8 million pairs of shoes were imported (Statistics Denmark's foreign trade statistics) and it is estimated that a single pair of shoes contains an average of 8g HFC-134a. Based on these figures, exports are estimated to be 0.3 tonnes HFC-134a.

Soft foam/aerosol sprays.

Emissions from soft foam (open cell foam) account for 100 per cent of the consumption in the year of application /4/. Emissions from soft foam occur during production and it is therefore not relevant to adjust for imports/exports.

The emission of HFC in the production of *soft foam* is identical to the consumption in Denmark, and the emission of HFC as a propellant in aerosol sprays is equal to the consumption of HFC-based aerosol sprays in Denmark, after adjusting for imports and exports. Total emissions from these two areas amount to 26.3 tonnes of HFC-134a, corresponding to 34,300 tonnes CO_2 equivalents, and to less than one tonne of HFC-152a, corresponding to 100 tonnes CO_2 equivalents. Compared with 2002, emissions have been reduced by more than 25,000 tonnes of CO_2 equivalents.

Medical products

Due to marginal emissions, HFC emissions from medical products have not been calculated.

4.3.4 Emissions of sulphur hexafluoride

The total emissions of SF_6 in 2003 have been calculated at about 1.3 tonnes, equivalent to a GWP contribution of about 32,000 tonnes CO_2 equivalents. Net consumption was 2.3 tonnes.

Emissions derive from four sources, of which power switches, laboratories, and double-glazed windows are the main sources, contributing about equal shares.

Insulating glass

Use of SF_6 in double-glazed windows was phased out in 2002, however, there are still emissions from existing double-glazed windows in Danish buildings.

Table 4.14 Emissions of SF_6 from double-glazed windows, tonnes

	2003	2010	2015
Consumption	0.0	0.0	0.0
Emissions from production	0.0	0.0	0.0
Release from fitted double-glazed windows	0.4	0.4	0.2
Exports	0.0	0.0	0.0
Disposal emissions	0.0	0.0	3.7
Stock	39.1	36.4	18.4
Actual emissions	0.4	0.4	4.0
GWP contribution, '000 tonnes CO_2 equivalents	9.4	8.8	94.5

Emissions will rise due to the disposal/substitution of existing double-glazed windows containing SF_6, and the estimated 2015 GWP contribution from double-glazed windows is 94,500 tonnes CO_2 equivalents.

Power switches in high-voltage plants

Power switches are filled or refilled with SF_6, either during new installation or during service and repair. Filling is usually carried out on new installations and a smaller proportion of the consumption is due to refilling /11/.

Emissions from power switches in high-voltage plants are released due to the following:

- release of 5 per cent on filling with new gas
- gradual release of 0.5 per cent from the stock (average figure covering normal operation and failure/accidents)
- release of 5 per cent from drawing off and recycling used gas.

No emissions are assumed to result from disposal since the used SF_6 is drawn off from the power switches and is either re-used internally by the power company concerned, or re-used externally through means of a collection scheme. Emissions resulting from external re-use are determined on the assumption that 0.5 per cent of the annual stock is sent for external re-use.

Table 4.15 shows the calculated actual emissions from SF_6 power switches.

Table 4.15 Emissions of SF_6 from power switches in high-voltage plants 2003, 2010, and 2015, tonnes

	2003	2010	2015
Consumption	1.9	3.0	3.0
Service emissions	0.1	0.2	0.2
Recycling/recovery emissions	0.0	0.0	0.0
Emissions from stock	0.3	0.4	0.5
Stock	63.5	80.8	92.8
Actual emissions	0.4	0.6	0.6
GWP contribution, '000 tonnes of CO_2 equivalents	10.1	13.4	14.9

At the request of the Danish Energy Authority, Eltra and Elkraft System have carried out a survey of SF_6 emissions during operation and following from accidents /20/. This survey covers about 1/9 of the stock in the Danish electricity sector. Emissions have been calculated at about 20 kg of SF_6. Additionally, there are 88 kg of contaminated SF_6 in depot, and about 1.1 tonnes of new gas in store.

If this data is assumed to be representative of the entire country, emissions in 2003 amount to about 180 kg. This is slightly under half of the calculated emissions of 0.4 tonnes in this survey.

On the basis of Eltra's survey, this evaluation method is still believed to provide a true picture of total emissions. The difference in figures is explained by the fact that the calculation method does not take account of the time delay, so that SF_6 is assumed to be both purchased and consumed within the year of calculation. The notes from Eltra state that there is about 1.1 tonnes in store, which upon later use will lead to emissions. Furthermore, more emissions are assumed to arise from the recycling or destruction of the 88 kg of contaminated gas in depot. If these emissions were actual emissions in 2003, it would mean emissions from Eltra and Elkraft System of about 80 kg of SF_6, and about 0.7 tonnes of SF_6 respectively, providing the data is representative for the entire country.

Laboratory purposes

Consumption for plasma erosion in connection with the manufacture of microchips in clean-room laboratories was registered in 2003. Furthermore, it is still assumed that consumption for analysis purposes is limited.

Consumption was 0.4 tonnes and this corresponds to actual emissions. Emissions have been calculated at about 9,700 tonnes CO_2 equivalents.

Training shoes

In the period 1990 to 1998, Denmark imported training shoes, which, according to the manufacturer, contained a total of about 1 tonne of SF_6. Emissions of SF_6 occur as a result of the disposal of the shoes. As in previous years, estimated emissions from training shoes are 0.11 tonnes, which is equivalent to a GWP contribution of about 2,650 tonnes CO_2 equivalents. It is assessed that emissions of SF_6 from training shoes will not occur after 2003, since it is assumed that all shoes containing SF_6 will have been disposed of by then.

4.3.5 Emissions of perfluorinated hydrocarbons

Actual emissions of perfluoropropane have been calculated at about 19,300 tonnes CO_2 equivalents for 2003 and total consumption was about 2.5 tonnes. In 2003, consumption of PFC was for refrigeration purposes exclusively. In addition, there was a "delayed" emission of 0.25 tonnes from consumption of PFCs in liquid cleaners in 2002 (cf. IPCC Reference Manual /4/ the consumption of liquid cleaners is broken down by 50 per cent in the year of consumption and 50 per cent in the subsequent year).

Perfluoropropane is the only known perfluorinated hydrocarbon used in Denmark. Emissions are released from refrigerants in commercial stationary and mobile refrigerators. Stock in commercial refrigerators has been calculated at about 22.7 tonnes. Since mixture products containing PFC are used in stationary refrigerators, adjustments have not been made for imports and exports of the substance in products.

Table 4.16 Emissions of PFCs from commercial refrigerators in 2003, 2010 and 2015, tonnes

	2003	2010	2015
Consumption	0.5	0.9	0.6
Emissions from filling	0.0	0.0	0.0
Emissions from stock	2.5	1.3	1.1
Stock	22.7	13.0	10.0
Actual emissions	2.5	1.4	1.1
GWP contribution, '000 tonnes CO_2 equivalents	17.6	9.5	7.5

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ODP values for ozone-depleting substances and GWP values for pure greenhouse gases

Table 1.a Ozone-depleting substances, their chemical formulas and ODP values - Regulated by the Montreal Protocol.

Substance	Chemical formula	ODP values
CFCs		
CFC-11	$CFCl_3$	1.0
CFC-12	CF_2Cl_2	1.0
CFC-113	$C_2F_3Cl_3$	0.8
CFC-115	C_2F_5Cl	0.6
Other CFCs	-	-
Tetrachloromethane	CCl_4	1.1
1,1,1-Trichloroethane	CH_3CCl_3	0.1
Halons		
Halon-1301	CF_3Br	10
Halon-1211	CF_2BrCl	3
Halon-2402	CF_2BrCF_2Br	6
Methylbromide	CH_3Br	0.6 (1)
HCFCs		
HCFC-22	CHF_2Cl	0.055
HCFC-123	$C_2HCL_2F_3$	0.02
HCFC-141 b	$C_2H_3FCl_2$	0.11
HCFC-142 b	$C_2H_3F_2Cl$	0.065
	-	

(1) Changed from 0.7 to 0.6 at the 7th Meeting of the Parties to the Montreal Protocol, December 1995.
0.6 is used in the calculations for 1996 and 1997.

Table 1.b
Pure [1] greenhouse gases, their chemical formulas and GWP values stipulated in the Kyoto Protocol

Substance	Chemical formula	GWP value
HFCs		
HFC-32	CH_2FH_2	650
HFC-125	C_2HF5	2,800
HFC-134 a	CF_3CFH_2	1,300
HFC-143 a	$C_2H_3F_3$	3,800
HFC-152 a	CF_2HCH_3	140
HFC-245		950
HFC-227	C3HF7	2,900
HFC-365		890
HFC-404 a[2]	-	3,260
HFC-401a[3]	-	18
HFC-402a[4]		1,680
HFC-407c[5]		1,525
HFC-408a[6]		1,030
HFC-409a[7]		0
HFC-410a[8]		1,725
HFC-507a[9]		3,300
Sulphurhexafluoride	SF_6	23,900
Perfluorinated hydrocarbons		
Tetrafluoromethane (perfluoromethane)	CF_4	6,500
Fluoroethane (perfluoroethane)	C_2F_6 C_3F_8	9,200 7,000
Fluoropropane (perfluoropropane)	$C\text{-}C_4F_8$	8,700
Fluorocyclobutane (perfluorocyclobutane)	C_6F_{14}	7,400
Fluorohexane (perfluorohexane)		

(1) No ozone-depleting effect.
(2) Mixture consisting of 52 % HFC-143a, 44 % HFC-125 and 4 % HFC-134a. The GWP value is determined from this.
(3) Mixture consisting of 53 % HCFC-22, 13 % HFC-152a and 34 % HCFC-124. The GWP value is determined from this.
(4) Mixture consisting of 38 % HCFC-22, 60 % HFC-125 and 2 % propane. The GWP value is determined from this.
(5) Mixture consisting of 25 % HFC-125, 52 % HFC-134a, and 23 % HFC-32. The GWP value is determined from this.
(6) Mixture consisting of 46 % HFC-143a and 7 % HFC-125. The GWP value is determined from this.
(7) A HFCFC mixture consisting entirely of HCFCs, where the GWP value - in accordance with the climate convention guidelines - is 0, since the mixture does not contain greenhouse gases. The real GWP value is 1,440.
(8) Mixture consisting of 50 % HFC-32 and 50 % HFC-125
(9) Mixture consisting of 50 % HFC-125, 50 % HFC-143a. The GWP value is determined from this.

Statistical data for calculations of imports/exports of fridges/freezers and mobile A/C systems

Table 1. Key figures for the content of HFC-134 in insulation foam and as a refrigerant per unit for calculation of imports and exports of fridges and freezers

Key figures	HFC-134a in insulation foam, g	HFC 134a refrigerant, g	HFC-134a, g/unit total
Fridge/ freezer	240	111	351
Fridges and freezers	240	65	305
Chest freezers	240	164	404
Cupboard freezers	240	127	367

Table 2. Imports and exports of HFC-134a calculated as net exports of fridges and freezers (source: Statistics Denmark's foreign trade statistics)

Exports, pcs	1998	1997	1996	1995	1994	1993	1992
Fridge/ freezer	26,387	65,491	40,040	48,332	47,851	72,017	66,488
Fridges and freezers	-109,550	4,308	-30,381	-90,011	-29,184	-11,382	-7,250
Chest freezers	815,523	778,580	701,748	879,172	855,691	771,198	766,453
Cupboard freezers	89,878	135,376	56,385	72,232	68,278	80,312	92,278
Exports, total units	822,238	983,755	767,792	909,725	942,636	912,145	917,969
Exports of foam (a16 chest freezers)	6,715	205,175	66,044	30,553	86,945	140,947	151,516
Total exports of HFC-134a, tonnes	338.3	388.5	309.0	371.2	372.4	90.7	0.0
HFC-134a (foam)	197.3	236.1	184.3	218.3	169.7	54.7	
HFC 134a (fridges)	141.0	152.4	124.7	152.9	202.7	36.0	
HFC-134a (foam, exports)	1.6	49.2	15.9	7.3	20.9	33.8	36.4

It should be noted that this is a considerable simplification since the quantity of HFC used for foam and refrigerant varies, depending on the producer and product size. The average quantities used are shown in Table 2.

Table 3. Statistical data on imports and exports of cars and lorries

Air conditioning	Cars	Lorries	Total, tonnes
Net imports, 1998	151,385	26,249	
Proportion with A/C	15,138.5	13,124.5	
Quantity HFC-134a, kg	11,353.8	16,405.6	27.8

Cars: 10% with A/C and 0.75 kg - 134a
Lorries: 50% with A/C and 1.25 kg - 134a

Consumption and emissions of ozone-depleting substances in Greenland

Statistics Denmark registers both imports to Greenland and exports from Denmark to Greenland.

The trends in supply of ODSs (only substances with position numbers in Statistics Denmark's foreign trade information) 1990-2003 are shown in Table 1.

Table 1. Trends in supply to Greenland based on data from Statistics Denmark, tonnes

Substance	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CFC-11	5.5	0.1	4.5	0	2.2	1.6	0	0	2.1	1.9	<0.3	0	0.4	4.0
CFC-12	6.0	0	0.1	0	0.7	6.7	10.3	0	1.2	0	0	0	0	0
CFC-113	-	-	-	-	-	-	-	-	0	0	<0.2	0	0	0
CFC-115	-	-	-	31	5.5	0	0	0.2	0.4	0	0	0	0	0
All CFCs	13	7	6	31	8	8	10	0.2	3.7	1.9	<0.5	0	0.4	4.0
HCFC-22	-	-	-	-	-	-	-	-	-	-	-	20	4.6	6.8
1,1,1,- tri-chloroethane	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0

Based on the statistics available it was not possible to evaluate the consumption of substances other than those shown in the table.

In 2003, Greenland imported 4.0 tonnes CFC-11 from Denmark (Statistics Denmark). There is a difference of 1 tonne CFC-11 between figures from Statistics Denmark and from Statistics Greenland.

In 2002, there were exports of 6.8 tonnes HCFC-22 to Greenland (importer data).

No reports of exports of 1,1,1-trichloroethane were recorded in 2003.

From the above data, ODP-weighted consumption in Greenland for 2003 was calculated at 4.36 ODP tonnes. This is an increase compared to 2002, when the ODP consumption was 0.66 tonnes ODP tonnes.

GWP contribution from HFCs, PFCs, and SF_6, 1993-2020.

The table below shows projections of determined GWP contributions.

The emission projections are determined by starting with a ‘steady state’ consumption using 2003 as the reference year and the cut-off dates for the phasing-out of specific substances, cf. the Statutory Order regulating certain industrial greenhouse gases. A tax effect is also included in the relevant areas of application and expected increases in several application areas are taken into account as much as possible, as are expected reductions in several of the application areas. However, projections of the consumption of HFC-404a in the emission calculations are based on conservative developments. The phasing out of HCFC-22 refrigerating plants is expected to lead to greater increases in the consumption of HFC-404a in commercial refrigerating plants than was presupposed, since HFC-404a together with CO2 plants are the most obvious substitution possibilities. From 1 January 2000, it has not been permitted to build new HCFC-22 systems, and from 1 January 2002, it has not been permitted to substitute with HCFC-22 in existing refrigerators.

The calculated GWP contribution expresses actual emissions, adjusted for imports and exports (the latest basis of calculation).

An improvement in the data on the use of SF6 in laboratories meant that there is a slight rise in the emissions from this source in 2002.

Table 1. GWP contribution from HFCs, PFCs, and SF_6 in 1000 tonnes, 1993-2020. The figures in this table need changing from, eg. 0,1 to 0.1.

	HFC-134a	HFC-152a	HFC-404a	HFC-401a	HFC-402	HFC-407c	HFC-507a	Andre HFC-er	PFC-er	SF6	I alt pr år
1993	89,7	4,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	101,2	195,1
1994	126,6	6,4	1,4	0,0	0,1	0,0	0,0	0,0	0,1	122,1	256,6
1995	194,9	6,1	15,3	0,0	1,2	0,0	0,0	0,4	0,5	107,3	325,6
1996	264,1	4,5	54,2	0,0	3,7	0,0	0,0	2,9	1,7	61,0	391,9
1997	222,6	2,1	85,7	0,0	6,6	0,3	0,4	6,0	4,1	73,1	400,9
1998	270,8	1,3	117,8	0,1	7,6	2,5	2,9	8,1	9,1	59,4	479,5
1999	290,5	5,3	176,8	0,1	8,7	5,4	5,7	10,2	12,5	65,4	580,5
2000	318,6	2,3	239,6	0,1	9,5	11,0	8,9	14,1	17,9	59,2	681,2
2001	338,2	1,8	236,8	0,1	9,0	16,6	14,3	29,4	22,1	30,4	698,9
2002	350,8	1,8	256,5	0,1	8,0	22,2	14,2	17,5	22,2	25,5	718,8
2003	329,2	0,2	290,0	0,1	7,0	33,8	17,0	17,2	19,3	31,9	745,6
2004	324,4	0,2	307,4	0,0	6,1	45,2	18,1	48,8	15,9	31,5	797,8
2005	320,1	0,2	323,1	0,0	5,5	55,4	19,2	49,3	14,0	31,8	818,6
2006	295,5	0,1	337,2	0,0	5,1	64,6	20,1	18,6	12,5	32,0	785,6
2007	295,9	0,1	348,5	0,0	4,7	71,8	20,8	19,0	11,1	32,2	804,0
2008	295,3	0,1	351,1	0,0	4,5	71,7	20,8	18,9	10,4	32,4	805,2
2009	282,3	0,1	348,4	0,0	4,3	70,5	20,4	18,6	9,9	32,6	787,2
2010	269,7	0,1	341,1	0,0	4,2	70,0	20,3	18,5	9,5	32,8	766,1
2011	260,4	0,1	304,5	0,0	4,0	69,6	20,2	15,9	9,2	65,1	748,9
2012	229,5	0,1	275,2	0,0	3,8	69,1	20,0	12,6	8,8	111,2	730,3
2013	215,3	0,1	250,4	0,0	3,6	66,5	17,4	10,2	8,4	121,2	693,1
2014	172,1	0,1	218,3	0,0	3,4	63,7	14,4	8,3	8,0	133,7	621,9
2015	150,6	0,0	177,0	0,0	3,1	57,5	11,7	4,2	7,5	119,0	530,6
2016	123,9	0,0	136,0	0,0	2,8	51,2	4,9	1,3	7,0	91,3	418,5
2017	107,4	0,0	109,6	0,0	2,5	41,9	5,2	0,0	6,6	76,4	349,7
2018	93,5	0,0	65,5	0,0	2,2	26,3	1,6	0,4	6,3	106,4	302,3
2019	91,4	0,0	44,6	0,0	2,0	12,1	0,2	-0,2	6,0	75,6	231,8
2020	89,7	0,0	27,4	0,0	1,8	0,4	-0,9	-0,7	5,7	55,1	178,6
I alt	**6413**	**37**	**5439**	**1**	**125**	**999**	**298**	**349**	**266**	**1917**	**15844,8**

Specification of methods and assumptions for determination of emissions for 1990-2003 as well as projections of GWP in accordance with *IPCC Good Practise Guidance and Uncertainty Management in National Greenhouse Gas Inventory*

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
	OF SUBSTITUTES FOR OZONE-DEPLETING SUBSTANCES (ODS SUBSTITUTES)					
	Refrigerant					
K1	Household fridges and freezers	HFC-134a	Tier 2 top-down approach: - information on refrigerant consumption provided by reports from the main producers of household fridges and freezers in DK. information on refrigerant consumption provided by reports from the main producers of household fridges and freezers in DK, accounting for no less than an estimated 95% of the market. Tier 2 bottom-up approach: - information on imports and exports of refrigerants in products based on the average quantity contained per unit and Danish statistics.	- release on filling = 2% (IPCC default) 1 % release from stock per year (IPCC default) Lifetime = 15 years (IPCC default) 0% release upon disposal (DK default). Up to and including 2000, the quantity remaining upon disposal was included as emissions (IPCC default). Legislation in Denmark ensures drawing-off of refrigerant, and consequently, the IPCC default is misleading in the Danish context.	Stock determined in 1998 for the period 1990-1998 based on information on consumption from Danish producers and estimates based on import/export statistics and average quantity of HFC contained in refrigerant and foam per unit (source: /2/). For the updating of stock, import/export data from 1998 is used, as well as information on annual HFC consumption by Danish producers. 1998 import/export data is = net exports of 141 tonnes HFC-134a refrigerant + net exports of 1.6 tonnes HFC-134a in foam (note: DK's largest exporter does not use HFC for foam moulding, therefore the export of HFC in foam is less than the export of refrigerants).	From 2001, net exports of refrigerants in household fridges are assumed to account for 50 per cent of consumption. The consumption in the projection is not influenced by new phasing-out regulations. The effect of charges on HFCs is expected to give an annual reduction in consumption of 5 per cent in the period 2001-2005.

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
K2	Commercial stationary refrigerators in retail stores, industry, etc., and stationary A/C systems in buildings etc.	HFC-134a, HFC-404a, HFC-401a, HFC-402a, HFC-407c, HFC-507a, other HFCs, PFCs (C_3F_8)	Tier 2 top-down approach: - information on refrigerant consumption was provided by importers/suppliers of refrigerants for commercial refrigerators in DK. - information on distribution of refrigerant consumption at different sites is estimated using information from user enterprises, the KMO and estimates from suppliers.	1.5% on refilling (DK default) 10% release from operation and accidents (DK default). 0% release from destruction (DK default) In the case of re-use it is assumed release occurs during the cleaning process equivalent to 2%. It is *good practice* not to account for any re-use since the original is accounted for in sales and imports.	In 2001/2002 an assessment was made of the national Danish leakage rate from commercial plants. This assessment was carried out by COWI for the Danish EPA. This result has led to a decrease in the leakage rates for filling, operation and disposal in compliance with IPCC guidelines /16/.	From 2007, the consumption of refrigerants merely represents the amount used for refilling existing systems (stock). It is assumed that the consumption of refrigerants for refilling stock will be reduced by 15 per cent in 2007 and will then diminish by 5 per cent per year until 2014. From 2015, it is assumed that consumption will only represent 10 per cent per year compared to current levels.
K3	Refrigerated vans and lorries	HFC-134a, HFC-404a	Tier 2 top-down approach - information on refrigerant consumption in refrigerated vans and lorries is based on consumption information from refrigerated transport companies as well as data from the KMO.	0.5% on refilling (DK default) 17% from operation annually (DK default, same as IPCC) 2% in reuse (DK default) Lifetime = 6-8 years 0% upon destruction; all refrigerants are drawn off and are either recycled or destroyed at the Kommune Kemi plant	In 2001/2002 an assessment was made of the national Danish leakage rate from refrigerated vans and lorries. This assessment was carried out by COWI for the Danish EPA. This result has led to a decrease in the leakage rates for filling and disposal in compliance with IPCC guidelines. The leakage rate for operation is still 17% in compliance with IPCC guidelines /16/.	The tax effect has not been included, since refrigerated vans and lorries are exempt from taxes. Stock is defined as 7.7 tonnes (HFC-134a) and 23.2 tonnes HFC-404a in 2000 /16/. Consumption has been projected as steady state compared to 2001.
K4	Mobile A/C systems	HFC-134a	Tier 2 bottom-up and top-down approach. Bottom-up approach for definition of Danish emission factor and estimate for stock and imports. Top-down approach	0.5% on refilling (DK default) 33% annual release during operation (complete refilling every 3 years - DK default).	In 2001/2002 an assessment was made of the national Danish leakage rate from mobile A/C systems. This	The projection is based on a steady state stock (203 tons).

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
			used for gathering of consumption data from importers for refilling of mobile A/C systems.	Lifetime for mobile A/C systems that are serviced is 6 years, equivalent to two refillings. Systems do not undergo maintenance after 6 years (DK default). 0% loss at destruction. Gas is collected and re-used/cleaned, or treated at Kommune Kemi (DK default). Emissions are calculated as 1/3 of stock from the previous year (n-1). This means the stock is the central calculation parameter. The stock is calculated using DAF annual statistics in relation to a number of conditions defined in /16/. Consumption per annum gives the quantity used in refilling systems which undergo servicing (max. 50% of existing systems).	assessment was carried out by COWI for the Danish EPA. This result has led to a small increase in the leakage rate for operation and a decrease for filling and disposal in relation to IPCC guidelines /16/. The stock figures are updated using statistics on vehicles in Denmark from DAF. The average expected filling for cars and vans is 750 g, 1.2 kg for lorries under 6 tonnes, 1.5 kg for lorries over 6 tonnes, and 9 kg for buses. Further calculation assumptions appear from /16/.	
	Foam production					
S1	Foam in household fridges and freezers (closed cell)	HFC-134a	Tier 2 top-down + bottom-up approach: - information on refrigerant consumption provided by reports from the main producers of household fridges and freezers in DK. information on refrigerant consumption provided by reports from the main producers of household fridges and freezers in DK, accounting for no less than an estimated 95% of the market.	10% release in foam production (IPCC default) 4.5% release from stock per year (IPCC default) Lifetime = 15 years (DK default) 22.5% remaining upon disposal which is destroyed in incineration and thereby is not released as emissions (DK default).	Stock of HFC in foam determined in 1998 for the period 1990-1998 based on information from Danish producers and estimates based on import/export statistics and average quantity of HFC contained in refrigerant and foam per unit /2/. For the updating of stock, import/export data from 1998 is used, as well as information on annual HFC consumption by Danish producers. 1998	

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
					import/export data is = net exports of 141 tonnes HFC-134a refrigerant + net exports of 1.6 tonnes HFC-134a in foam (note: DK's largest exporter does not use HFC for foam moulding, therefore the export of HFC in foam is less than the export of refrigerants).	
S2	Soft foam (open cell)	HFC-134a HFC-152a Other HFCs (HFC-365)	Tier 2 - information on foam blowing agents for soft foam is derived from reports provided by the main producer in Denmark, which still employs HFC in foaming processes. This producer is thought to represent approx. 80% of the Danish soft foam consumption.	Emissions = 100% of the HFCs sold in the current year (IPCC default)		
S3	Joint filler (open cell)	HFC-134a HFC-152a	Tier 2 top-down approach. - There are no longer any Danish producers of joint filler employing HFC as a foaming agent. Emissions are due to previous estimates by producers of imported joint filler products.	Emissions = 100% of imported quantity contained in joint filler in the current year (IPCC default).	The estimated imports in 1998 by a joint filler producer were 10 tonnes HFC-134a and 1 tonne HFC-152a. This estimate was based on the assumption that there is an average of 100 g HFC-134a and 25 g HFC-152a per tin of joint filler imported.	
S4	Foaming of polyether (for shoe soles)	HFC-134a HFC-152a	Tier 2 top-down approach Information regarding consumption is identical to the consumption reported by producer in 1999 + an estimate of imports/exports of HFC in shoe soles, 1998. Tier 2 bottom-up approach: Imports of HFCs contained in shoes are based on the average amount per shoe and on Danish statistics.	Emission (Danish default): - Production = 15 % - Use = 4.5 % - Lifetime = 3 years - Disposal = 71.5%, destroyed in incineration and thereby not released as emissions.	The calculation of the HFC stock in shoe soles is based on the following assumptions: it is assumed that 5% of all shoes with plastic, rubber and leather soles contain polyether containing 8 g of HFC-134a per shoe. Net export with the same consumption in Danish	

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
					production is 0.3 tonnes HFC-134a.	
S5	System foam (for panels, insulation, etc.)	HFC-134a HFC-152a Other HFCs (HFC-365)	Bottom-up Tier 2 approach on the basis of information from enterprises	Emissions = 0. HFC is used as a component in semi-manufactured goods and emissions first occur when the goods are put into use.	All system foam produced in Denmark is exported, therefore emissions can only occur in the country where the goods are put into use.	
	Aerosols					
	Aerosol sprays (industrial products)	HFC-134a	Tier 2. - information on propellant consumption is derived from reports on consumption from the only major producers of HFC-containing aerosol sprays in Denmark. The importers are estimated to account for 100% of Danish consumption.	Emissions = 50% of the HFC sold to this area of application in the current year and 50% of the consumption in the second year (IPCC default for top-down data)	Top-down data. Estimates of imports/exports are based on the producer's assessment of imports equivalent to 20% of Danish production in the current year. Exports are quantified by the producer.	
	MDI (metered dose inhalers)	HFC-134a	Tier 2 bottom-up approach - consumption was studied in 1999 and was evaluated as minimal.			Due to minimal emissions, this class of products is no longer included in Denmark's national inventory.
	Solvents					
R1	Liquid cleaners	PFC (C_3F_8 Perfluorpropane)	Tier 2. - information on consumption of PFC in liquid cleaners is derived from two importers' sales reports. This is thought to represent 100% of the Danish consumption of PFCs in liquid cleaners.	Emissions = 50% of the HFC sold to this area of application in the current year and 50% of the consumption in the second year (IPCC good practice for top-down data)		Top-down data Phasing-out cf. Statutory Order 1/9 2002. It is assumed that the consumption is equally distributed over all months.
	EMISSIONS OF SF_6 FROM ELECTRICAL EQUIPMENT AND OTHER SOURCES					
	Insulation gas in double glazing	SF_6	Tier 2 - information on consumption of SF6 in double glazing is derived from importers' sales reports to the application area. The importers account for 100% of the Danish	Emission (DK-default): - 15% during production of double glazing. - 1 % per year during the lifetime of the window		Emissions data and lifetimes are based on information from the window producers and industry experts in Denmark /2/.

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
			sales of SF_6 for double glazing. In addition, the largest producer of windows in Denmark has provided consumption data, with which import information is compared.	- Lifetime = 20 years - Disposal - 66% of the filled content of double glazing in the production year. - Net exports = 50% of the consumption in the current year		The stock is determined on the basis of consumption information provided by importers back to 1990. The first Danish consumption was registered in 1991. In the projection of emissions, it is assumed that the consumption of SF_6 in Danish window production was phased out in 2003, after which emissions only arise from stock.
	Insulation gas in high-voltage power switches	SF_6	Tier 3c country-level mass-balance approach - information on consumption of SF_6 in high-voltage power switches is derived from importers' sales reports (gas or gas-containing products). The importers account for 100% of the Danish sales of SF_6. The electricity sector also provides information on the installation of new plant and thus whether the stock is increasing.	Emission (Danish default): - release on filling = 5% - loss / release in operation = 0.5 % per year - release in reuse/drawing off = 5%. - release upon disposal = 0%		There is one supplier (Siemens) that imports its own gas for filling in Denmark. Suppliers (AAB, Siemens, Alstom) report on new installations. The stock in 2000 was 57.6 tonnes of SF_6, which covers power switches of all sizes in production and transmission plants. The stock has been evaluated on the basis of a questionnaire survey in 1999 which encompassed the entire Danish electricity sector /11/.
	Shock-absorbing gas in Nike Air training footwear	SF_6	Tier 2 - top-down approach Importer has estimated imports to Denmark of SF_6 in training footwear.	Lifetime training footwear = 5 years		Importer/wholesaler reports that imports for the period 1990-1998 amounted to approx. 1 tonne, equivalent to emissions of 0.11 tonnes per year in the period 1995-2003. For the period 1999-2005, the importer estimated imports to represent approx. 1/3, corresponding to 0.037 tonnes

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
						per year in the period 2004-2010.