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Ozone depleting substances and the greenhouse gases HFCs, PFCs and SF_6

Danish consumption and emissions 2002

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APPENDICES

1 Summary and conclusions

1.1 Ozone-depleting substances

ODP-weighted consumption for 2002 has been calculated at 42.97 ODP tonnes, which is a reduction of 42.19 ODP tonnes compared to 2001, which measured 85.16 ODP tonnes.

The table below shows ODP-weighted consumption calculated on the basis of information on imports from Statistics Denmark, 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 2001-2002, tonnes

Substance	Net consumption, 2001	ODP-weighted consumption, 2001	Net consumption, 2002	ODP-weighted consumption, 2002
CFCs (1)	2.6	2.08	0.95	0.76
Tetrachloro-methane	1.25	1.26	0.87	0.96
1,1,1-trichloroethane	0.05	0.005	0.02	-
Halons	0	0	0	0
Methyl bromide	(only feedstock)	-	(only feedstock)	-
HCFCs	889.9	81.45	390	41.25
HCFC-22	249.1	13.7	24.5	1.35
HCFC-123	18	0.36	-	-
HCFC-141b	609	66.99	360	39.6
HCFC-142b	0	0	0	0
Total		85.16		42.97

(1) When calculating the ODP-weighted consumption of CFCs, only CFC-113 has been registered and included in the basis of the calculations.

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 2002 are shown in Table 1.2.

Table 1.2 Consumption of HCFCs by application area in 2002, tonnes

Application area	HCFC-22	HCFC-123	HCFC-141b	HCFC-142b
System foam (for panels, insulation, etc.)	0	0	360	0
Refrigerant	24.5	0	0	0
Total	24.5	0	360	0

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

Figure 1.1 shows the development of ODP-weighted consumption.

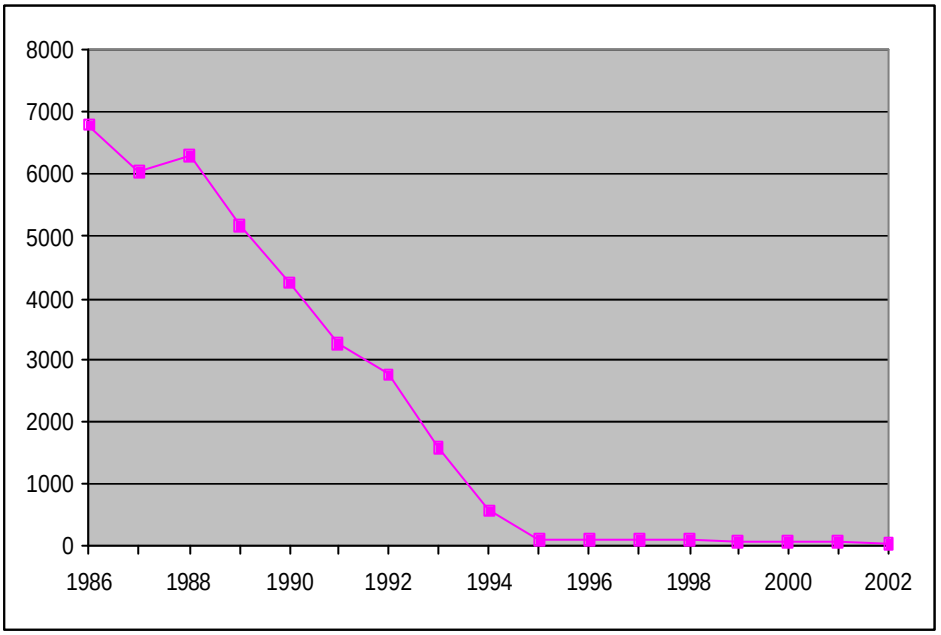

Figure 1.1 The development of ODP-weighted consumption 1986-2002, tonnes

The specific consumption figures for individual substances and groups of substances and the ODP contribution calculated for the period 1986-2002 appear in Table 3.1 in Chapter 3.

1.2 Greenhouse gases

The GWP-weighted actual emissions of HFCs, PFCs, and SF_6 in 2002 measured approx. 715,000 tonnes CO_2 equivalents. The equivalent emissions were approx. 698,900 tonnes CO_2 equivalents in 2001, which is equivalent to a total increase of approx. 16,100 tonnes CO_2 equivalents.

Emissions of HFCs, PFCs, and SF_6 in 2001 accounted for less than 1 per cent of the total Danish GWP contribution /18/.

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

Table 1.3 Consumption, actual emissions, stock, adjusted for imports/exports as well as GWP contribution from greenhouse gases 2002, tonnes

Source	Substance	Consumption and imports	Stock	Actual emissions	GWP contribution	Total GWP contribution
Refrigerants for commercial stationary A/C systems and refrigerators	HFC-134a	131.6	714.6	67.0	87,070	
	HFC-404a	173.5	806.1	73.2	238,556	
	HFC-401a	0.0	31.5	3.9	71	
	HFC-402a	0.0	36.3	4.2	7,054	
	HFC-407c	89.1	207.0	14.6	22,243	
	HFC-507a	14.4	53.3	4.6	14,157	
	Other HFCs	7.5	97.9	10.2	17,530	
	PFC	1.4	25.1	2.7	18,668	
	All subs.					**405,347**
Household fridges/freezers						
Refrigerant	HFC-134a	115.4	727.0	9.1	11,821	
	HFC-404a	4.5	68.3	0.8	2,451	
Insulation foam	HFC-134	72.3	1,456.0	82.5	107,229	
	HFC-152	0.0	2.6	0.1	17	
	All subs.					**121,518**
Refrigerant for mobile A/C	HFC-134a	31.9	207.6	63.0	81,855	**81,855**
Refrigerated vans and lorries	HFC-134a	0.6	7.8	1.5	1,955	
	HFC-404a	10.7	30.8	4.8	15,522	
	HFC-402a	0.0	2.9	0.6	989	
	All subs.					**18,466**
Shoe soles	HFC-134a	5.0	0.3	2.0	2,563	**2,563**
Soft foam and aerosols, etc.	HFC-134a	44.8		44.9	58,357	
	HFC-152a	11.9		11.9	1,738	
	All subs.					**60,095**
Joint filler	HFC-134a	0.0		0.0	0	
	HFC-152a	0.0		0.0	0	
	All subs.					**0**
Liquid cleaner	PFC	0.5		0.5	3,500	**3,500**
Double glazing	SF6	0.0	38.8	0.4	9,535	**9,535**
Power switches in high-voltage plants	SF6	1.4	62.2	0.4	9,464	**9,464**
Laboratories	SF6	0.0		0.0	0	**0**
Training footwear	SF6	0.0	0.5	0.1	2,629	**2,629**
Total	HFCs	713.2	4,450.2	398.6	671,176	
	PFCs	1.9	25.1	2.7	22,168	
	SF6	1.4	101.0	0.9	21,628	
GWP contribution	Total				**714,971**	

In Figure 1.2 below, total GWP contributions from HFCs, PFCs, and SF_6 are shown in relation to individual sources. The figure shows which sources were responsible for the greatest individual contributions in 2002.

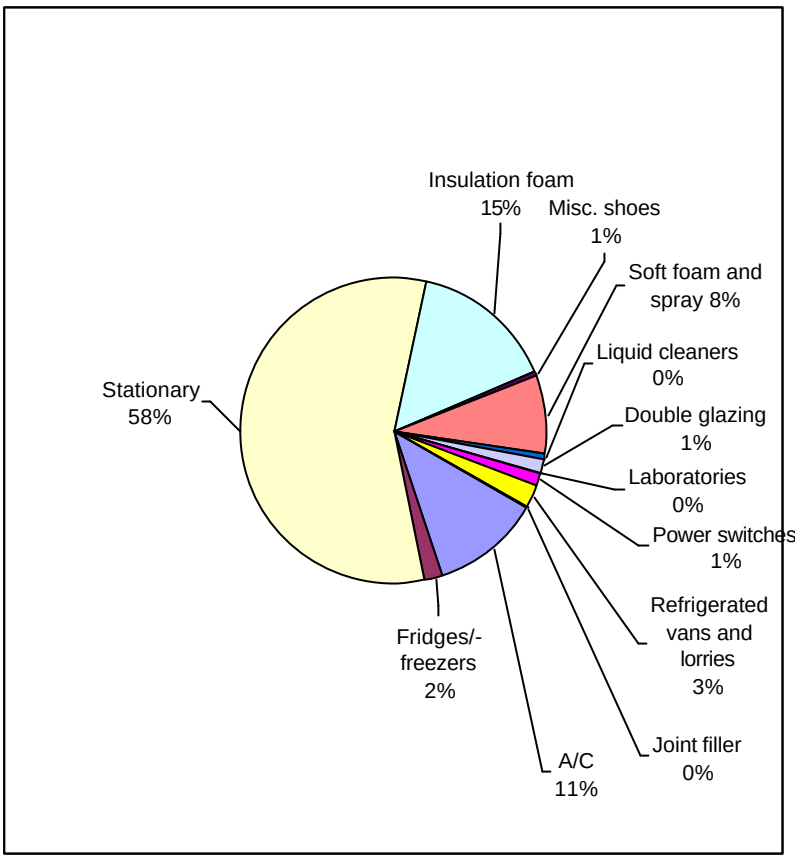

Figure 1.2 The relative distribution of the GWP contribution analysed by source

The figure shows that emissions from refrigerants used in commercial stationary refrigerators account for the largest GWP contribution. Such refrigerators make up approx. 58 per cent of the total actual contribution in 2002. The contribution is primarily due to HFCs, and, to a lesser degree, PFCs.

The second largest GWP contribution, measuring 21 per cent, comes from continuing emissions of HFCs from the insulating foam in fridges and freezers.

11 per cent of the GWP contribution derives from HFC emissions in the production of soft foam and the use of aerosol sprays employing HFCs.

The primary sources of SF_6 emissions in 2002 are from power switches, accounting for about 1 per cent of the total GWP contribution.

HFCs comprise approx. 93.9 per cent of the total GWP contribution in 2002. Emissions of SF_6 make up 3 per cent and emissions of PFC contribute 3.1 per cent to the total contribution. Compared to the level in 2001, the relative proportion of HFC emissions has risen slightly. The relative distribution is shown in Figure 1.3 below.

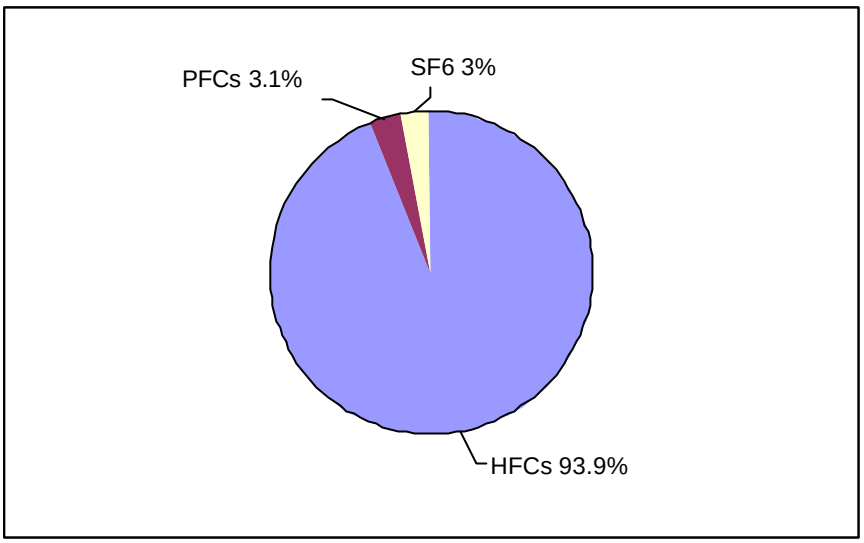

Figure 1.3 The relative distribution of the GWP contribution from HFCs, PFCs, and SF_6, 2002

1.2.1 HFCs

The total consumption of HFCs measures 713.2 tonnes in 2002, which is an increase compared to the consumption of approx. 676 tonnes in 2001. Primarily, consumption of HFC-404a and HFC-407c has risen.

The total GWP contribution from HFCs is approx. 671,200 tonnes CO_2 equivalents, which is an increase of approx. 24,800 tonnes (calculated according to the most recent calculation method) compared to the GWP contribution from HFCs in 2001.

1.2.2 Sulphur hexafluoride (SF_6)

Consumption of sulphur hexafluoride was 1.4 tonnes in 2002, which represents a significant drop in consumption when compared to 4.7 tonnes in 2001. This is due to significantly reduced consumption of SF_6 for power switches (GIS stations) in the electricity sector. In 2001, a GIS station was installed and this alone represented 3 tonnes of the total consumption.

Actual emissions have been calculated as 0.9 tonnes, equivalent to a GWP contribution of 21,600 tonnes CO_2 equivalents. In 2001, emissions were approx. 30,400 tonnes CO_2 equivalents.

1.2.3 Perfluorinated hydrocarbons (PFCs)

Consumption of perfluorinated hydrocarbons (perfluoropropane) measured 1.9 tonnes in 2002. 0.5 tonnes are estimated to have been used for cleaning liquids, and the remaining 1.4 tonnes were used as refrigerants. The actual GWP-weighted emissions were 22,200 tonnes CO_2 equivalents, which is almost the same as in 2001.

1.2.4 Trends in the total GWP contribution of potent greenhouse gases

Figure 1.4 shows the trend in Danish GWP contributions in 1992-2002 from HFCs, PFCs, and SF_6. The relative difference in the calculation of the total GWP value, derived from the present and earlier calculation methods, is illustrated in the figure.

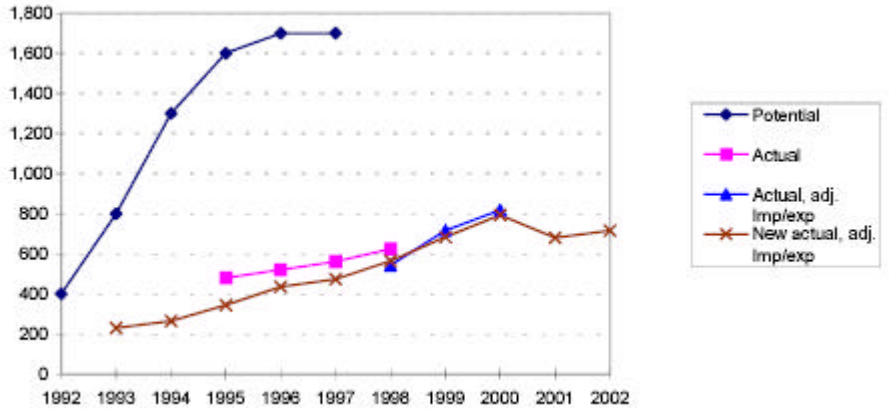

Figure 1.4 Developments in the GWP-weighted potential, actual and adjusted actual emissions 1992-2002, '000 tonnes CO2 equivalents

The figure shows that, in 2002, there was again an increase in the total GWP contribution.

Developments in the GWP contribution 1992-2002 can also be seen in Table 1.4 below.

Table 1.4 Total GWP-contribution from HFCs, PFCs, SF6 '000 tonnes CO2 equivalents, determined using four different methods during this period

	Potential	Actual	Actual, adjusted Imp/exp.	New actual, adjusted Imp/exp.
1992	400			
1993	800			230
1994	1,300			263
1995	1,600	480		344
1996	1,700	520		435
1997	1,700	560		472
1998		625	577	564
1999			700	683
2000			818	793
2001				699
2002				715

2 Introduction

On behalf of the Danish Environmental Protection Agency, the consulting firm, PlanMiljø, has conducted an assessment of Danish consumption and emissions of ozone-depleting substances and the industrial greenhouse gases (also called F-gases) HFCs, PFCs, and SF_6 for 2002. The evaluation survey has been carried out in continuation of previous assessments /13/ and references in them.

The report provides an evaluation of actual emissions of HFCs, PFCs, and SF_6. The calculation of actual emissions takes into account emissions from stock contained in products, and adjustments have been made for imports and exports of the substances contained in products. Appendix 5 describes the specific emission factors, etc.

The report has been prepared partly to enable Denmark to fulfil its international obligations to provide information on the area and partly to follow the trend in consumption of ozone-depleting substances and emissions of HFCs, PFCs, and SF_6. An example of reporting of Danish emissions is given in reference /18/.

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 depleting potentials of specific substances - ODP values (Ozone-Depleting Potential).

Greenhouse gases cause an increase in the ability of the atmosphere to retain heat radiated from the earth. Consequently the temperature of the earth's surface rises and this can lead 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 "pure" greenhouse 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 substitutes for the greenhouse gases HFCs, PFCs and SF_6 /10/.

2.1 Monitoring Group

The project has been overseen by a monitoring group, which has reviewed the results of the assessment. The monitoring group consisted of:

- Frank Jensen, Danish EPA
- Erik Lyck, National Environmental Research Institute, Denmark (NERI)
- Marianne Kodahl, Confederation of Danish Industries (DI)
- N.N., Statistics Denmark
- Tomas Sander Poulsen, PlanMiljø

2.2 Objective

The objective of the project is to evaluate the 2002 consumption of recently produced ozone-depleting substances and the consumption and actual emissions of the greenhouse gases HFCs, PFCs, and SF_6. The evaluation has been made partly in accordance with the IPCC guidelines, the Intergovernmental Panel on Climate Change /4/, and partly following the methods 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 'pure' potent greenhouse gases covered by the Kyoto Protocol under the Climate Change Convention, and their chemical formulas and GWP values (Global Warming Potential).

2.3 Scope and definitions

Ozone-depleting substances

This evaluation survey covers the net consumption of ozone-depleting substances. The term net consumption is understood as the amount of imported goods in bulk or drums, not counting 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 as raw material used 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 user enterprises (usually purchasing departments), and Statistics Denmark. The method of data gathering used ensures that the information collected corresponds to the quantities of substances that are traded. The purchase and sales figures are utilised in this evaluation as an expression synonymous with the level 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 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 in Denmark are transported for treatment at chemical waste processing plants in Denmark. This data is included in the evaluation, but is not offset in the consumption figures, as was the case in all previous surveys.

Greenhouse gases

The evaluation of actual emissions of the greenhouse gases HFCs, PFCs and SF_6 has been carried out in continuation of foregoing assessments which have become increasingly more accurate as advances have been made in internationally approved guidelines (IPCC Guidelines) and the ability to gather more detailed data.

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

2.4 Method

Consumption and emissions

The evaluation of consumption and calculation of emissions and stock have been 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
- Danish Refrigeration Installers' Environmental Scheme (KMO)
- Previous evaluations of HFCs, PFCs and SF_6 /2, 11, 13, 16/.

Information for evaluation is firstly gathered by means of a questionnaire survey. The responses to the questionnaires are 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 registrations and statistics from the KMO, etc.

The information gathered from importers and suppliers is recorded with information on consumer enterprises in order to monitor any disagreements between purchase and sales information and application of the substances. In some cases, the application of individual substances can be estimated on the basis of two sources, given that the majority of the consuming enterprises are known. In cases where not all the user enterprises specify the application of substances, the consumption of individual substances is estimated from the

information provided by importers, suppliers, and any industry-related organisations, such as the KMO.

Occasionally, there are inconsistencies between the information provided by suppliers and user enterprises. This is partly due to imports from other EU countries, changes in inventories of substances, or a lack of correspondence between the quantities sold and consumed. It can also be due to a degree of uncertainty in the method of calculation used by enterprises. Sales and consumption information has been harmonised.

The average degree of uncertainty in the report's consumption figures (sold and bought quantities) is estimated at approx. 10-15 per cent, and slightly greater for data regarding the areas of application. 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 has been 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 evaluation year, accounting for the time lapse between consumption and emissions. Actual emissions include Danish emissions from production, from products during their lifetimes, and from waste 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, an estimate is made of emissions from a specific application area based on information from producers using substances in production and 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 the actual emissions during the consumption phase and disposal phase.

Tier 2 bottom-up analyses have been carried out within selected areas over a number of years. The analyses have quantified the stock and, in some cases, Danish emission factors. Detailed analyses have been carried out for commercial refrigerators, mobile A/C systems, fridges, freezers, and SF_6

power switches. The analyses have been evaluated in separate reports /2, 11, 16/:

Bottom-up includes:

- Screening of the market for products in which greenhouse gases are used.
- Calculation of averages for the content of greenhouse gases per product unit.
- Calculation of emissions during the lifetime of products and at disposal.
- Identification of technological development trends that have significance for emissions of greenhouse gases.
- Calculation of imports and exports on the basis of defined key figures, information from Statistics Denmark on foreign trade, and industry information.

The results from this analysis are built on further in the evaluation of actual emissions for the current year.

Consumption and emissions of greenhouse gases are, wherever possible, carried out for individual substances, even though the consumption of certain HFCs has been very limited. This has been done to ensure transparency of evaluation in the calculation of GWP values. However, the continued use of a category for "Other HFCs" has been necessary since not all importers and suppliers have detailed records of sales for 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 distribution of substances in the areas of application is judged to arise from the consumption of HFC-404a and HFC-134a in commercial refrigerators and mobile refrigerators. The distribution is significant in the differences in the emission calculations in the short term (approx. five years), but balances out in the long term. This is because the distribution is only significant for the rate at which emissions are released.

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

2.5 Explanation of terminology

The following terms and abbreviations are used throughout this report:

- *User enterprise:* 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 quantity of substances in imports registered in Denmark during the year of evaluation. These figures are provided by wholesalers and by producers in Denmark

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

- *KMO:* Danish Refrigeration Installers' Environmental Scheme

- *Stock:* The amount of substance contained in products 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 relating to relevant substances (including both mixed and pure substances). All ODSs reported by the importers are new ODSs.

The information from importers is supplemented with statistical information from Statistics Denmark for 2002. Information on CFC-11, CFC-12, CFC-113, tetrachloromethane, 1,1,1-trichloroethane, and methyl bromide regarding imports and exports is available from Statistics Denmark, but for HCFCs, halons and other CFCs, the statistics are provided only for groups of substances and not for individual substances. Therefore, Statistics Denmark cannot be used as a source for these substances. Statistical data is used for cross-checking information on imports. 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. It is therefore assumed that, in imports of CFC-113, the difference between data from importers and data from Statistics Denmark derives from imports of re-used ODSs.

There are no imports for feedstock except for methyl bromide.

None of the exported amounts of HCFC-22 and HCFC-141b are used for feedstock or for "essential use". It has not been possible to quantify in detail the export of 1,1,1-trichloroethane but it has been assumed that none is used for essential use or for feedstock purposes.

The foreign trade statistics for 2002 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, etc.), 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.

In the case of CFCs, Statistics Denmark does not distinguish between new and re-used CFCs. Data on CFCs from Statistics Denmark are therefore not used in the evaluation. The Statistics Denmark information can only be used for halons, tetrachloromethane, and 1,1,1-trichloroethane when making direct comparisons with information from importers and user enterprises.

3.1 Imports and exports

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

3.1.1 CFCs

The sales of new CFCs in 2002, based on information on imports were 0.95 tonnes. In 2001, sales were 2.6 tonnes. This reduction is mainly due to a particular importer reporting, in 2002, that there are no longer any imports due to changes in the market.

Three importers report sales of 0.95 tonnes of CFC-113 for laboratory purposes.

Statistics Denmark registered imports of 20 kg of CFC-113 in 2001.

There is no other information available for imports of other CFCs.

3.1.2 Tetrachloromethane

In 2002, three importers reported imports and sales of a total of 0.87 tonnes of tetrachloromethane for laboratory purposes. In 2001, imports totalled 1.25 tonnes.

Statistics Denmark registered imports of 292 kg in 2002.

3.1.3 1,1,1-trichloroethane

In 2002, two importers reported imports and sales of approx. 20 kg of 1,1,1-trichloroethane.

Statistics Denmark registered imports of 4.1 tonnes in 2002.

3.1.4 Halons

No information has been received regarding imports of halons in 2002.

3.1.5 Methyl bromide

Methyl bromide was only imported for feedstock in 2002.

3.1.6 HCFCs

Five enterprises have imported HCFCs in 2002.

The consumption of HCFC-22 and HCFC-141b has fallen, and there has been no consumption of HCFC-142b.

In 2002, imports of HCFC-22 (new and regenerated) totalled approx. 178 tonnes, of which 5.5 tonnes came from HFC mixtures. Re-exports were

approx. 148 tonnes, ie. net imports of HCFC-22 in 2002 were approx. 30 tonnes, of which 24.5 tonnes were imported as pure HCFC-22. In 2001, the consumption of HCFC-22 after re-exports was 249 tonnes.

Imports of HCFC-141b totalled 360 tonnes in 2002. In 2001, imports totalled 609 tonnes.

There were no imports of HCFC-142b in 2002. In 2001, imports totalled 15.8 tonnes.

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

Substance	1987	1989	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CFC-11	3,046	2,300	1,3	593	54	0	0	0	0	0	0	0	0
	3,046	*2,300*	*1,3*	*593*	*54*								-
CFC-12	1,378	825	612	495	243	0	0	0	0	0	0	0	0
	1,378	*825*	*612*	*495*	*243*								-
CFC-113	469	327	253	162	70	3	5	2	1.4	3.3	4.8	2.6	0.95
	375.2	*261.6*	*202.4*	*129.6*	*56*	*2.4*	*4*	*1.6*	*1.12*	*2.64*	*3.84*	*2.08*	0.76
CFC-115	83	68	56	50	26	0	0	0	0	0	0		
	49.8	*40.8*	*33.6*	*30*	*15.6*								
All CFCs	4,97(	3,520	2,2	1,30	393	3	5	2	1.4	3.3	4.8	2.6	0.95
ODP-weighted consumption	*4,846*	*3,427*	*2,1*	1247.6	*368.6*	*2.4*	*4*	*1.6*	*1.12*	*2.64*	*3.84*	*2.08*	*0.76*
Tetrachloro-methane	4	2	3	<1	0.7	1.7	1.5	2.0	0.7	1.3	0.6	1.25	0.87
ODP-weighted consumption	*4.4*	*2.2*	*3.3*	*1*	*0.77*	*1.87*	*1.65*	*2.2*	*0.77*	*1.43*	*0.66*	*1.26*	*0.96*
1,1,1-trichloro-ethane	686	396	1,0	940	569	104	0	0.9	0.2	0.03	0	0.05	0.002
ODP-weighted consumption	*68.6*	*39.6*	*101.5*	*94*	*56.9*	*10.4*	*0*	*0.09*	*0.02*	*0.003*	*0*	*0.005*	-
Halon 1302	n.i.	105	45	14	5	0	0	0	0	0	0	0	0
		1,050	*450*	*140*	*50*								
Halon 1211	n.i.	15	4	1	0	0	0	0	0	0	0	0	0
		45	*12*	*3*									
Halon 2402	n.i.	0	0	0	0.7	0	0	0	0	0	0	0	0
					4.2								
All halons	100	120	44	15	6	0	0	0	0	0	0	0	0
ODP-weighted consumption	n.s	*1,095*	*462*	*143*	*54.2*	0	0	0	0	0	0	0	0
Methyl bromide[1)]	40	51	31	17	12	9	8	5	0	0	0	(179.5)	(191)
ODP-weighted consumption	*24*	*30.6*	*18.6*	*10.2*	*7.2*	*5.4*	*4.8*	*3*	*0*	*0*	*0*	-	-
HCFC-22	374	455	1,0	813	750	748	610	600	534	566	347	249.1	24.5
(pure)	*20.6*	*25*	*55.3*	*44.7*	*41.2*	*41.1*	*33.5*	*33*	*29.4*	*31.1*	*19.1*	*13.7*	*1.35*
	0	0	0	*0*	*0*	*0*	*0*	*0*	*0*	0	*0*	18	0
HCFC-123												*0.36*	-
	0	0	90	340	510	410	440	585	621	447.1	538.8	609	360
HCFC-141b			*9.9*	*37.4*	*56.1*	*45.1*	*48.4*	*64.3*	*68.3*	*49.2*	*59.3*	*66.99*	*39.6*
	0	0	130	326	145	195	160	17	17	15.8	15.8	0	0
HCFC-142b			*8.45*	*21.2*	*9.4*	*12.7*	*10.4*	*1.1*	*1.1*	*1*	*1*	*0*	-
	0	0	0	0	0	5	<5	20	0	0	0	0	0
Other HCFCs						*n.s*	*n.s*	*n.s*					-
												13.8	5.5
HCFC-22 from HFC mixture												*0.76*	*0.3*
All HCFCs	374	455	1,2	1,47	1,41	1,302	1,215	1,222	1,172	1,029	901.6	889.9	390
ODP-weighted consumption	*20.6*	*25*	*73.65*	*103.3*	*106.7*	*98.9*	*92.3*	*98.4*	*98.8*	*81.3*	*79.4*	*81.45*	*41.25*
Total ODP-weighted consumption	*6,02(*	*5,150*	*2,7*	*1,59*	*590*	*121*	*108*	*111*	*101.5*	*85.3*	*83.9*	*85.2*	*42.97*

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, using information provided by importers and producers.

Table 3.2 HCFC consumption distribution in application areas for 2002, based on information from importers and producers, tonnes

Application area	HCFC-22	HCFC-141b	HCFC-142b
System foam (for panels, insulation, etc.)	0	360	0
Refrigerant	30	0	0
Total	30	360	0

3.1.7 Treatment

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 is used from importers that receive and send on used ODSs for treatment at the KK plant.

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

The ODSs treated in 2002 appear from the table below.

Table 3.3 Treated ODSs in 2002, tonnes

ODS	Quantity, tonnes
HCFC-22	5.6
CFC-12	10.3
CFC-11	14.4

Some of the HCFC-22 results from HFC mixtures (HFC-401a, HFC-402a, HFC-403a, HFC-408a, HFC-409a and HFC-502a) that are sent by Danish importers to the Kommune Kemi treatment plant for processing either as mixtures of pure refrigerants or in mixture cylinders.

4 Greenhouse gases

4.1 Imports 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, 1994-2002.

4.1.1 HFCs

HFCs were imported by ten enterprises in 2002, of which five are Danish suppliers and four are user enterprises, importing directly from other EU countries.

Total imports (minus re-exports) of all HFCs, according to the importers, increased from 676 tonnes in 2001 to 713.2 tonnes in 2002. This corresponds to an increase of approx. 5 per cent compared to 2001.

The imports of HFC-134a have fallen from 472.8 tonnes in 2001 to 401.6 tonnes in 2002. Imports of HFC-152a have increased from 11.1 tonnes in 2001 to 11.9 tonnes in 2002. Imports of HFC-404a have increased from 126.3 tonnes in 2001 to 188.7 tonnes in 2002. The increase in the consumption of HFC-404a is due to consumption by commercial refrigerators. Imports of HFC-407c increased from 40.3 tonnes in 2001 to 89.1 tonnes in 2002. HFC-407c is a substitute refrigerant for HCFC-22 in eg. stationary A/C systems.

Imports of other HFCs (HFC-408a, HFC-409a, HFC-410a) measured 7.5 tonnes in 2002 compared with 11.4 tonnes in 2001. In 2001, HFC-365, 227 and 23 were also imported and used, but no imports were registered for these substances in 2002. Imports of HFC-507a have increased to 14.4 tonnes in 2002. In 2001, imports totalled 2.2 tonnes.

In 2002, there were no registered imports of HFC-401a and HFC-402a. The consumption of these substances was relatively small in 2001.

4.1.2 Sulphur hexafluoride

In 2002, three importers reported imports and sales of a total of 1.4 tonnes sulphur hexafluoride. In 2002, sulphur hexafluoride was used exclusively in power switches in high-voltage plants. Use of SF_6 in the metal industry was phased out in 2000 and in the glass industry in 2001.

4.1.3 Perfluorinated hydrocarbons

Three importers report imports of mixture products containing perfluorinated compounds. The substance in this case is perfluoropropane, $C_3F_{8,}$ for

refrigerant application in commercial refrigerators. Imports of this substance amount to approx. 1.45 tonnes.

As in previous years, one producer is assumed to have had imports and sales of liquid cleaners for electronic equipment, containing approx. 0.5 tonnes of perfluoropropane.

Table 4.1 Developments in imports of greenhouse gases, tonnes

Substance	1987	1989	1992	1994	1995	1996	1997	1998	1999	2000	2001	2002
HFC-134a	0	0	20	524	565	740	700	884	644.6	711.1	472.8	401.6
HFC-152a	0	0	4	51	47	32	15	14	35.8	16.4	11.1	11.9
HFC-401a	-	-	-	-	-	-	-	15	15	9.5	4.1	0
HFC-402a	-	-	-	-	-	-	-	10	10	4.2	0.8	0
HFC-404a	0	0	0	36	119	110	110	146	193.7	193.1	126.2	188.7
HFC-407c	-	-	-	-	-	-	-	17	40	44.7	40.3	89.1
HFC-507a	-	-	-	-	-	-	-	10	10	23.85	2.2	14.4
Other HFCs	0	0	0	1	14	20	65	15 [1)]	29.2[1)]	24.14[1)]	18.4[1)]	7.5[2)]
All HFCs	0	0	24	612	745	902	890	1,112	978.3	1,026	676	713.2
Sulphur hexafluoride	n.i.	n.i.	15	21	17	11	13	9	12.1	9	4.7	1.4
Perfluorinated hydrocarbons	0	0	0	0	1.5	3	8	6	7.9	6.9	3.7	1.95

[1)] The category "other" includes HFC-408a, -409a, -410a + HFC-365, HFC-23 and HFC-227 (in the emission calculation a worst-case figure is used on the basis of the GWP value for HFC-410a). There were, however, no imports in 2002.

n.i.= not informed

n.e. = not evaluated

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

4.2 Consumption analysed by application area

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

Table 4.2 Consumption of HFC analysed by application area in 2002, tonnes

Application area	HFC-134a	HFC-152a	HFC-401a	HFC-402a	HFC-404a	HFC-407c	HFC-507a	HFC-365, -227	Other HFCs
Insulation foam (fridges, freezers etc.)	72.3	0	0	0	0	0	0	0	0
Refrigerant (household and commercial fridges, freezers etc.)	115.4	0	0	0	4.5	0	0	0	0
Refrigerant (commercial stationary refrigerators and A/C systems) [1)]	131.6	0	0	0	173.5	89.1	14.4	0	7.5
Transport refrigerators [2)]	0.6	0	0	0	10.7	0	0	0	0
Refrigerants in mobile A/C [2)]	31.9	0	0	0		0	0	0	0
Other (including aerosol sprays and soft foam)	49.8	11.9	0	0	0	0	0	0	0
Total	401.6	11.9	0	0	188.7	89.1	14.4	0	7.5

1) Estimate based on the residual amount of HFC-134a, for which there is no application information available from the producers. The residual amount is used in commercial refrigerators and mobile refrigerators, based on the importers' estimated application distribution.

2) KMO statistics, 2002

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

4.2.1 Consumption of HFC as a refrigerant

The general trend in Danish consumption of HFCs for refrigerants fluctuates somewhat for the individual HFCs. In 2001, consumption of HFC-404a fell, but in 2002, it increased to the same level as in 2000. Consumption of HFC-134a used for foam and as a refrigerant for production of fridges/freezers has been falling, but the trend is rising with regard to mobile A/C systems, and total consumption of HFC-134a for refrigeration has increased.

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

The consumption of refrigerants relating to household fridges and freezers is calculated based on information from user enterprises.

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

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

Table 4.3 Relative consumption of refrigerants according to refrigerant application, tonnes

Substance HFC	Fridges/-freezer s (commercial & household)	Commercial refrigerators and A/C systems	Mobile A/C systems	Refrigerated vans and lorries	Total	Percentage
-134a	115.4	131.6	31.9	0.6	**279.5**	48%
-401a	-	-	-	-	**-**	0%
-402a	-	-	-	-	**-**	0%
-404a	4.5	173.5	-	10.7	**188.7**	33%
-407c	-	89.1	-	-	**89.1**	16%
-507a	-	14.4	-	-	**14.4**	2%
Other	-	7.5	-	-	**7.5**	1%
Total	**120**	**416.1**	**31.9**	**11.3**	**579**	**100%**
	21%	72%	5%	2%	**100**	

In 2002, there was an increase in the consumption of refrigerants for commercial refrigerators and stationary A/C systems.

4.2.2 Consumption of HFC for foam production and as a propellant

There has been a significant reduction in the general consumption of HFC-134a for foam production since 2001. This reduction is merely due to less consumption of HFC-134a for insulation foam production for fridges/freezers. The reduction is partly due to reductions in production at one HFC-based manufacturer and substitution by other foaming agents.

The consumption of HFC-134a and HFC-152a for other purposes, such as soft foam production and for use as a propellant, is approximately the same as 2001. The consumption of HFC-134a amounts to 49.8 tonnes in 2002 compared to 48 tonnes in 2001.

In 2002, there was no registered consumption of HFC-365 and HFC-227.

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

In 2002, the use of HFCs as propellants in aerosols for special purposes was slightly less than in 2001.

4.2.3 Consumption of SF_6

The overall consumption of SF_6 in 2002 was 1.4 tonnes. This consumption has only been used for power switches in high-voltage plants.

Table 4.4 Consumption of SF_6 analysed by application area, tonnes

Application	DK consumption, tonnes
Double glazing	-
Power switches in high-voltage plants	1.4
Laboratory purposes	-
Total	1.4

4.2.4 Consumption of PFCs

Total consumption of perfluoropropane (C_3F_8) in 2002 amounted to approx. 1.95 tonnes. Approx. 1.45 tonnes of this was used in refrigerant products; perfluoropropane is contained in two different mixture products comprising either 9 per cent or 39 per cent (weight) of the product respectively. The remaining approx. 0.5 tonnes perfluoropropane was used in liquid cleaners for electrical and electronic components.

Other applications of PFCs have not been reported in Denmark.

4.3 Emissions of HFCs, PFCs and SF_6

This section describes actual emissions of the greenhouse gases HFCs, PFCs, and SF_6 for 2002. The calculations are based on the aforementioned reports on consumption of these substances analysed by application areas (section 4.2). In the case of the 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, tier method etc., in relation to individual substance and application area. The table in Appendix 5 provides an overview of the IPCC methods employed. 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 2002 and projected emissions

The GWP-weighted actual emissions of HFCs, PFCs, and SF_6 in 2002 measured approx. 715,000 tonnes CO_2 equivalents. The corresponding emissions were approx. 698,900 tonnes CO_2 equivalents in 2001, which corresponds to a total increase of approx. 16,100 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 from substance groups, tonnes

Substance group	DK consumption, tonnes	GWP contribution, tonnes
HFCs	713.2	671,200
PFCs	1.9	22,200
SF_6	1.4	21,600
Total		715,000

4.3.2 Emissions of HFCs from refrigerants

In this year's evaluation of emissions from refrigerants, the following distinctions have been made:

- Fridges and freezers for household use
- 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* with refrigerants (0.5 per cent to 2 per cent of consumption depending on the 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 prevents such emissions. The release is defined as the writing-off of stock (the quantity of refrigerant contained in a product).

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

Commercial refrigerators and stationary A/C systems

The largest source of emissions comes from stationary commercial refrigerators used in supermarkets and in industry. The most commonly used refrigerants in this product group are HFC-134a and HFC-404a.

The primary refrigerant used in A/C systems is HFC-407c, a high-temperature refrigerant and substitute product for HCFC-22.

Used to a lesser extent are the refrigerants HFC-401a, HFC-402a, HFC-408a, HFC-409a, HFC-410a and HFC-507c.

It is not necessary to correct for imports and exports of HFCs in stationary commercial refrigerators since filling takes place at the site of operation following installation.

Table 4.6 shows actual emissions evaluated for specific HFCs. Total emissions of all HFCs are given in CO_2 equivalents to take into account the different GWP values of the substances.

The calculation of the GWP contribution in the category "other HFCs" (HFC-408a, HFC-409a and HFC-410a) incorporates a worst-case assumption made on the grounds of HFC-410a (50 per cent HFC-32, 50 per cent HFC-125). The GWP value for HFC-410a is 1,725.

Table 4.6 Actual emissions and GWP contribution from commercial refrigerators 2002 and 2010, tonnes

	Substance	Consumption, DK	Stock	Actual emissions	GWP contrib. 2002	GWP contrib. 2010
Commercial refrigerators and stationary A/C systems						
	HFC-134a	131.6	714.6	67.0	87070	110169
	HFC-404a	173.5	806.1	73.2	238556	360692
	HFC-401a	0.0	31.5	3.9	71	0
	HFC-402a	0.0	36.3	4.2	7054	3048
	HFC-407c	89.1	207.0	14.6	22243	66090
	HFC-507a	14.4	53.3	4.6	14157	25718
	Other HFCs 1)	7.5	97.9	10.2	17530	15322
	All subs.				**386680**	**581039**

1) The category "other HFCs" includes HFC-408a, -409a and -410a (in the emission calculation, a worst-case figure is used on the grounds of the GWP value for HFC-410a).

2) The possible future scenario takes account of the effect of the new statutory order on phasing-out of HFCs and other substances, and the effect of an implemented tax scheme. Conditions relating to the substitution of HCFC-22 systems with HFC-134a and HFC-404a systems are also taken into account.

In the projection of emissions for 2010, in which specific phase-out dates are taken into account, as established in the Statutory Order on Regulation of Certain Industrial Greenhouse Gases, it is estimated that the GWP contribution from commercial refrigerators in 2010 will be approx. 581,000 tonnes.

Projections of the consumption of HFC-404a in the emission calculations are based on conservative developments. The phasing out of HCFC-22 refrigerators is expected to lead to an increase in consumption of HFC-404a in commercial refrigerators that is significantly steeper than assumed, since HFC-404a systems and CO2 systems are the most obvious substitution options. 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.

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, figures estimating the previous imports/exports in Environmental Project no. 523 were 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 survey 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 (cf. Appendix 5). These taxes will lead to a gradual reduction in consumption up to total phase-out on 1 January 2006. 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 2002 and 2010.

Table 4.7 Emissions of refrigerants from fridges/freezers 2002 and 2010, tonnes

	HFC-134a		HFC-404A	
	2002	2010	2002	2010
Consumption	115.4	99.0	4.50	4.50
Emissions during production	2.3	2.0	0.09	0.09
Exports	57.7	49.5	0	0
Stock	727.0	997.8	68.34	95.11
Emissions from stock	6.8	9.8	0.66	2.68
Emissions from treatment	0.0	0.0	0	0
Actual emissions	9.1	11.8	0.75	1.11
GWP contribution, '000 tonnes CO_2 equivalents	11.8	15.4	2.45	3.60

Total emissions of HFC refrigerants from fridges/freezers in 2002 measured 14,250 tonnes CO_2 equivalents. In the projections of actual emissions, a small increase is expected to approx. 19,000 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 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 only used for refilling. Initial filling is carried out by car manufacturers.

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.

Table 4.8 Assumptions used in the calculation of stock in mobile A/C systems, 2002

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

The Danish Automobile Dealers Association (DAF) publishes annual statistics of the number of vehicles in Denmark /17/. These data form the basis for evaluating the HFC-134a stock in vehicles in Denmark below. Calculations are also provided for the percentage of installed A/C systems that are currently undergoing servicing and are thus being refilled with refrigerants upon leakage and other repairs. This forms the basis for determining the amount of refilling of HFC-134a in vehicles in Denmark in 2002. Amount of refilling = Danish consumption.

The results are shown in the table below.

Table 4.9 Calculation of Danish stock in mobile A/C systems in 2002 grouped by vehicle type, tonnes

	2002 (number)	Stock	Filling maintenance	Consumption of HFC-134a for refilling of mobile A/C systems
Cars	1,892,900	141.9	71.0	23.7
Buses	8,177	14.7	2.9	1.0
Vans	353,302	14.1	7.0	2.4
Lorries	49,106	36.8	14.7	4.9
TOTAL		**207.6**	**95.7**	**31.9**

The total stock of HFC-134a in mobile A/C systems in Denmark has been calculated as approx. 207.5 tonnes in 2002. Stock is expected to increase further in coming years since there is a continuing trend of more vehicles and new vehicles having A/C systems. The filled volume of HFC-134a in mobile air conditioning systems in 2002 was calculated at 31.9 tonnes which is 1 tonne more than in 2001. This volume of refrigerants alone accounts for usage in refilling during 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 2002. This assumption is very conservative as all signs indicate continued increases in vehicles with A/C systems.

Table 4.10 Calculated actual emissions of HFC-134a from mobile A/C systems in 2002 and 2010, tonnes

	2002	2010
Imported via vehicles	27.8	27.8
Consumption from refilling	31.9	31.9
Total addition to stock	59.7	59.7
Emissions from filling	1.4	1.4
Emissions from operation of stock	61.5	58.6
Total reduction in stock	63.0	60.0
Stock	207.6	194.9
Actual emissions, tonnes	63.0	60.0
GWP contribution, '000 tonnes	81.9	78.0

Refrigerated vans and lorries

Actual emissions related to refrigerated vans and lorries have not previously been evaluated as an individual application area, but have been included in a total category called "mobile refrigerators and A/C systems" in previous years. This year, data from the KMO has made it possible to evaluate the area individually, but it has not been possible to evaluate refrigerated vans and lorries individually for previous years. The emission factors are listed in Appendix 5.

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

Actual emissions from refrigerated vans and lorries in 2002 are stated in the table below.

Table 4.11 Calculated and actual emissions of HFC-134a and HFC-404a from refrigerated vans and lorries in 2002 and 2010, tonnes

	HFC-134a		HFC-404A	
	2002	2010	2002	2010
Consumption	0.59	0.59	10.7	10.7
Emissions from filling	0.03	0.03	0.5	0.5
Stock contribution	0.56	0.56	10.2	10.2
Emissions from stock	1.47	0.77	4.2	8.8
Stock	7.76	4.31	30.8	53.3
Actual emissions	1.50	0.80	4.8	9.4
GWP contrib., '000 tonnes	1.95	1.04	15.5	30.5

In addition, there are emissions from HFC-402a from stock of approx. 0.6 tonnes, corresponding to 1,000 tonnes CO_2 equivalents. There was no registered consumption of HFC-402a for refrigerated vans and lorries in 2002. It is assumed that the substance has been phased out, which is why actual emissions in 2010 are only approx. 100 tonnes CO_2 equivalents.

Total actual emissions from refrigerated vans and lorries were thus just below 18,500 tonnes CO_2 equivalents in 2002.

4.3.3 Emissions of HFCs from foam plastic products and propellants

The calculation of the emissions of HFCs used in foam plastic products includes two calculation principles, 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 emission 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
Emissions during production	10%	100%	15%
Annual release	4.5%	-	4.5%
Lifetime	15 years	-	1-10 (3 years)

Insulation foam

Hard foam plastics produced with HFC-134a are mainly used in insulating foam in fridges/freezers. The emission calculations for insulating foam in fridges/freezers are adjusted for imports and exports of fridges/freezers. The calculations are carried out on the basis of 1998 figures for the average quantity contained in fridges/freezers etc. for household use. Based on manufacturer information, the average content has been estimated at 240 g per product, and in 1998 there were net exports of two tonnes HFC-134a (see Appendix 2).

Usage of HFC-134a in insulating foam in industrial and commercial refrigerators is very limited.

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

Table 4.13 Emissions of HFCs from insulating foam, tonnes

	2002	2010
Consumption, HFC-134a	72.3	0.0
Emissions during production	7.2	0.0
Exports	2.0	0.0
Stock	1,456.0	903.0
Emissions from stock	75.3	75.1
Actual emissions	82.5	75.1
GWP contribution, '000 tonnes of CO_2 equivalents	107.2	97.7

In the projections for 2010, it is estimated that the stock will be reduced as a result of the phase-out of HFC-134a in foam production by 1 January 2006 in compliance with the Statutory Order regulating certain industrial greenhouse gases.

Polyether foam production

There is only one Danish producer of polyether foam, and again this year, the enterprise concerned in this specialist area of production did not wish to provide any information on its consumption. Therefore, the enterprise's consumption of HFC-134a in 1999 is taken as their polyether-based shoe

production in 2002. The consumption in 1999 was reported as approx. 5 tonnes and actual emissions are estimated at 2,0 tonnes, equivalent to 2,600 tonnes CO_2 equivalents. The calculation makes the assumption that no emissions are released upon disposal since the gases are destroyed during 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 approx. 12.8 million pairs of shoes were imported (Statistics Denmark, Foreign Trade) and it is estimated that a single pair of shoes contains an average of 8 g HFC-134a. Based on these figures, exports are estimated to be 0.3 tonnes HFC-134a.

Joint filler/soft foam/aerosol sprays

Emissions of 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 thus not necessary to adjust for imports/exports.

Joint filler based on HFCs as propellants/foaming agents is no longer produced or imported into Denmark.

Emissions of HFC in the production of *soft foam* are identical to the consumption in Denmark and emissions of HFC as a propellant used in aerosol sprays are equal to the consumption of HFC-based aerosol sprays in Denmark after adjusting for imports and exports. Total emissions from these two areas are 44.9 tonnes HFC-134a, corresponding to 58,400 tonnes CO_2 equivalents, and 11.9 tonnes HFC-152a, corresponding to 1,700 tonnes CO_2 equivalents, which is a small increase compared with 2001.

Medical supplies

Due to marginal emissions, HFC emissions from medical supplies have not been evaluated.

4.3.4 Emissions of sulphur hexafluoride

Total emissions of SF_6 in 2002 have been determined at approx. 0.9 tonnes, equivalent to a GWP contribution of approx. 21,600 tonnes CO_2 equivalents. Net consumption was 1.4 tonnes.

Emissions derive from three sources, of which power switches and double glazing are the main sources.

Double glazing

Emission calculations for SF_6 from double glazing have been evaluated using information from producers and industry experts. The emission factors below are employed in the calculation. Emissions of SF_6 in the lifecycle of double glazing consists of three phases:

- Production, 15 per cent resulting from filling.

- Gradual release following installation, 1 per cent per year.

- Emissions during disposal of windows, equivalent to the remaining quantity of SF_6. Based on an average expected lifetime of 20 years this gives emissions of 66 per cent during disposal. The calculation assumes that the gas is not drawn off from the windows prior to disposal.

The calculation of imports and exports of double glazing filled with SF_6 takes into account estimated net exports of 50 per cent.

Table 4.14 Emissions of SF_6 from double glazing, tonnes

	2002	2010	2015
Consumption	0.0	0.0	0.0
Emissions from production	0.0	0.0	0.0
Release from double glazing	0.4	0.4	0.2
Exports	0.0	0.0	0.0
Emissions at disposal	0.0	0.0	3.7
Stock	39.5	36.4	18.4
Actual emissions	0.4	0.4	4.0
GWP contribution, '000 tonnes CO_2 equivalents	9.5	8.8	94.5

Emissions will rise due to the start of disposal/substitution of windows with SF_6 double glazing and in 2015 it is estimated that the GWP contribution from double glazing will be 94,500 tonnes CO_2 equivalents.

Metal works

Metal works in Denmark no longer use sulphur hexafluoride in magnesium smelting.

Power switches in high-voltage plants

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

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

- release of 5 per cent on filling with new gas

- gradual release of 0.5 per cent of the stock,

- release of 5 per cent on drawing off and recycling of 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 enterprise concerned or is 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 SF6 from power switches in high-voltage plants 2002, 2010, and 2015, tonnes

	2002	2010	2015
Consumption	1.4	3.0	3.0
Emissions during maintenance	0.1	0.2	0.2
Emissions from reuse	0.0	0.0	0.0
Emissions from stock	0.3	0.4	0.5
Stock	62.2	82.0	94.0
Actual emissions	0.4	0.6	0.6
GWP contribution, '000 tonnes CO_2 equivalents	9.5	13.6	15.0

Laboratories/trace gas

In 2002, there was no registered consumption for analysis purposes (SF_6 may be used as a trace gas).

Training footwear

Information provided by importers shows that the quantity of SF_6 contained in imported training footwear totals approx. 1 tonne, imported during the period 1990-1998. Emissions of SF_6 occur as a result of the disposal of the shoes. Emissions from training footwear in 2002 are estimated at 0.11 tonnes as in previous years, which is equivalent to a GWP contribution of approx. 2,650 tonnes CO_2 equivalents. The consumption of SF_6 for use in training footwear will end in 2003.

4.3.5 Emissions of perfluorinated hydrocarbons

Actual emissions of perfluoropropane were calculated at 22,000 tonnes CO_2 equivalents in 2002 and total consumption measured approx. 3.7 tonnes. Perfluoropropane is the only known perfluorinated hydrocarbon used in Denmark. Emissions are released from refrigerants in commercial stationary and mobile refrigerators and from cleaning liquids for electronic equipment.

Consumption of perfluoropropane in refrigerants for commercial refrigerators in 2002 was approx. 1.9 tonnes and the stock in commercial refrigerators was evaluated at approx. 25.1 tonnes. Emissions in 2002 were determined as approx. 2.7 tonnes, equivalent to a GWP contribution of 22,700 tonnes of CO_2 equivalents. 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 2002, 2010 and 2015, tonnes

	2002	2010	2015
Consumption	1.4	1.2	0.7
Emissions from filling	0.0	0.0	0.0
Emissions from stock	2.6	1.7	1.3
Stock	25.1	15.9	11.9
Actual emissions	2.7	1.7	1.3
GWP contribution, '000 tonnes CO_2 equivalents	18.7	11.7	9.0

Consumption of perfluoropropane in liquid cleaners for electronic equipment has also been reported as 0.5 tonnes in 2000, and actual emissions amounted to 3,600 tonnes CO_2 equivalents. After this, the use of PFC-containing liquid cleaners is expected to be phased out in Denmark.

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ODP values for ozone-depleting substances and GWP values for clean 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
Methyl bromide	CH_3Br	0.6 (1)
HCFCs		
HCFC-22	CHF_2Cl	0.055
HCFC-123	$C_2HCL_2F_3$	0.02
HCFC-141b	$C_2H_3FCl_2$	0.11
HCFC-142b	$C_2H_3F_2Cl$	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-134a	CF_3CFH_2	1,300
HFC-143a	$C_2H_3F_3$	3,800
HFC-152a	CF_2HCH_3	140
HFC-245		950
HFC-227	C3HF7	2,900
HFC-365		890
HFC-404a(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
Sulphur hexafluoride	SF_6	23,900
Perfluorinated hydrocarbons		
Tetrafluoromethane (perfluoromethane)	CF_4	6,500
Fluoroethane (perfluoroethane)	C_2F_6	9,200
Fluoropropane (perfluoropropane)	C_3F_8	7,000
Fluorocyclobutane (perfluorocyclobutane)	$C\text{-}C_4F_8$	8,700
Fluorohexane (perfluorohexane)	C_6F_{14}	7,400

(1) No ozone-depleting effect.
(2) Mixture consisting of 52 per cent HFC-143a, 44 per cent HFC-125 and 4 per cent HFC-134a. The GWP value is determined from this.
(3) Mixture consisting of 53 per cent HCFC-22, 13 per cent HFC-152a and 34 per cent HCFC-124. The GWP value is determined from this.
(4) Mixture consisting of 38 per cent HCFC-22, 60 per cent HFC-125 and 2 per cent propane. The GWP value is determined from this.
(5) Mixture consisting of 25 per cent HFC-125, 52 per cent HFC-134a, and 23 per cent HFC-32. The GWP value is determined from this.
(6) Mixture consisting of 46 per cent HFC-143a and 7 per cent 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 per cent HFC-32 and 50 per cent HFC-125
(9) Mixture consisting of 50 per cent HFC-125, 50 per cent HFC-134a. 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
Fridges/freezers	240	111	351
Fridges	240	65	305
Chest freezers	240	164	404
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, units	1998	1997	1996	1995	1994	1993	1992
Fridges/freezers	26,387	65,491	40,040	48,332	47,851	72,017	66,488
Fridges	-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
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 an over-simplification since the quantity of HFC used for foam and refrigerant varies depending on the producer and product size. The average quantities used in the evaluation are shown in Table 2.

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

Airconditioning	Cars	Lorries	Total, tonnes
Net imports, 1998	151,385	26,249	
Proportion with A/C	151,38.5	13,124.5	
Amount of HFC 134a, kg	11,353.8	16,405.6	27.8

Car: 10% with A/C and 0.75 kg - 134a
Lorry: 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) 1990-2002 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
CFC-11	5.5	0.1	4.5	0	2.2	1.6	0	0	2.1	1.9	<0.3	0	0.4
CFC-12	6.0	0	0.1	0	0.7	6.7	10.3	0	1.2	0	0	0	0
CFC-113	-	-	-	-	-	-	-	-	0	0	<0.2	0	0
CFC-115	-	-	-	31	5.5	0	0	0.2	0.4	0	0	0	0
All CFCs	13	7	6	31	8	8	10	0.2	3.7	1.9	<0.5	0	0.4
HCFC-22	-	-	-	-	-	-	-	-	-	-	-	20	4.6
1,1,1, - trichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	0.08

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

In 2002, Greenland imported 0.4 tonnes CFC-11 from Denmark.

In 2002, imports of 4.6 tonnes HCFC-22 (importer data) and imports of 84 kg 1,1,1-trichloroethane were registered.

From the above data, ODP-weighted consumption in Greenland for 2001 was calculated at 0.66 ODP tonnes. This is a small reduction compared to 2001, when the ODP consumption was 1.1 tonnes ODP.

Imports of HCFC-22 cannot be quantified on the basis of information on foreign trade from Statistics Denmark. The substance group "halogen derivatives of methane, ethane or propane", however, is assumed to contain HFCs and HCFCs and exports from Denmark to Greenland were 11.6 tonnes in 2002. In 2001, exports were 10.1 tonnes, in 2000 they were 0 tonnes, and in 1999 they were 29.3 tonnes.

Another substance group that may also contain HCFCs and HFCs, is the substance group "halogen derivatives only containing derivatives from

chlorine and fluorine". Exports to Greenland from this substance group were 8.5 tonnes in 2002.

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 2002 as the reference year and employing a series of dates for the phasing-out of specific substances in accordance with 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 refrigerators is expected to lead to an increase in consumption of HFC-404a in commercial refrigerators that is significantly steeper than assumed, since HFC-404a systems and CO2 systems are the most obvious substitution options. 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 using HCFC-22 in existing refrigerators.

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

Table 1. GWP contribution from HFCs, PFCs, and SF_6 in '000 tonnes, 1993-2020

	HFC-134a	HFC-152a	HFC-404a	HFC-401a	HFC-402	HFC-407c	HFC-507a	Other HFC's	PFC-er	SF6	Total per year
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	21.6	715.0
2003	359.2	1.8	292.7	0.1	6.9	33.6	17.2	17.1	19.4	23.6	771.5
2004	364.3	1.7	325.0	0.0	5.8	43.8	19.9	16.7	16.7	22.0	816.0
2005	373.9	1.7	353.9	0.0	5.0	53.0	22.4	16.3	15.4	22.2	863.9
2006	324.5	0.1	379.8	0.0	4.3	61.3	24.6	16.0	14.4	22.4	847.4
2007	328.7	0.1	400.3	0.0	3.7	67.7	26.4	15.7	13.4	22.6	878.7
2008	328.1	0.1	404.1	0.0	3.5	67.6	26.3	15.7	12.7	22.8	881.0
2009	314.9	0.1	401.6	0.0	3.4	66.5	25.9	15.4	12.2	23.0	863.0
2010	302.2	0.1	394.8	0.0	3.2	66.1	25.7	15.3	11.7	23.2	842.4
2011	292.8	0.0	358.7	0.0	3.1	65.7	25.6	12.8	11.2	55.6	825.5
2012	262.0	0.0	329.7	0.0	3.0	65.2	25.4	9.4	10.7	101.7	807.2
2013	247.7	0.0	305.1	0.0	2.8	62.6	22.7	7.1	10.2	111.6	770.0
2014	204.5	0.0	273.2	0.0	2.7	59.8	19.7	5.2	9.6	124.2	698.9
2015	183.0	0.0	232.0	0.0	2.5	53.7	16.9	1.1	9.0	109.5	607.7
2016	156.2	0.0	191.0	0.0	2.2	47.4	10.1	-1.8	8.4	81.8	495.5
2017	138.2	0.0	161.1	0.0	2.0	38.5	10.0	-2.8	8.0	66.9	421.8
2018	123.2	0.0	113.7	0.0	1.8	23.2	5.9	-2.1	7.5	96.8	370.0
2019	110.0	0.0	74.7	0.0	1.6	10.5	2.5	-1.5	7.2	66.1	271.1
2020	98.4	0.0	42.9	0.0	1.4	0.0	-0.3	-1.0	6.9	45.6	193.9
I alt	**6979**	**42**	**6218**	**1**	**113**	**944**	**373**	**243**	**295**	**1742**	**16951.0**

Specification of methods and assumptions for 1999-2002 calculations of emissions and projections of GWP emissions in accordance with *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.*

ID	Source	Substance	Method	Emission factor	Remarks	Projection assumptions
	EMISSION 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, 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.	2% release on filling (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 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 import/export data are equal to net exports of 141 tonnes HFC-134a refrigerant and net exports of 1.6 tonnes of HFC-134a in foam (note: Denmark's largest exporter does not use HFC in foam production. Therefore, exports of HFC in foam are less than exports 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.
K2	Commercial stationary refrigerators in retail stores, industry, etc., and stationary A/C	HFC-134a, HFC-404a, HFC-401a, HFC-402a,	Tier 2 top-down approach: - information on refrigerant consumption was provided by importers/suppliers of refrigerants for commercial refrigerators	1.5% on refilling (DK default) 10% release from operation and accidents (DK default). 0% release from destruction (DK	In 2001/2002 an assessment was made of the national Danish leakage rate from commercial plants. This	From 2007, the consumption of refrigerants merely represents the amount used for refilling existing systems

ID	Source	Substance	Method	Emission factor	Remarks	Projection assumptions
	systems in buildings etc.	HFC-407c, HFC-507a, other HFCs, PFCs (C_3F_8)	in DK. - information on distribution of refrigerant consumption at different sites is estimated using information from user enterprises, the KMO and estimates from suppliers.	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.	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/.	(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	Top-down Tier 2 approach - information on refrigerant consumption in refrigerated vans and lorries is based on consumption information from manufacturers of refrigerated vans and lorries 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 used for gathering of consumption data from importers for refilling of mobile A/C systems.	0.5% on refilling (DK default) 33% annual release during operation (complete refilling every 3 years - DK default). 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	In 2001/2002 an assessment was made of the national Danish leakage rate from mobile A/C systems. This 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 compliance with IPCC guidelines /16/. The stock figures are updated	The projection is based on a steady state stock (203 tonnes).

ID	Source	Substance	Method	Emission factor	Remarks	Projection assumptions
				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).	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 foam blowing agent 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 import/export data are equal to net exports of 141 tonnes HFC-134a refrigerant and net exports of 1.6 tonnes of HFC-134a in foam (note: Denmark's largest exporter does not use HFC in foam. Therefore, exports of HFC in foam are less than exports of	

ID	Source	Substance	Method	Emission factor	Remarks	Projection assumptions
					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.	
	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.	Emissions (Danish default): - Production = 15% - Use = 4.5% - Lifetime = 3 years - Disposal = 71.5%, destroyed in incineration and thereby is 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 holding 8 g of HFC-134a per shoe. Net exports with the same consumption in Danish production are 0.3 tonnes HFC-134a.	
	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-	Emissions = 50% of the HFC sold to this area of application in the current year and 50% of the consumption in the second year	Top-down data. Estimates of imports/exports are based on the producer's assessment of imports	

ID	Source	Substance	Method	Emission factor	Remarks	Projection assumptions
			containing aerosol sprays in Denmark. The importers are estimated to account for 100% of Danish consumption.	(IPCC default for top-down data)	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 Perfluoro-propane)	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 Being phased out, cf. Statutory Order of 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					
	Insulating gas in double glazing	SF_6	Tier 2 - information on consumption of SF_6 in double glazing is derived from importers' sales reports to the application area. The importers account for 100% of the Danish 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.	Emissions (DK default): - 15% during production of double glazing. - 1% per year during the lifetime of the double glazing. - 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		Emissions data and lifetimes are based on information from the window producers and industry experts in Denmark /2/. 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 will be phased out by 2003, after which emissions will arise from stock only.

ID	Source	Substance	Method	Emission factor	Remarks	Projection assumptions
	Insulating 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 increased.	Emissions (DK default): - release on filling = 5% - release during 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 per year in the period 2004-2010.