DANISH MINISTRY OF THE ENVIRONMENT

Environmental Protection Agency

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

Danish consumption and emissions, 2006

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APPENDICES

1 Summary

1.1 Ozone-depleting substances

ODP-weighted consumption for 2006 based on reporting from importers has been calculated at 3.05 ODP tonnes. Compared to 2005 it is an increase of 1.29 ODP tonnes. The increase is caused by a larger consumption of HCFC-141b.

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

Table 1.1 Overview of consumption and ODP-weighted consumption in 2003-2006, Tonnes

Substance	Net consumption, 2003	ODP-weighted consumption, 2003	Net consumption, 2004	ODP-weighted consumption, 2004	Net consumption, 2005	ODP-weighted consumption, 2005	Net consumption, 2006	ODP-weighted consumption, 2006
CFCs [1]	0.1	0.08	0.001	0	0.001	0	0	0
Tetrachloro-methane	0.36	0.39	0.033	0.036	0	0	0	0
1,1,1-Trichloroethane	0.02	-	0.009		0.01	-	0	0
Halons	0	0	0	0	0	0	0	0
Methyl bromide	(only feedstock)	-	(feedstock)	-	(feedstock)	-	(feedstock)	-
HCFCs	204.65	16.88	142.68	2.79	114.3	1.76	93.7	3,05
HCFC-22 (new)	96,7	5.3	0	0	0	0	0	0
HCFC-22 (regenerated)	-	-	112.1	0	95.6	0	66	0
HCFC-22 (HFC mix)	-	-	10.3	0.56	5.3	0.29	0	0
HCFC-123	-	-	-	-	-	-	-	-
HCFC-141b	102.35	11.26	20.28	2.23	13.4	1.47	27,7	3,05
HCFC-142b	0	0	0	0	0	0	0	0
Total		17.36		2.83		1.76		3,05

(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.

HCFCs are used as refrigerants or for foam production (system foam). The areas of application of HCFCs in 2006 are shown in Table 1.2.

Only regenerated HCFC-22 is used as a refrigerant in Denmark. Thus, there is a reexport of new HCFC-22 to other countries. According to compliance with the UN methodology, regenerated HCFC-22 is not included in calculation of the ODP weighted consumption.

HCFC-141b is used in production of system foam

Table 1.2 Danish consumption of HCFCs by application area in 2006, tonnes.

Application area	HCFC-22	HCFC-123	HCFC-141b	HCFC-142b
System foam (for panels, insulation, etc.)	0	0	27,7	0
Refrigerants, New	0	0	0	0
Refrigerants, regenerated	66	0	0	0
Refrigerants, HFC mixtures	0	0	0	0
Total	66	0	27,7	0

Statistics Denmark has registered an irregular import/export of CFC's in 2006. The import/export are not confirmed from the importers. There are registered an exports of 1,8 tonnes of CFC-11 and an import of 1,7 tonnes and an export of 3,1 tonnes of CFC-12. Export of CFC-11 and CFC-12 are banned and therefore this registration has undergone an investigation to clarify whether the import were actual or coursed by data failure. Statistics Denmark have examined there data and concluded that there were no data failure. In the light of the conclusion, this case is handed over to DEPA's Chemical Inspection. Before the use of CFC's are determined by source, the emissions are not included in the calculation of ODP tonnes.

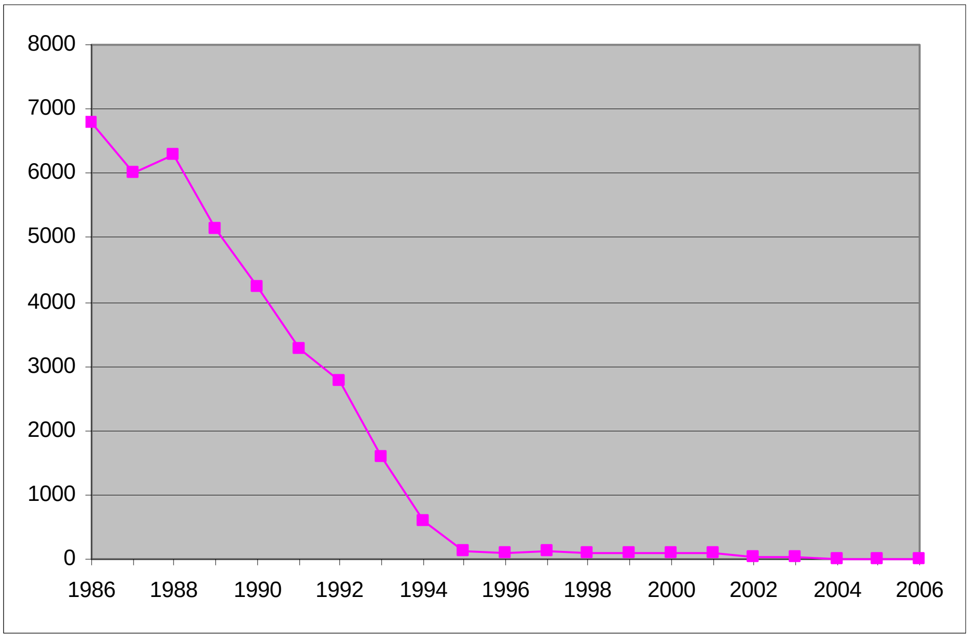

Figure 1.1 The development of ODP-weighted consumption 1986-2006, tonnes.

The specific figures for consumption of individual substances and groups of substances and the ODP contribution calculated for the period 2000-2006 and year 1992 is shown in Table 3.1 in Chapter 3.

1.2 F-gases

The GWP-weighted actual emissions of HFCs, PFCs, and SF_6 in 2006 were 885,3 thousand tonnes CO_2 equivalents. The corresponding emissions were 839,5 thousand tonnes CO_2 equivalents in 2005, as reported in /13/.
The emission has increased for all three substance groups; HFC's, PFC's and SF6. In particular HFC-404a emission from commercial refrigerants and HFC-134a emission from system foam production (export) and commercial refrigerants. Further the SF6 emission from plasma erosion and analysis purpose have increased. Finally a new sector for PFC/HFC emissions has been identified. The substances are used (in a smaller scale) in manufacturing of optical fibres.

The HFC consumption in commercial refrigerants has increased with app. 80 tonnes in total compared to 2005. It also has an effect on the future emission trends, because the stock in commercial refrigeration has increased further.

In Table 1.3 below, consumption, actual emissions and stock in products are summarised.

Table 1.3 Consumption, actual emissions, stock, adjusted for imports/exports as well as GWP contribution from greenhouse gases 2006, tonnes.

Source	Substance	Consumption and imports, DK, tonnes	Stock, tonnes	Actual emissions, tonnes	GWP contribution, CO2 eqv. tonnes	GWP contribution in total, CO2 eqv. Tonnes
Refrigerants for commercial stationary refrigerators and A/C systems	HFC-134a	170,3	920,7	86,2	112 079	
	HFC-404a	165,5	1 114,3	108,2	352 675	
	HFC-401a	0,0	13,0	1,6	29	
	HFC-402a	0,0	20,9	2,4	4 075	
	HFC-407c	70,6	410,3	38,9	59 353	
	HFC-507a	6,1	60,9	6,2	19 176	
	Other HFC-er	12,8	110,4	11,0	19 060	
	PFC	0,0	15,0	1,8	12 306	
	All substances					578 752
Household fridges/freezers						
Refrigerants	HFC-134a	63,0	842,7	9,5	12 307	
	HFC-404a	4,3	83,2	0,9	3 032	
Insulatonfoam	HFC-134	0,0	1 147,8	78,2	101 601	
	HFC-152	0,0	2,2	0,1	14	
	All substances					116 954
Refrigerants for mobile A/C systems	HFC-134a	34,4	223,6	66,6	86 642	86 642
Refrigerated vans and lorries	HFC-134a	0,4	5,1	1,0	1 288	
	HFC-404a	6,6	34,2	6,0	19 717	
	HFC-402a	0,0	1,2	0,3	422	
	All substances					21 427
Other PUR foam and system foam	HFC-134a/245/365	166,2	0,0	16,3	21 196	21 196
Soft foam and aerosol sprays etc.	HFC-134a	12,5		15,1	19 689	
	HFC-152a	11,6		11,6	344	
	All substances					20 033
Liquid cleaners	PFC	0,0		0,0	0	0
Fibre optics	PFC-14	0,3		0,3	1 638	
	PFC-318	0,2		0,2	1 740	
	HFC-23	0,1		0,1	936	
	All substances					4 314
Double glazing	SF6	0,0	37,9	0,4	9 159	9 159
High-voltage power switches	SF6	3,7	71,0	0,5	12 949	12 949
Laboratories	SF6	0,6		0,6	13 884	13 884
Total	HFC-er	724,5	4 990,6	460,3	833 635	
	PFC-er	0,0	15,0	1,8	15 684	
	SF6	4,2	108,9	1,5	35 992	
GWP contribution	Total				885 311	

In Figure 1.2 below, total GWP contributions from HFCs, PFCs, and SF_6 is shown in accordance to individual sources for emission in 2006.

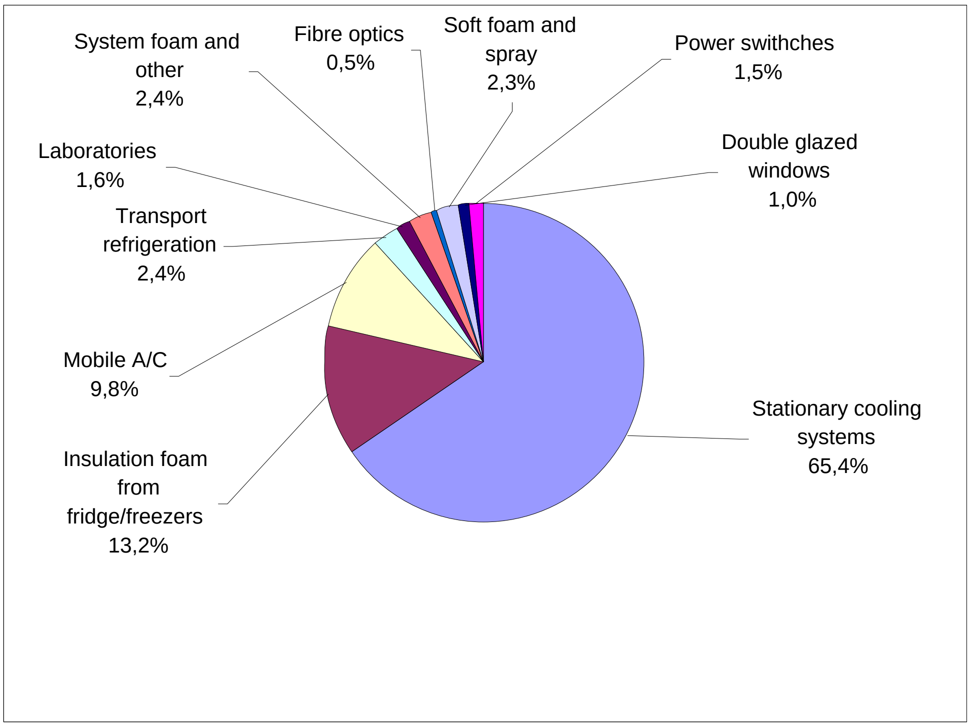

Figure 1.2 The relative distribution of GWP emissions, analysed by source

The figure shows that emissions from refrigerants used in commercial stationary refrigerators account for the largest GWP contribution. These refrigerators cover 65,4 per cent of the total actual contribution in 2006. The contribution is primarily from HFCs, and a small part is from PFCs.

The second-largest GWP contribution, accounting for 13,2 per cent, comes from ongoing releases of HFC-134a stock in insulating foam in fridges and freezers.

Mobile A/C contribute with 9,8 per cent and only 2,3 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 sources of SF_6 emissions in 2006 were power switches, double glazing windows and laboratories/plasma erosien. These account for 4,1 per cent of the total GWP contribution.

HFCs comprise app. 94 per cent of the overall GWP contribution in 2006, Emissions of SF_6 comprise 4 per cent and emissions of PFC contribute with 2 per cent of the total emission.

The relative distribution is shown in Figure 1.3 below.

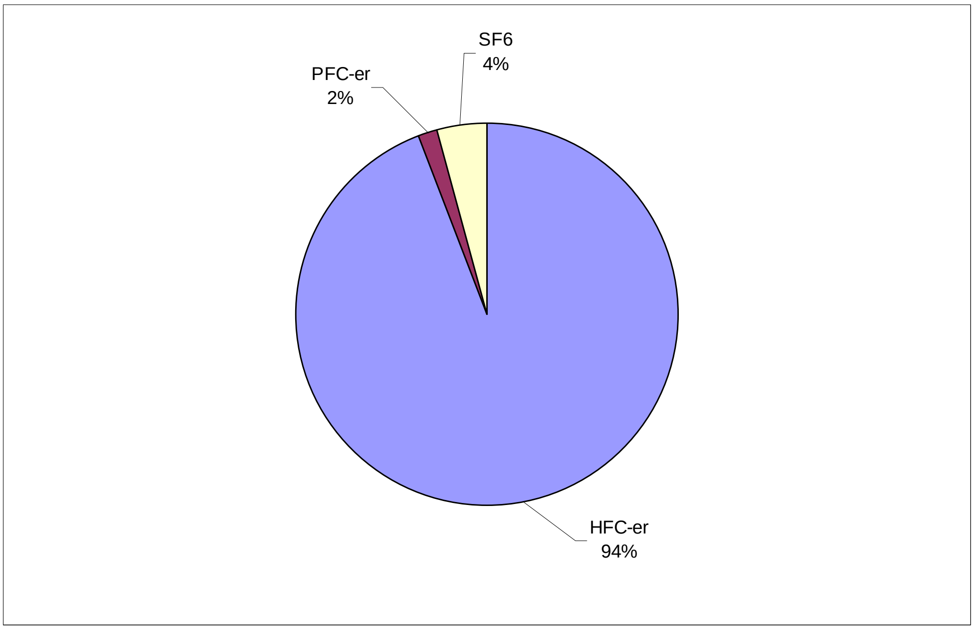

Figure 1.3 The relative distribution of the GWP contribution from HFCs, PFCs, and SF_6, 2006.

1.2.1 HFCs

In 2006, the total import (minus re-export) of pure HFC's and HFC blends were approx. 724,5 tonnes. Compared to 2005, where total consumption was approx. 559,4 tonnes, the import has increased with total 165,1 tonnes. The import of almost all HFC's has increased, only import of HFC-417 and 413a are reduced.

Actual emissions from HFC's have been calculated to approx. 833,600 tonnes CO_2 equivalents. In 2005, emissions were 803 900 tonnes CO_2 equivalents. It is an increase of approx. 29 700 tonnes CO_2 equivalents.

The actual emission from HFC's has exceeded to highest level since HFC's has been introduced.

1.2.2 Sulphur hexafluoride (SF_6)

The consumption of sulphur hexafluoride was 4,23 tonnes in 2006, which is an increase of approx. 0,7 tonnes compared to 2005.

Actual emissions have been calculated at 1.5 tonnes, equivalent to a GWP contribution of app. 36 000 tonnes CO_2 equivalents. In 2005, emissions were 21 700 tonnes CO_2 equivalents. This level of emission from SF_6 is the highest level in last six years.

1.2.3 Per fluorinated hydrocarbons (PFCs)

In 2006, the emission of PFC's origins from production of fibre optics and emission from commercial refrigeration containing R413a. The total GWP-weighted PFC emission is 15 680 tonnes CO_2 equivalents. The actual emission from stock containing R413a and consumption was 12 300 tonnes CO_2 equivalents, which is a continuation of the reduction since 2002. The actual emission from PFC-14 and PFC-318 in production of fibre optics is app. 0,5 tonnes and the actual GWP-weighted emission is 3 380 tonnes CO_2 equivalents.

1.2.4 Trends in total GWP contribution from F-gases

Figure 1.4 shows the trend in Danish GWP contributions 1992-2006 from HFCs, PFCs, and SF_6. The differences from the present calculations of the total GWP value compared with earlier calculation methods are illustrated in the figure.

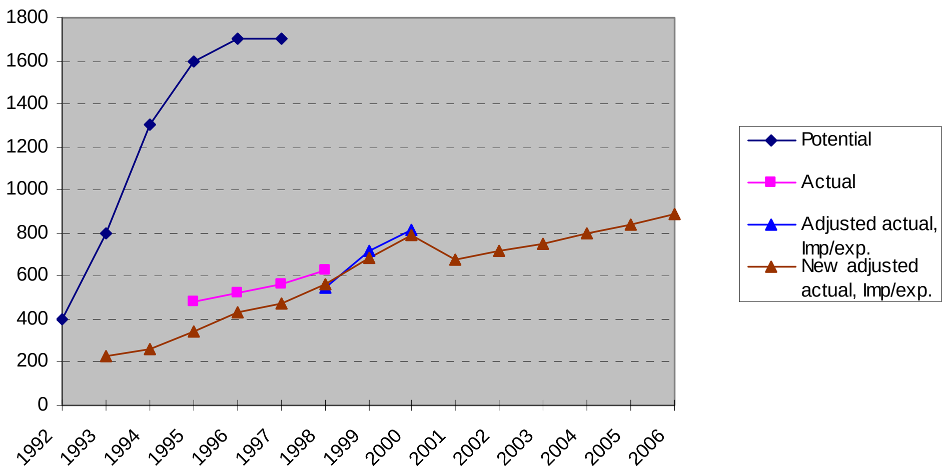

Figure 1.4 Trends in GWP-weighted potential, actual and adjusted actual emissions 1992-2006, 1 000 tonnes CO_2 equivalents.

The figure shows that the GWP emission also in 2006, has increased further and exceeded the highest level for calculation of actual emissions.

The development in the GWP contribution 1992-2006 can also be seen in Table 1.4 below.

Table 1.4 Total GWP-contribution from HFCs, PFCs, SF_6, 1 000 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
2004				797
2005				839
2006				885

2 Introduction

On behalf of the Danish Environmental Protection Agency (Danish EPA), the consulting firm PlanMiljø ApS 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 2006. 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 4 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, 19, 21, 23/, and most recently, in reference /24/.

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:

- Lone Kielberg, Danish EPA
- Mikkel Aamand Sørensen, Danish EPA
- Erik Lyck, National Environmental Research Institute, Denmark (NERI)
- Lau Vørs, AKB Denmark (Authorized Refrigeration Installers Association)
- Torkil Høft, KMO
- Sven-Erik Jepsen, Confederation of Danish Industries (DI)
- Tomas Sander Poulsen, PlanMiljø ApS

2.2 Objective

The objective of this project was to map the 2006 consumption of newly produced industrial ozone-depleting substances and the consumption and actual emissions of HFCs, PFCs, and SF_6. The evaluation was made in accordance with the IPCC guidelines (Intergovernmental Panel on Climate Change) /4/, and 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 which 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 regenerated ozone-depleting substances or substances used as raw material in the production of other substances, such as tetra chloromethane, 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.

F-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 guidance (IPCC Good Practice Guidance) 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 were carried out on the basis of information from seven sources:

- Importers, agency enterprises, wholesalers, and suppliers
- Consuming enterprises, and trade and industry associations
- Recycling enterprises and chemical waste recycling plants
- Statistics Denmark
- Danish Environmental Protection Agency
- 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 is 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 and consistency in time in the calculation of the sum of HFCs as their 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 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 4 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 greenhouse F-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).

The information from importers was supplemented with statistical information from Statistics Denmark for 2006. 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 2006 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 CFC-113 in 2006 was 0 tonnes. In 2005 the sales of new CFC-113 was 0,01 tonnes.

Statistics Denmark registered imports of 0,026 tonnes of CFC-113, and 1,675 tonnes of CFC-12 in 2006. Import of CFC-12 is banned and therefore enterprises' calculations are being re-examined. The case is handed over to DEPA's chemical Inspection.

3.1.2 Tetrachloromethane

In 2006, information from companies on imports and sales of tetrachloromethane were 0 tonnes. In 2005, imports and sales were also 0 tonnes.

Statistics Denmark registered imports of 0,033 tonnes in 2006. Because of the small amount, no re-examination of data will be carried out.

3.1.3 1,1,1-Trichloroethane

In 2006 the information from companies on import of 1,1,1-Trichlorethane was 0 tonnes. In 2005 the import of 1,1,1-Trichlorethane were 0.01 tonnes.

Statistics Denmark registered imports of 0.252 tonnes in 2006. Because of the small amount, no re-examination of data has been carried out.

3.1.4 Halons

There was no import of halons in 2006. Consumption of new halon has been phased out for several years but halons still occur in fire fighting equipment in ships and aircrafts. The installed amount is not estimated.

3.1.5 Methyl bromide

Methyl bromide was again in 2006 only imported for use in feedstock.

3.1.6 HCFCs

Six enterprises imported HCFCs in 2006.

Consumption of regenerated HCFC-22 has decreased but consumption of HCFC-141b has increased. There has been no consumption of HCFC-142b.

In 2006, import and consumption of HCFC-22 (regenerated) were about 66 tonnes. In 2005 the consumption of regenerated HCFC-22 were 95,6 tonnes.

Import and consumption of HCFC-141b were 27,7 tonnes in 2006. Import of HCFC-141b was 13.4 tonnes in 2005.

There were no import of HCFC-142b in 2006 as well in 2005, and Danish consumption of this substance has been phased out.

There has been an import and re-export of new HCFC-22 and HFC-blends which contain new HCFC-22 in 2006.

Table 3.1 Developments in consumption and potential emissions from 1992 and 2000-2006, tonnes (ODP- weighted tonnes are shown in italics).

Substance	1992	2000	2001	2002	2003	2004	2005	2006
CFC-11	1 307	0	0	0	0	0	0	0
	1 307	-	-	-	-	-	-	-
CFC-12	612	0	0	0	0	0	0	0
	612	-	-	-	-	-	-	-
CFC-113	253	4.8	2.6	0.95	0.1	0.001	0.001	0
	202.4	*3.84*	2.08	*0.76*	*0.08*	-	-	-
CFC-115	56	0	0	0	0	0	0	0
	33.6	-	-	-	-	-	-	-
All CFCs	2 228	4.8	2.6	0.95	0.1	0	0	0
ODP-weighted consumption	*2 155*	*3.84*	*2.08*	*0.76*	*0.08*	*0*	*0*	*0*
Tetrachloro-methane	3	0.6	1.25	0.87	0.36	0.033	0	0
ODP-weighted consumption	*3.3*	*0.66*	*1.26*	*0.96*	*0.4*	*0.036*	*0*	*0*
1,1,1-Trichloro-ethane	1 015	0	0.05	0.002	0.025	0.009	0.01	0
ODP-weighted consumption	*101.5*	*0*	*0.005*	-	*0.0025*	-	-	-
Halon 1302	45	0	0	0	0	0	0	0
	450							
Halon 1211	4	0	0	0	0	0	0	0
	12							
Halon 2402	0	0	0	0	0	0	0	0
All halons	44	0	0	0	0	0	0	0
ODP-weighted consumption	*462*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Methyl bromide[1)]	31	0	Only feed-stock	Only feed-stock	Only feed-stock	Only feed-stock	Only feed stock	Only feed Stock
ODP-weighted consumption	*18.6*	*0*	-	-	-	-	.	.
HCFC-22 (new + reg[2)])	1 005	347	249.1	24.5	96.7	112.1	95.6	66
	55.3	*19.1*	*13.7*	*1.35*	*5.3*	*0*	*0*	*0*
HCFC-123	0	0	18	0	0	0	0	0
			0.36	-	-	-	-	-
HCFC-141b	90	538.8	609	360	102.3	20.3	13.4	27,7
	9.9	*59.3*	*66.99*	*39.6*	*11.3*	*2.23*	*1.47*	*3,05*
HCFC-142b	130	15.8	0	0	0	0	0	0
	8.45	*1*	*0*	-	-	-	-	-
Other HCFCs	0	0	0	0	0	0	0	0
				-	-	-	-	-
HCFC-22 from HFC mixture			13.8	5.5	5.6	10.3	5.3	0
			0.76	*0.3*	*0.3*	*0.56*	*0.29*	*0*
HCFCs	1 203	901.6	889.9	390	204.7	142.7	114.3	111,7
ODP-weighted consumption	*73.65*	*79.4*	*81.45*	*41.25*	*16.9*	*2.79*	*1.76*	*3,05*
Total ODP-weighted consumption	*2 758*	*83.9*	*85.2*	*42.97*	*17.4*	*2.83*	*1.76*	*3,05*

1) Information from the Danish EPA environmental statistics.

2) In accordance to guidelines from UNEP, regenerated substances is not calculated in the ODP-weighted consumption. HCFC-22 consumption from 2004-2006 is only regenerated HCFC-22 and has therefore 0 as the ODP-weighted value.

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 Danish HCFC consumption 2006, based on information from importers and producers, tonnes.

Application area	HCFC-22	HCFC-141b	HCFC-142b
System foam (for panels, insulation, etc.)	0	27,7	0
Refrigerants, New	0	0	0
Refrigerants, regenerated	66	0	0
Refrigerants, HFC mixtures	0	0	0
Total	66	27,7	0

3.1.7 Disposal

Denmark has two treatment facilities for destruction of ODSs - Kommune Kemi and Uniscrap A/S. All ODSs to be disposed are sent to these plants.

Kommune Kemi (KK) 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. Treatment of substances at KK does not lead to emissions of ODS.

Uniscrap A/S register the specific annual quantities of individual substances disposed at the facility.

The ODSs disposed in 2006 are shown in the table below.

Table 3.3 Disposed ODSs in 2006, tonnes.

ODS	Quantity, tonnes
HCFC-22	13,4
CFC-12	10,5
CFC-11	8,7

Some of the HCFC-22 originates from disposed HFC blends (HFC-401a, HFC-402a, HFC-408a, HFC-409a).

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, 1994-2006.

4.1.1 HFCs

HFCs were imported by fourteen enterprises in 2006. Five of these are end-users, which import directly from other EU countries.

In 2006, the total import (minus re-export) of pure HFCs and HFC blends were approx. 724,5 tonnes. Compared to 2005, where total consumption was approx. 559,4 tonnes, the import has increased with total 165,1 tonnes. The import of almost all HFC’s has increased, only import of HFC-417 and 413a are reduced.

The 2006 import of HFC-134a is increased to 280,7 tonnes compared to 2005, where the import was 235,4 tonnes. Further more is 0,45 tonnes HFC 134a imported in the blend refrigerant R417 blend (50% HFC-134a). The total increase is coursed by higher consumption from commercial refrigeration system. Contrary the use of HFC-134a in soft foam and aerosol sprays has been reduced to less than half.

Import of HFC-404a increased from 162,4 tonnes in 2005 to 176,4 tonnes in 2006. The increase is, as for HFC-134a, coursed by higher consumption from commercial refrigeration system.

Imports of HFC-407c were increased from 61,6 tonnes in 2005 to 70.6 tonnes in 2006. HFC-407c is a substitute refrigerant for HCFC-22 in refrigerators. Over the last decade there has been an increase in import of HFC-407c. 2005 was the first year where the import was reduced. In 2006 the increase seems to continue the last decade’s tendency.

In total has the consumption of HFC-134a, HFC-404a and HFC-407 in commercial refrigeration system increased with more than 80 tonnes from 2005 to 2006. It indicates that activities with installation of new HFC-refrigeration systems in the sector have been extensive up to 1.1. 2007 where a ban against installation of new HFC systems are brought into force.

Imports of HFC-507a have increased to 6.1 tonnes in 2006. In 2005, the import was 5.4 tonnes.

The import of HFC-410a was 7,7 tonnes and the import of other HFC refrigerants and blends were 5,6. There were no imports of R413a in 2006.

The import of HFC-152a was 11,6 tonnes in 2006. This is a doubling of the import from 2005.

There were no Danish consumption of HFC-401a and HFC-402a in 2006 but one importer registered a minor re-export.

4.1.2 Sulphur hexafluoride

Six importers reported having imported and sold 4.23 tonnes of sulphur hexafluoride in 2006. Sulphur hexafluoride was mainly used in power switches, but smaller amounts are used as an agent for plasma erosion in production of micro chips and in laboratories for analysis purposes.

4.1.3 Per fluorinated hydrocarbons

There has been an import of PFC-14 (CF_4) and PFC-318 ($c\text{-}C_4F_8$) of approx. 0,5 tonnes in 2006. The PFC's are used in production of optical fibres. This is considered as a new consumption area in Denmark.

There has been no import of per fluoro compound C_3F_8, which was contained in the blend refrigerant R413 used in commercial refrigerators.

Table 4.1 Developments in imports of greenhouse gases, tonnes.

Substance	1987	1989	1992	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
HFC-134a	0	0	20	524	565	740	700	884	644,	711,1	472,8	401,6	241,2	306.5	235.4	280,7
HFC-152a	0	0	4	51	47	32	15	14	6	16,4	11,1	11,9	3,3	11	5.5	11,6
HFC-401a	-	-	-	-	-	-	-	15	35,8	9,5	4,1	0	0,2	0	0	0
HFC-402a	-	-	-	-	-	-	-	10	15	4,2	0.8	0	1,7	0	0	0
HFC-404a	0	0	0	36	119	110	110	146	10	193,1	126,2	188,7	145	252.6	162.4	176,4
HFC-407c	-	-	-	-	-	-	-	17	193,7	44,7	40,3	89,1	96,8	101.3	61.6	70,6
HFC-507a	-	-	-	-	-	-	-	10	40	23,8	2,2	14,4	9,2	10.6	5.4	6,1
HFC-365	-	-	-	-	-	-	-	-	10	-	-	-	18	7.2	18.5	81,5
HCF-410 a	-	-	-	-	-	-	-	-	-	-	-	-	-	2.6	3.1	7,7
Other HFCs[1]	0	0	0	1	14	20	65	15	- 29,2	24,1	18,4	7,5	13	14,4	68.4	89,9
All HFCs	0	0	24	612	745	902	890	1112	978.3	026,	676	713.2	528.3	706.2	560.3	724,5
Sulphur hexafluoride	n.i.	n.i.	15	21	17	11	13		12.1	9	4.7	1.4	2.2	2.34	3.58	4,23
Perfluorinated hydrocarbons	0	0	0	0	1.5	3	8		7.9	6.9	3.7	1.95	0.5	0.3	0.45	0

1) The category "other" includes HFC-408a, HFC-409a, HFC-413a, HFC-417a, HFC-245fa, HFC-227

4.2 Consumption by sectors

The evaluation of consumption divided into sectors 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 distributed according to sectors.

Table 4.2 Consumption of HFC distributed on sectors in 2006, tonnes.

	134a	152a	401a	402a	404a	407c	507a	410a	413a	417a	Others	Total from sectors
Insulation foam	0,0											0,0
Foam systems	0,0										166,2	166,2
Soft foam	2,7	0,3										3,1
Other applications	9,8	11,3										21,1
Household fridges/freezers	63,0				4,3							67,3
Commercial refrigerators	160,3		0,0	0,0	165,5		6,1	7,7	0,0	0,9	4,3	344,8
Transport refrigeration	0,4				6,6							7,0
Mobile A/C	34,4											34,4
Stationary A/C	10,0					70,6						80,6
Total	280,7	11,6	0,0	0,0	176,4	70,6	6,1	7,7	0,0	0,9	170,5	724,5

There are no other known sectors using HFCs in Denmark than those appearing in Table 4.2.

4.2.1 Consumption of HFC refrigerant

In recent years, the Danish consumption of HFC refrigerants points toward increased use of HFCs in commercial refrigeration and 2006 is no exception. In 2005 the import decreased for the first time, but 2006 show an increasing trend again. This is expected to stop in 2007 because the consumption of HFC refrigerants only will be to refilling of existing installations.

The general increase in HFC refrigerants in commercial systems is a natural consequence of the phase-out of air conditioners based on R-22 (HCFC). More over, commercial refrigeration with R-12 and R-502 were replaced by R-22 systems after 1995 when CFCs were banned in Denmark. This added to the percentage of refrigeration systems with R-22. The production of new R-22 systems was prohibited in 2000 and substitution with R-22 in existing systems was prohibited in 2002.

The use of HFC’s as refrigerant in commercial refrigeration and A/C systems is covering approx. 74 per cent of the total consumption in 2006. The most commonly used refrigerant in commercial refrigeration is still HFC-404a and HFC-134a.

Approx. 26 per cent of the HFC consumption is used in foam blowing and for other purposes than refrigeration.

The consumption of HFC-134a as a refrigerant in fridges/freezers was again reduced in 2006 with approx. 2,5 tonnes. The decrease is not considered as an indication of a general reduction in the production in the Danish refrigeration sector but an indication of that the sector has substituted to alternative refrigerants.

The consumption of refrigerants in vans and lorries have decreased slightly and is considered as a normal year to year movement. The consumption of refrigerants for mobile A/C systems have again increased 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, divided on refrigeration units, 2006, tonnes.

Substance HFC	Fridges /freezers	Commercial refrigerators and A/C systems	Mobile A/C systems	Refrigerated vans and trucks	Total	In per cent
-134a	63	170,3	34.4	0.4	268.1	50,2%
-401a	-	-	-	-	-	0%
-402a	-	-	-	-	-	0%
-404a	4.3	165,5	-	6,6	176.4	33.0%
-407c	-	70,6	-	-	70,6	13.2%
-507a	-	6.1	-	-	6.1	1.1%
Others	-	12.9	-	-	12,9	2,4%
Total	67,3	425,4	34.4	7	534,1	100%
	12.6%	79,6%	6.4%	1.3%	100%	

4.2.2 Consumption of HFC as foam blowing agent and as propellant

In 2006, the consumption of HFC's in system foam and in other PUR foam and system foam has increased further.

It is considered that the trend in the recent years is a general reduction of the HFC consumption as a blowing agent and this 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. Thus, there is an increase in the recent years in production of system foam for export. This is in line with the statutory order, where it is stated that products produced for export has an exemption.

In 2006, the uses of HFCs as propellants in aerosols for specific purposes were about 12 tonnes. This estimate is based on DEPA's grant of exemptions and production. The consumption seems to be stable tending to a decrease.

As 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 2006 was app. 4.23 tonnes. Consumption of SF_6 was used for power switches in high-voltage power systems and laboratories.

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	3.65
Laboratories and micro chip production (plasma erosion)	0.58
Total	4.23

4.2.4 Consumption of PFCs

The consumption of PFC's (per fluoropropane) in 2006 was 0,45 tonnes. This year none of the consumption is related to the blend refrigerant Isceon 49 and the trend from recent years indicates it is close to phase out. The consumption of PFC's in blends for refrigeration purposes were amounted to about 0.45 tonnes in 2005. The PFC consumption in 2006 derives from a new area – optics fibre production. This area has used PFC-14 (0,25 tonnes) and PFC-318 (0,2 tonnes) for technical purpose in optics fibre production.

4.3 Emissions of F-gases: HFCs, PFCs and SF_6

This section reports the actual emissions of the greenhouse gases HFCs, PFCs, and SF_6 for 2006. All emissions are calculated as ***actual*** emissions according to IPCC's tier 2 methodology. The calculation is 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 (see also chapter two for principal description of methodology). The specific emission calculation refers to appendix 4 which shows the particular emission factors, calculation method and assumptions, determination of IPPC Tier method etc., in relation to calculation of emissions from individual substance and application areas /4, 16/.

4.3.1 Actual emissions of F-gases

The GWP-weighted actual emissions of HFCs, PFCs, and SF_6 in 2006 is calculated to 885,3 thousand tonnes CO_2 equivalents. The corresponding emissions were approx. 839,5 thousand tonnes CO_2 equivalents in 2005, which corresponds to a calculated total increase of approx. 45,8 thousand 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 2005	Consumption, tonnes 2006	GWP contribution, tonnes 2005	GWP contribution, tonnes 2006
HFCs	559.6	724,5	803 900	833 635
PFCs	0.5	0,5	13 900	15 684
SF_6	3.6	4,2	21 700	35 992
Total			835 500	885 311

The HFC emission from commercial refrigerators, especially from the main refrigerant HFC-134a, HFC-404a and HFC-407c were again higher in 2006 as compared to 2005, first of all because of increased emission from stock but also partly because of an increased consumption. Furthermore the emission from production of system foam for export purposes has significantly increased in 2006 compared to 2005. The only source where the emission have been reduced is from soft foam and aerosol sprays etc. The reduction is approx. 30 percent compared to 2005.

4.3.2 Emissions of HFCs from refrigerants

As required in the IPCC guidance for calculation of emission of f-gases a distinction is made between:

- Fridges and freezers for household use and retailers etc.
- Commercial refrigeration (in industry and retail) and stationary air conditioning systems
- Mobile air conditioning systems (in cars, trucks, bus, trains etc.)
- Refrigerated vans and lorries

Actual emissions from these sources occur in connection with:

- ***filling*** of refrigerants (0.5 percent 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 percent to 33 percent 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. Anyhow disposal is defined as an activity where zero emission occurs and this principal statement are used in order to reduce stock (the quantity of substances contained in a product after end life time).

Appendix 4 shows the specific emission factors used in the calculations.

Commercial refrigeration and stationary A/C systems

Commercial refrigeration, used e.g. in retail, supermarket, restaurants etc. or in industry, and stationary A/C systems, also used by retailers and industry, as well in offices, constitute the largest source of emissions. The most commonly used refrigerants in this product group are HFC-134a, HFC-404a and HFC-407c.

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 phased out in Denmark.

It is not relevant to adjust for imports and exports of HFCs in stationary commercial refrigeration and A/C systems since filling of refrigerants only will take place on site when the unit are installed.

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.

Table 4.6 Actual emissions and GWP contribution from commercial refrigeration 2006, 2010, 2015 and 2020, tonnes

Substance	Consumption, DK, 2006	Stock, 2006	Actual emissions, 2006	GWP contribution, 2006	GWP contribution 2010	GWP contribution 2015	GWP contribution 2020
HFC-134a	170,3	920,7	86,2	112 079	110 951	58 144	6 563
HFC-404a	165,5	1 114,3	108,2	352 675	359 954	195 499	1 603
HFC-401a	0,0	13,0	1,6	29	0	5	3
HFC-402a	0,0	20,9	2,4	4 075	2 487	1 447	855
HFC-407c	70,6	410,3	38,9	59 353	61 964	49 695	864
HFC-507a	6,1	60,9	6,2	19 176	19 068	10 908	0
Other HFCs 2)	12,8	110,4	11,0	19 060	18 851	4 503	0
All substances				566 446	573 275	320 202	9 887

1) The projected future scenario takes into account the effect of a 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.

2) 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).

As the figure indicate the emissions from commercial refrigeration will continue in several years even there are no installation of new HFC refrigeration systems because of the statutory order which not allow construction of new installations after 1. January 2007. In the trend analysis, the total emission from this sector is estimated to more than 320,000 tonnes CO_2 equivalents in year 2015. But after then a significant reduction is expected and in year 2020 most HFC refrigeration systems is considered phased out.

Refrigerators/freezers

Actual emissions from refrigerants in refrigerators 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 4).

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 percent of the consumption pr. year. The calculation is made on the basis of Statistics Denmark's foreign trade statistics /3/ of average figures of the amount of HFC-134a in a standard fridge/freezer manufactured in 1999. This figure has not been updated

Table 4.7 below shows actual emissions from refrigerators/freezers in 2006 and 2010.

Table 4.7 Emissions of refrigerants from refrigerators/freezers 2006 and 2010, tonnes

	HFC-134a		HFC-404a	
	2006	2010	2006	2010
Consumption	63,0	63,0	4,3	4,3
Emissions during production	1,3	1,3	0,1	0,1
Exports	31,5	31,5	0,0	0,0
Stock	842,7	881,5	83,2	94,7
Emission from stock	8,2	8,8	0,8	2,7
Emissions during destruction	0,0	0,0	0,0	0,0
Actual emissions	9,5	10,1	0,9	1,1
GWP contribution, 1000 tonnes CO2 equivalents	12,3	13,1	3,0	3,6

Total emissions of HFC-134a and HFC-404a refrigerants from refrigerators/freezers in 2006 were approx. 12 300 tonnes CO_2 equivalents. In the future scenario of actual emissions, it is estimated that the total emission in 2010 is 13 100 tonnes CO_2 equivalents coursed by an increasing stock.

Mobile A/C

Emissions from mobile A/C systems are mainly due to leakage and accident 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, vans and trucks. 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, 2006

	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 still undergo servicing, and therefore still 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 2006. Refilled stock = Danish consumption.

The results are shown in the table below.

Table 4.9 Determination of amounts of HFC-134a involved in mobile A/C systems in 2006

	No. of Vehicles	Stock, kg, tonnes HFC-134a	Maintenance, filling, tonnes HFC-134a	Average filling per year, tonnes HFC-134a
Private cars	2 013 230	151,0	75,5	25,2
Busses	9 034	16,3	3,3	1,1
Vans	458 867	18,4	9,2	3,1
Trucks	50 720	38,0	15,2	5,1
SUM		223,6	103,1	34,4

The total stock of HFC-134a in mobile A/C systems in Denmark in 2006 was calculated to be about 223,6 tonnes, which are a further increase compared to 2005 stock.. In 2006, the volume of HFC-134a filled onto mobile air conditioning systems was 34,4 tonnes. This volume of refrigerants was used solely for refilling in connection with the maintenance of existing systems /16/. It is indicated from suppliers of mobile A/C refrigerants, that the consumption is even higher than this estimated. One supplier assumes the consumption to be approx. 40 tonnes of HFC-134a per year.

The table below shows a projection of calculated actual emissions from mobile A/C systems in Denmark.

Table 4.10 The calculated actual emissions of HFC-134a from mobile A/C systems in 2006, 2010 and 2015, tonnes

	2006	2010	2015
Imports via automobiles	6,6	6,6	6,6
Consumption to refilling	34,4	38,4	43,4
Total stock increase	41,0	45,0	50,0
Emissions from filling	1,5	1,7	2,0
Emissions from stock	65,1	68,9	71,9
Total emission	66,6	70,6	73,8
Stock	223,6	231,6	241,6
Actual emissions	66,6	70,6	73,8
GWP contribution, 1000 tonnes CO2 equivalents	86,6	91,8	96,0

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 46-49 tonnes refrigerants, either HFC-134a, HFC-404a or HCFC-22.

Actual emissions from refrigerated vans and lorries in 2006 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 2006 and 2010, tonnes.

	HFC-134a		HFC-404a	
	2006	2010	2006	2010
Consumption	0,40	0,40	6,6	6,6
Emissions from filling	0,02	0,02	0,3	0,3
Contribution to stock	0,38	0,38	6,3	6,3
Emissions from Stock	0,97	0,66	5,7	6,0
Stock	5,12	3,61	34,2	35,5
Actual emissions	0,99	0,68	6,0	6,3
GWP contribution, 1000 tonnes CO2 equivalents	1,29	0,89	19,7	20,6

There have been no consumption of HFC-402a for refrigerated vans and lorries since the substance has been banned. But the emission from stock is still about 0.3 tonnes HFC-402a, corresponding to 400 tonnes CO_2 equivalents.

Thus, the total actual emissions from refrigerated vans and lorries were app. 21 430 tonnes CO_2 equivalents in 2006 which is a slight increase compared to 2005 where emissions were 20,890 tonnes CO_2 equivalents.

4.3.3 Emissions of HFCs from foam plastic products and propellants

Tree 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 calculation principles are summerized in table 4.12 below

Table 4.12 Emission 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

There has been no hard foam plastic produced with HFC-134a as blowing agent in 2007. The import of HFC-134a in products with insulation foam, e.g. household fredges and freezers, are considered to 0 in 2007. This is difficult to verify and no applicable method seems available. The actual emissions are therefore solely from existing stock of household fredges and freezers.

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

Table 4.13 Emissions of HFCs from insulating foam, tonnes

	2006	2010	2015
Consumption, HFC-134a	0,0	0,0	0.0
Emissions during production	0,0	0,0	0.0
Exports	0,0	0,0	0.0
Stock	1 147,8	757,5	159.1
Emission from stock	78,2	66,7	17.9
Actual emissions	78,2	66,7	17.9
GWP contribution, 1000 tonnes of CO_2 equivalents	101,6	86,7	23.2

In the projections for 2010 and 2015, it is estimated that the stock will be reduced significantly in 2015 as a result of the phase-out of HFC-134a as blowing agent and from 2018 it is estimated that there will be no more actual emissions from this source.

Foam blowing of Polyether based shoe soles

The consumption of HFC-134a used in polyether-based foam blowing in DK production of shoe soles has been 0 since 2005. Because of the regulation, general awareness among Danish importers/retailers and the general trend with substituting HFC-134a with alternative blowing agents, it is considered that the Danish import of polyether based products, e.g. shoe soles etc. are 0 from year 2007.

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 also equal to the consumption of HFC-based aerosol sprays in Denmark, after calculation of imports and exports. Total emissions from these two areas amount to 12,5 tonnes of HFC-134a and 11.6 tonnes of HFC-152a, corresponding to 20 000 tonnes CO_2 equivalents. Compared with 2005, emissions have been decreased by approx. 9 300 tonnes of CO_2 equivalents because of a significant reduction in use of HFC-134a in soft foam blowing but also a reduction in emissions from aerosols.

Medical products

The emissions from medical products are marginal and have not been calculated.

Optical fibre production

Optical fibre production constitute a new sector for F-gas emissions. Both HFC and PFC' are used for technical purpose in Danish optics fibre production.

HFC-23 is used as a protection and cleaning gas in the production process. The emission factor is therefore determined as 100 per cent release during production. The actual emission from HFC-23 is 930 tonnes CO_2 equivalents in 2006 and it is assumed that this sector will increase during the coming years.

4.3.4 Emissions of sulphur hexafluoride

The total emissions of SF_6 in 2006 have been calculated to 1.5 tonnes, equivalent to a GWP contribution of about 35 990 tonnes CO_2 equivalents. Net consumption was 4.2 tonnes.

Emissions derive from three sources - power switches, double-glazed windows and laboratories.

Double-glazed windows

Use of SF_6 in double-glazed windows was phased out in 2002, however, there are still emissions from stock in existing double-glazed windows in Danish buildings. The stock is estimated from consumption data from Danish producers of double-glazed windows 1992-2002 and life time for double-glazed windows are determined to 20 years.

Emission from double glazed windows are calculated on following factors:

- 15 per cent emission from production
- 1 per cent gradual emission from stock pr. year
- 65 per cent emission when disposal after 20 years

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

	2006	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	37,9	36,4	18,4
Actual emissions	0,4	0,4	4,0
GWP contribution, 1000 tonnes CO_2 equivalents	9,2	8,8	94,5

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

Power switches in high-voltage transmission stations

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 transmission systems are released due to the following:

- release of 5 per cent on filling with new gas (average figure covering normal operation and failure/accidents)

- 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 (average figure covering normal operation and failure/accidents)

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 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 2006, 2010, and 2015, tonnes.

	2006	2010	2015
Consumption	3,6	3,0	3,0
Service emissions	0,2	0,2	0,2
Recycling/recovery emissions	0,0	0,0	0,0
Emissions from stock	0,3	0,4	0,5
Stock	67,9	80,8	92,8
Actual emissions	0,5	0,6	0,6
GWP contribution, 1000 tonnes of CO_2 equivalents	12,5	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 in 2003 /20/. This survey covers about 1/9 of the stock in the Danish electricity sector. The survey calculated the emissions at about 20 kg of SF_6. Additionally, there were 88 kg of contaminated SF_6 in depot, and about 1.1 tonnes of new gas in store (2003).

If this data is assumed to be representative of the entire country, emissions in 2003 amount to about 180 kg. This is under half of the calculated emissions of 0.5 tonnes in this emission calculation of 2006.

On the basis of Eltra's survey, the applied evaluation method is still considered 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.

Laboratory purposes

Consumption of SF6 in laboratories covers two purposes:

- Plasma erosion in connection with the manufacture of microchips in clean-room laboratories
- Analysis purposes to a limited extend.

Consumption was 0.6 tonnes in 2006 and it was primary for plasma erosion purpose. The emission was app. 13 900 tonnes CO_2 equivalents.

Training shoes

In the period 1990 to 1998, Denmark imported training shoes, which, according to the manufacturer, contained SF_6. It is assessed that emissions of SF_6 from training shoes will not occur after 2003, while it is assumed that all shoes containing SF_6 is disposed by then.

4.3.5 Emissions of per fluorinated hydrocarbons

In 2006, the consumption of refrigerant R413a which contain per fluorinated hydrocarbons, was 0 tonnes. The actual GWP-weighted emission from this source is 12 300 tonnes CO_2 equivalents, which is a further reduction compared to the last four years. This emission is released from refrigerants in commercial stationary and mobile refrigerators. Stock in commercial refrigerators has been estimated at about 15 tonnes in 2006. While refrigerants containing PFC are only used in stationary refrigerators, no estimates for imports and exports are relevant.

Table 4.16 Emissions of PFCs from commercial refrigerators in 2006, 2010 and 2015, tonnes

	2006	2010	2015
Consumption	0,0	0,0	0,0
Consumption	0,0	0,0	0,0
Emissions from stock	1,8	1,0	0,6
Stock	15,0	8,9	5,2
Actual emissions	1,8	1,0	0,6
GWP contribution, 1000 tonnes CO_2 equivalents	12,3	6,9	4,0

Optical fibre production

The PFC consumption in 2006 derives from a new area – optics fibre production. This area has used PFC-14 (0,25 tonnes) and PFC-318 (0,2 tonnes) for technical purpose in optics fibre production.

The PFC's are used as a protection and cleaning gas in the production process. The emission factor is therefore determined as 100 per cent release during production. The actual emission from PFC-14 and PFC-318 is 3 380 tonnes CO_2 equivalents in 2006 and it is assumed that this sector will increase during the coming years.

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ODP values for ozone-depleting substances and GWP values for F-gases

Table 1.a Ozone-depleting substances, their chemical formulas and Ozone Depleting Potential (ODP) - Regulated by the Montreal Protocol.

Substance	Chemical formula	ODP values
CFCs		
CFC-11	$CFCl_3$	
CFC-12	CF_2Cl_2	
CFC-113	$C_2F_3Cl_3$	
CFC-115	C_2F_5Cl	
Other CFCs	-	
Tetrachloromethane	CCl_4	
1,1,1-Trichloroethane	CH_3CCl_3	
Halons		
Halon-1301	CF_3Br	
Halon-1211	CF_2BrCl	
Halon-2402	CF_2BrCF_2Br	
Methylbromide	CH_3Br	
HCFCs		
HCFC-22	CHF_2Cl	[illegible]
HCFC-123	$C_2HCL_2F_3$	
HCFC-141 b	$C_2H_3FCl_2$	
HCFC-142 b	$C_2H_3F_2Cl$	[illegible]
	-	

Table 1.b
F-gases, their chemical formulas and GWP values stipulated in the Kyoto Protocol

Substance	Chemical formula	GWP value
HFCs		
HFC-32	CH_2FH_2	
HFC-125	C_2HF5	
HFC-134a	CF_3CFH_2	
HFC-143a	$C_2H_3F_3$	
HFC-152a	CF_2HCH_3	
HFC-245		
HFC-227	C3HF7	
HFC-365		
HFC-404 a(1)	-	
HFC-401a(2)	-	
HFC-402a(3)		
HFC-407c(4)		
HFC-408a(5)		
HFC-409a(6)		
HFC-410a(7)		
HFC-507a(8)		
Sulphurhexafluoride	SF_6	23
Perfluorinated hydrocarbons		
Tetrafluoromethane (perfluoromethane)	CF_4	
Fluoroethane (perfluoroethane)	C_2F_6 C_3F_8	
Fluoropropane (perfluoropropane)	$C\text{-}C_4F_8$	
Fluorocyclobutane (perfluorocyclobutane)	C_6F_{14}	
Fluorohexane (perfluorohexane)		

(1) Mixture consisting of 52 % HFC-143a, 44 % HFC-125 and 4 % HFC-134a. The GWP value is determined from this.
(2) Mixture consisting of 53 % HCFC-22, 13 % HFC-152a and 34 % HCFC-124. The GWP value is determined from this.
(3) Mixture consisting of 38 % HCFC-22, 60 % HFC-125 and 2 % propane. The GWP value is determined from this.
(4) Mixture consisting of 25 % HFC-125, 52 % HFC-134a, and 23 % HFC-32. The GWP value is determined from this.
(5) Mixture consisting of 46 % HFC-143a and 7 % HFC-125. The GWP value is determined from this.
(6) A HCFC mixture consisting entirely of HCFCs, where the GWP - in accordance with the climate convention guidelines - is 0, since the mixture does not contain greenhouse gases. The real GWP value is 1,440.
(7) Mixture consisting of 50 % HFC-32 and 50 % HFC-125
(8) Mixture consisting of 50 % HFC-125, 50 % HFC-143a. The GWP value is determined from this.

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) 1990-2006 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	2004	2005	2006
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	4.3	10.8	1.8
CFC-12	6.0	0	0.1	0	0.7	6.7	10.3	0	1.2	0	0	0	0	0	0	0	0
CFC-113	-	-	-	-	-	-	-	-	0	0	<0.2	0	0	0	0	4.5	0
CFC-115	-	-	-	31	5.5	0	0	0.2	0.4	0	0	0	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	4.3	15.3	1,8
HCFC-22	-	-	-	-	-	-	-	-	-	-	-	20	4.6	6.8	14.8	-	4.1
1,1,1,- tri-chloroethane	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0	0	0	-

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

In 2006, Greenland imported 1.8 tonnes CFC-11 from Denmark (Statistics Denmark).

The import of HCFC-22 in Greenland is not possible to determine from Statistic Denmark data. But data from Danish suppliers shows that the export of new HCFC-22 for refrigeration purpose was 4.1 tonnes in 2006.

No reports of import/exports of 1,1,1-trichloroethane were recorded in 2006.

From the above data, ODP-weighted consumption in Greenland for 2006 was 2.02 ODP tonnes. This is a decrease compared to 2005, where the ODP weighted consumption was 14.4 tonnes ODP tonnes. Greenlands ODP weigthed emission is app. 1 ODP tonnes lower than the total Danish 2006 emission.

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 2006 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.

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 1000 tonnes, 1993-2020

	HFC-134a	HFC-152a	HFC-404a	HFC-401a	HFC-402	HFC-407c	HFC-507a	Other HFCs	PFC-er	SF6	Total pr 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	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	346,9	0,8	312,7	0,0	6,1	45,3	18,2	17,8	15,9	33,1	796,8
2005	347,2	0,2	358,1	0,0	5,2	55,3	19,4	18,4	13,9	21,8	839,5
2006	354,8	0,4	375,4	0,0	4,5	59,4	19,2	20,0	15,7	36,0	885,3
2007	364,9	0,4	392,3	0,0	3,9	63,5	19,2	20,3	13,9	35,5	913,8
2008	370,5	0,4	395,0	0,0	3,4	63,4	19,1	20,2	12,4	35,7	920,2
2009	363,8	0,5	391,7	0,0	3,0	62,4	19,1	19,9	11,2	35,9	907,5
2010	352,0	0,5	384,2	0,0	2,7	62,0	19,1	19,8	10,3	36,1	886,6
2011	343,3	0,6	347,4	0,0	2,4	61,6	19,0	17,2	9,6	69,3	870,4
2012	313,1	0,6	318,0	0,0	2,1	61,2	19,0	13,8	8,9	115,4	852,2
2013	299,6	0,7	293,0	0,0	1,9	58,6	16,5	11,5	8,3	125,4	815,4
2014	257,1	0,7	260,7	0,0	1,7	55,8	13,5	9,6	7,8	137,9	744,8
2015	236,1	0,7	219,2	0,0	1,5	49,7	10,9	5,4	7,4	123,2	654,3
2016	210,1	0,8	178,0	0,0	1,4	43,5	4,2	2,6	7,0	95,5	542,9
2017	192,4	0,8	147,9	0,0	1,2	34,8	5,0	1,2	6,6	80,6	470,7
2018	177,5	0,8	100,4	0,0	1,1	19,9	1,8	1,6	6,3	110,6	420,1
2019	174,6	0,9	76,4	0,0	1,0	6,3	0,6	1,0	6,0	79,8	346,7
2020	163,1	0,9	21,9	0,0	0,9	0,9	-1,0	0,9	5,8	59,3	252,7
I alt	**7663**	**47**	**6046**	**1**	**105**	**895**	**286**	**307**	**276**	**1968**	**17594,6**

Specification of methods and assumptions for determination of emissions for 1990-2006 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.

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
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 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).	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 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/.	The projection is based on a steady state stock (203 tons).
	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,	

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
					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).	
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	Emission (Danish default): - Production = 15 % - Use = 4.5 % - Lifetime = 3 years	The calculation of the HFC stock in shoe soles is based on the following assumptions: it is assumed that 5% of all shoes with	

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
			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.	- Disposal = 71.5%, destroyed in incineration and thereby not released as emissions.	plastic, rubber and leather soles contain polyether containing 8 g of HFC-134a per shoe. Net export with the same consumption in Danish 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.
	Others					

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
O1	Fibre Optics production	PFC-14 PFC-318 HFC-227	Tier 2. - information on consumption of PFC in production of fibre optics is derived from importers' sales report with specific information on the amount used for production of fibre optics.. This is thought to represent 100% of the Danish consumption of PFC-14 and PFC-318 for that purpose	Emission = 100% in the production year = year for consumption	This is a new consumption area which are added for first time in 2006 emission calculation.	It is considered that consumption will be steady state in projection estimated.
	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 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.	Emission (DK-default): - 15% during production of double glazing. - 1 % per year during the lifetime of the window - 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 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	Emission (Danish default): - release on filling = 5% - loss / release in operation = 0.5 % per year - release in reuse/drawing off = 5%.		There is one supplier (Siemens) that imports its own gas for filling in Denmark. Suppliers (AAB, Siemens, Alstom) report on new

ID	Source	Substance	Methods	Emission factor	Remarks	Projection assumptions
			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.	- release upon disposal = 0%		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.

Assessment of Good Practice Guidance compliance in DK F-gas calculation 2006

The Danish F-gas emissions are calculated for the historical years up to 2006. The time series of emissions are calculated using Good practice principles and the series goes back to 1993, but are to be considered complete from the year 1995.

Key Source Categories

F-gases are determined as a key source category. The contribution of F-gases to national greenhouse gas emission is approx. 1% of total emission in the most recent historical years of the inventories.

Future trend scenarios

A trend scenario is elaborated until 2020. The scenario is bases on a “steady state” trend but with an inclusion of dates for out phase of determined substances as stated in legal acts.

Methodology

In the following the relevant decision trees from the GPG (Good Practice Guidance) chapter 3 are investigated with respect to the Danish F-gas calculations compliance with GPG.

Emission of substitutes from ODS – decision tree figure 3.11

For the Danish calculation of F-gases it is basically a Tier 2 bottom up approach which is used, while data is reported from identified importers and users of F-gasses in DK. As for verification using import/export data a Tier 2 top down approach is applied. In an annex 4 to the F-gas emission report 2006 (Environmental Protection Agency), there is a specification of the applied approach for each sub source category.

Emission factors

Consumption data of F-gases are provided by suppliers and/or producers. Emission factors are primarily defaults from GPG which are assessed to be applicable in a national context.

In case of commercial refrigerants and Mobile Air Condition (MAC), national emission factors are defined and used. In case of PUR foam blowing of shoe and use of system foam EF are stated by the producer. Because of the relative low consumption from PUR foam blowing of shoes and system foam a certain uncertainty is assessed as acceptable.

Import/export data
Import/export data for sub category sources where import/export are relevant (MAC, fridge/freezers for household) are quantified on estimates from import/export statistic of products + default values of amount of gas in product. The estimates are transparent and described in the annex referred to above.

Import/export data for system foam and commercial refrigerators and stationary air condition are specified in the reporting from importers and users.

Consistency
The time series are consistent as regards methodology. No potential emission estimates are included as emissions in the time series and same emission factors are used for all years.

Reporting and documentation
The national inventories for F-gases are provided on a yearly basis and documented in a yearly report (Environmental Protection Agency, 2004 and 2005).

Detailed data from importers and users and calculations are available and archived in electronic version. The report contains summaries of EF used and information on sources, Further details on methodology and EF are included in annex to the report.

Activity data are described in a spread sheet for the current year. The spread sheet contains the current year as well as the years back. The current version is used with spreadsheet for data for the current year linking to the Danish inventory databases and for the CRF format. In case of changes to the previous reported data this is work out in spreadsheet versions accordingly and reported with explanations as required in the CRF format.

Source specific QA/QC and verification

Comparison of emissions estimates using different approaches
Inventory agencies should use the Tier 1 potential emissions method for a check on the Tier 2 actual emission estimates. Inventory agencies may consider developing accounting models that can reconcile potential and actual emissions estimates and may improve determination of emission factors over time.

This comparison has been carried out in 1995-1997 and for all three years it shows a difference of approx. factor 3 higher emissions by using potential emission estimates.

Inventory agencies should compare bottom-up estimates with the top-down Tier 2 approach, since bottom-up emission factors have the highest associated uncertainty. This technique will also minimise the possibility that certain end-uses are not accounted for in the bottom-up approach.

This exercise has been partly conducted since data from importers (top down) are assessed against data from users (bottom up) to ensure, that import and consumption are more or less equal. The consumption reported from users are always adjusted to the import of substances, which are the most exact data we have.

The uncertainty due to this is, if not all importers are identified because new imported are introduced to the DK market.

National activity data check

For the Tier 2a (bottom-up) method, inventory agencies should evaluate the QA/QC procedures associated with estimating equipment and product inventories to ensure that they meet the general procedures outlined in the QA/QC plan and that representative sampling procedures were used. This is particularly important for the ODS substitutes sub-sectors because of the large populations of equipment and products.

No QA/QC plan specifically for the F-gas calculation is developed. However, QC procedures were carried out as described below.

The spread sheets containing activity data has incorporated several data-control mechanisms, which ensure, that data estimates do not contain calculation failures. A very comprehensive QC procedure on the data in the model for the whole time-series has for this submission been carried out in connection to the process which provided (1) data for the CRF background Tables 2(II).F. for the years (1993)-2002 and (2) provided data for potential emissions in CRF Tables 2(I). This procedure consisted of a check of the input data for the model for each substance. As regards the HFCs this checking was done according to their trade names. Conversion was made to the HFCs substances used in the CRF tables etc. A QC was that emission of the substances could be calculated and checked comparing results from the substances as trade names and as the "no-mixture" substances used in the CRF.

Emission factors check

Emission factors used for the Tier 2a (bottom-up) method should be based on country-specific studies. Inventory agencies should compare these factors with the default values. They should determine if the country-specific values are reasonable, given similarities or differences between the national source category and the source represented by the defaults. Any differences between country specific factors and default factors should be explained and documented.

Country specific emission factors are explained and documented for MAC and commercial refrigerants and SF6 in electric equipment. Separate studies has been carried out and reported. For other sub source categories, the country specific emission factor is assessed to by the same as the IPCC default emission factors.

Emission check

Since the F-gas inventory is developed and made available in full in spread sheets, where HFCs data are for trade names, special procedures are performed to check the full possible correctness of the transformation to the CRF-format through Acces databases.

Uncertainties

In general uncertainty in inventories will arise through at least three different processes:

A. Uncertainties from definitions (e.g. meaning incomplete, unclear, or faulty definition of an emission or uptake);
B. Uncertainties from natural variability of the process that produces an emission or uptake;
C. Uncertainties resulting from the assessment of the process or quantity, including, depending on the method used,: (i) uncertainties from measuring; (ii) uncertainties from sampling; (iii) uncertainties from reference data that may be incompletely described; and (iv) uncertainties from expert judgement.

Uncertainties due to poor definitions are not expected as an issue in the F-gas inventory. The definitions of chemicals, the factors, sub source categories in industries etc. are well defined.

Uncertainties from natural variability are probably occurring in a short term time period, while estimating emissions in individual years. But in a long time period – 10-15 years, these variabilities levels out in the total emission , because input data (consumption of F-gases) are known and are valid data and has no natural variability due to the chemicals stabile nature.

Uncertainties that arise due to imperfect measurement and assessment are probably an issue for:

emission from MAC (HFC-134a)
emission from commercial refrigerants (HFC-134a)

lead to inexact values of the specific consumption of F-gases.

The uncertainty varies from substance to substance. Uncertainty is greatest for HFC-134a due to a widespread application in products that are imported and exported. The greatest uncertainty in the areas of application is expected to arise from consumption of HFC-404a and HFC-134a in commercial refrigerators and mobile refrigerators. The uncertainty on year to year data is influenced by the uncertainty on the rates at which the substances are released. This results in significant differences in the emission determinations in the short term (approx. five years), differences that balances in the long term.

I connection to the work on the Danish National Inventory report general uncertainty estimates for F-gases has been worked out to make the uncertainties for the Danish inventories complete. Refer this report given in the reference list in the main report

Further improvement of uncertainty analysis with respect to the calculation of F-gas emissions are to be considered in future calculations.

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