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

Danish consumption and emissions 2001

Tomas Sander Poulsen
Cowi Consulting Engineers AS

Danish Environmental Protection Agency
Danish Ministry of the Environment

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1 Summary and Conclusions

1.1 Ozone-depleting Substances

The ODP-weighted consumption for 2001 has been calculated at 83.9 OPD tonnes, showing a slight increase of 1.26 OPD tonnes on 2000 levels, which measured 83.9 ODP tonnes. This increase is due to a greater consumption of HCFC-141b. The consumption of other ozone-depleting substances is roughly the same as in 2000.

Analysis of individual substances in the ODP consumption for 2001shows that the contribution is mainly due to HCFC-141b and HCFC-22.

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

Table 1. Overview of consumption and ODP-weighted consumption in 2000-2001, tonnes

Substance	Net consumption, 2000	ODP consumption, 2000	Net consumption, 2001	ODP consumption, 2001
CFCs (1)	4.8	3.84	2.6	2.08
Tetrachloromethane	0.6	0.66	1.25	1.26
1,1,1-Trichloroethane	0	0	0.05	0.005
Halons	0	0	0	0
Methylbromide	0	0	(179.5)	0
HCFCs	901.6	79.4	889.9	81.45
HCFC-22	347	19.1	249.1	13.7
HCFC-123	0	0	18	0.36
HCFC-141b	538.8	59.3	609	66.99
HCFC-142b	15.8	1	0	0
Total	-	83.9		85.16

(1) The calculation of the ODP consumption of CFCs is made entirely on the basis of values registered for CFC-113.

Consumption of methylbromide has been stated in brackets and it is only used as feedstock for other chemical production. Therefore it is not included as an emission.

CFCs, tetrachloromethane, and trichloroethane are used exclusively for laboratory purposes. HCFCs are used as refrigerants in cooling or for foam production. The range of application of HCFCs in 2001 is shown in Table 1.2.

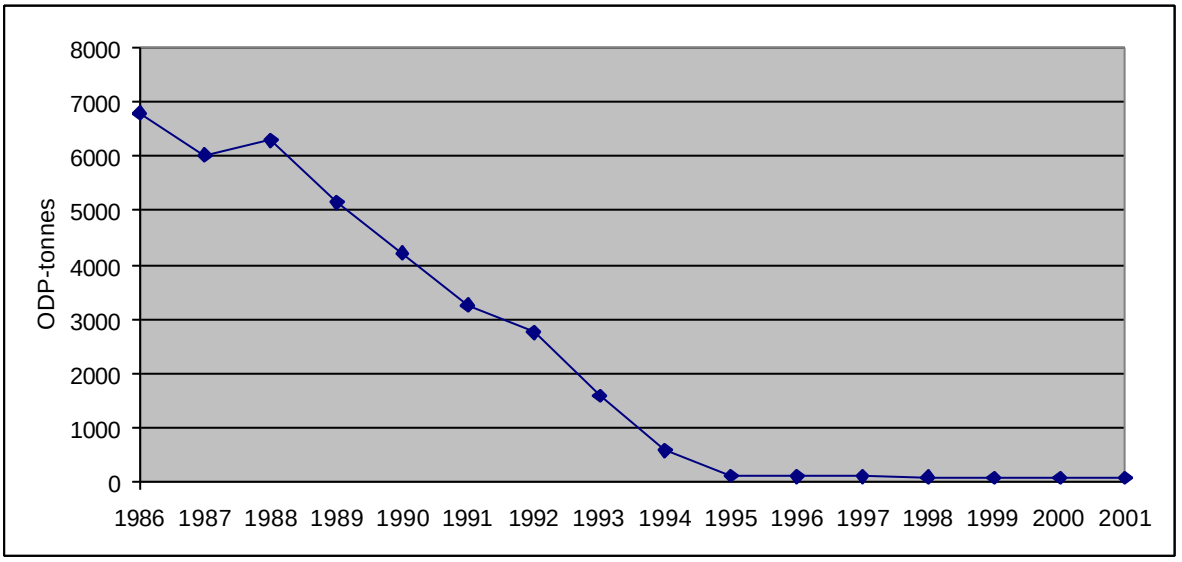
Table 2 Consumption distribution of HCFC application areas in 2001, tonnes.

Application	HCFC-22	HCFC-123	HCFC-141b	HCFC-142b
Foam (for panels, insulation, etc.)		18	609	0
Refrigerants	249.1		0	0
Total	249.1	18	609	0

HCFC-22 is used as a refrigerant, and HCFC-141b and HCFC-142b are used for foam.

Figure 1.1 shows the development of ODP-weighted consumption.

Figure 1.1 The development of ODP consumption 1986-2001, tonnes.



The specific consumption figures for individual groups of substances and the ODP-weighted contribution for the period 1986-2001 are shown in Table 3.1.

1.2 Greenhouse gases

The GWP-weighted actual emission for HFCs, PFCs, and SF_6 in 2001 measures approx. 698,900 tonnes CO_2 equivalents. In 2000, the equivalent emission was approx. 793,000 tonnes CO_2 equivalents (818,000 tonnes CO_2 equivalents using a previous method of calculation), which corresponds to

an overall reduction of approx. 94,000 tonnes CO_2 equivalents. This is the first time a reduction has been seen in the actual emissions of strong greenhouse gases in Denmark.

The emission of HFCs, PFCs, and SF_6 in 2001 accounted for less than 1% of the total Danish GWP contribution /18/.

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

Table 3 Consumption, actual emission, stock, adjusted for import/export as well as GWP-emissions 2001, tonnes.

Application	Substance	Danish Consumption	Stock	Actual emission	GWP emission
Commercial refrigerators and stationary A/C	HFC-134a	102.4	650	62.6	81 300
	HFC-404a	113.7	705.7	67.7	220 600
	HFC-401a	4.1	39.4	4.5	100
	HFC-402a	0.8	42	4.7	7 800
	HFC-407c	40.3	132.5	10.9	16 600
	HFC-507a	2.2	43.5	4.6	14 300
	Other HFCs	16.3	100.3	9.6	16 600
	PFC	3.2	26.5	2.6	18 500
	All substances				375 800
Household fridges/freezers					
- refrigerants	HFC-134a	130.1	678	8.8	11 500
	HFC-404a	6.5	64.6	<1	2 380
- insulating foam	HFC-134	158.9	1462	84.8	110 200
	HFC-152	0	3	>0	180
	All substances				124 080
Mobile A/C refrigerants	HFC-134a	30.9	205.1	46.2	60 000
Refrigerated vans and lorries	HFC-134a	2.4	8.7	1.4	1 900
	HFC-404a	5.9	24.9	4.2	13 800
	HFC-402a	0	3.5	0.7	1 200
	All substances				16 900
Shoe soles	HFC-134a	5	42.2	2.1	2 800
Soft foam and aerosol-spray	HFC-134a	42.8	-	44.3	57 600
	HFC-152a	11.1	-	11.1	1 600
	HFC-365	3.7	-	3.7	6 400
	HFC-227	3.7	-	3.7	6 400
	All substances				72 000
Joint filler	HFC-134a	10	-	10	13 000
	HFC-152a	1	-	1	140
	All substances				13 140
Detergent	PFC	0.5	-	0.5	3 600
Sealed glazing units for window panes	SF_6	0.2	39.9	0.4	10 200
Power switches in high-voltage plant	SF_6	4.4	61.2	0.5	12 550
Laboratories	SF_6	0.2	-	0.2	5 000
Running shoes	SF_6	0	0.5	0.1	2 650
Metal work	SF_6	0	-	0	0
Total	HFCs	676	3536	426.7	646 400
	PFCs	3.7	22	4.5	22 100
	SF_6	4.7	99.3	2.5	30 400
GWP emission	**Total**				698 900

In Figure 1.2 below the total GWP-weighted emission from HFCs, PFCs, and SF_6 is shown in relation to source. The figure shows which applications are responsible for the greatest individual emissions in 2001.

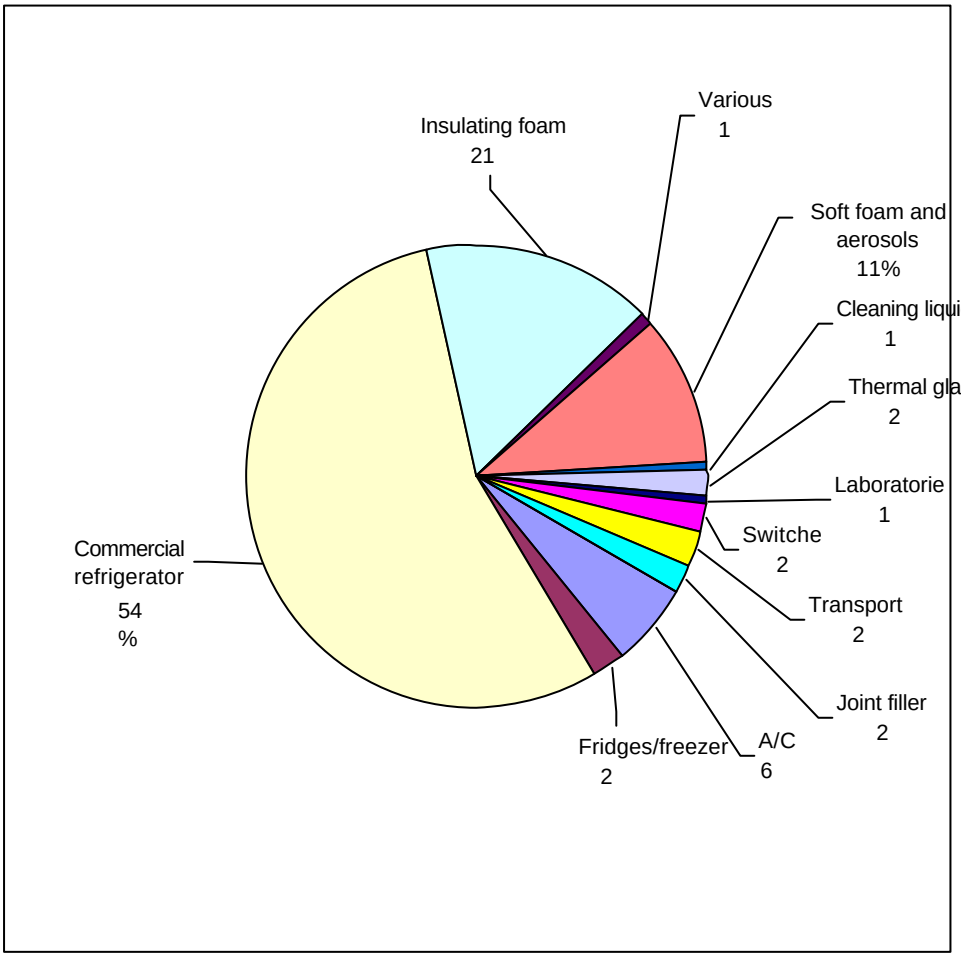


Figure 1.2 GWP contribution in % from HFCs, PFCs, and SF_6 by source.

The figure shows that emissions from refrigerants used in commercial stationary refrigerators account for the largest GWP contribution. Such refrigerators make up 54% of the total actual contribution in 2001. The contribution is primarily due to HFCs, and to a lesser degree PFCs.

The second largest GWP contribution, measuring 17.8%, comes from the continuing emission of HFC from the insulating foam in fridges and freezers.

10.3% of the GWP contribution derives from HFC emission in the production of soft foam and the use of aerosol sprays employing HFC.

The primary sources of SF_6 emission in 2001 are from power switches, accounting for about 1.8% of the total GWP contribution.

HFCs comprise approx. 92% of the total GWP contribution. The emission of SF_6 makes up 4.5% and the emission of PFC contributes 3.5% to the total contribution. Compared to the level in 2000, the relative proportion of

HFC emissions has risen. The relative distribution of the emissions is shown in the figure below.

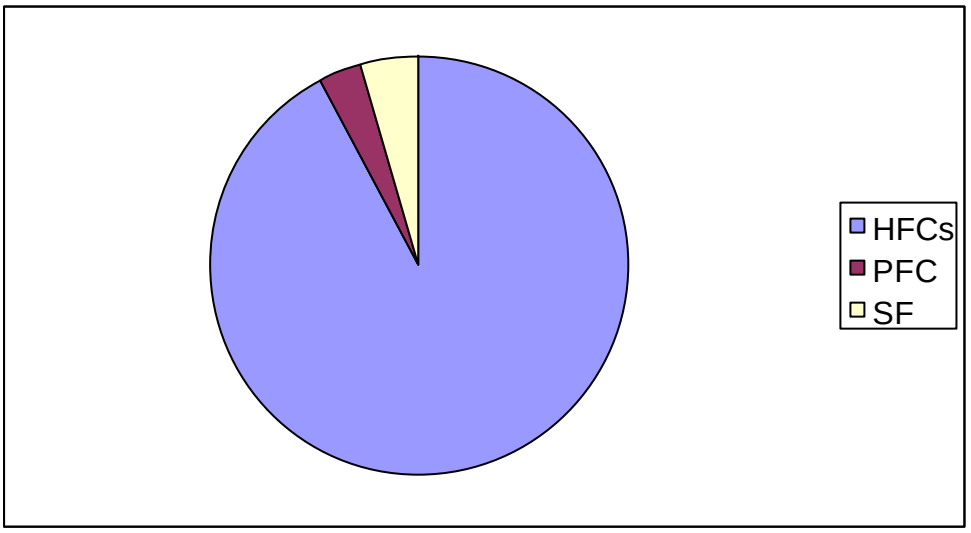


Figure 1.3 The relative distribution of the GWP contribution from HFCs, PFCs, and SF_6, 2001.

1.2.1 HFCs

The total consumption of HFCs measures 676 tonnes in 2001, which is a significant reduction, compared to the consumption of approx. 1,027 tonnes in 2000. In general, the consumption of all HFCs has decreased.

The total GWP contribution from HFCs is approx. 646,400 tonnes CO_2 equivalents, which is a reduction of roughly 24,400 tonnes (calculated according to the new method) compared to the GWP contribution in 2000.

1.2.2 Sulphurhexafluoride (SF_6)

The consumption of sulphurhexafluoride was 4.7 tonnes in 2001, which represents a drop in consumption when compared to 4.3 tonnes in 2001. The decrease is due to a considerable reduction in the use of SF_6 for sealed glazing units for windowpanes.

The actual emission has been calculated as 1.3 tonnes, equivalent to a GWP contribution of 30,400 tonnes CO_2 equivalents. This is a 50 % reduction compared to 2000 when the contribution was approx. 59,200 tonnes CO_2 equivalents.

1.2.3 Perfluorinated hydrocarbons (PFCs)

The consumption of perfluorinated hydrocarbons (perfluoropropane) measured almost 3.7 tonnes in 2000 and the emission has been determined at approx. 3.1 tonnes, which derives from the filling and continuing emission of refrigerants - approx. 2.6 tonnes, partly from the use of PFC detergent for electronics - approx. 0.5 tonnes (perfluoropropane).

The actual GWP-weighted emission is 22,100 tonnes CO_2-equivalents which is a slight reduction compared with 2000.

1.2.4 Trends in the total GWP-weighted contribution of strong greenhouse gases

Figure 1.4 shows the trend in the Danish GWP contribution in 1992-2001 from HFCs, PFCs, and SF_6. The relative difference in the determination of the total GWP value, derived from the present and earlier calculation methods, is illustrated in the figure.

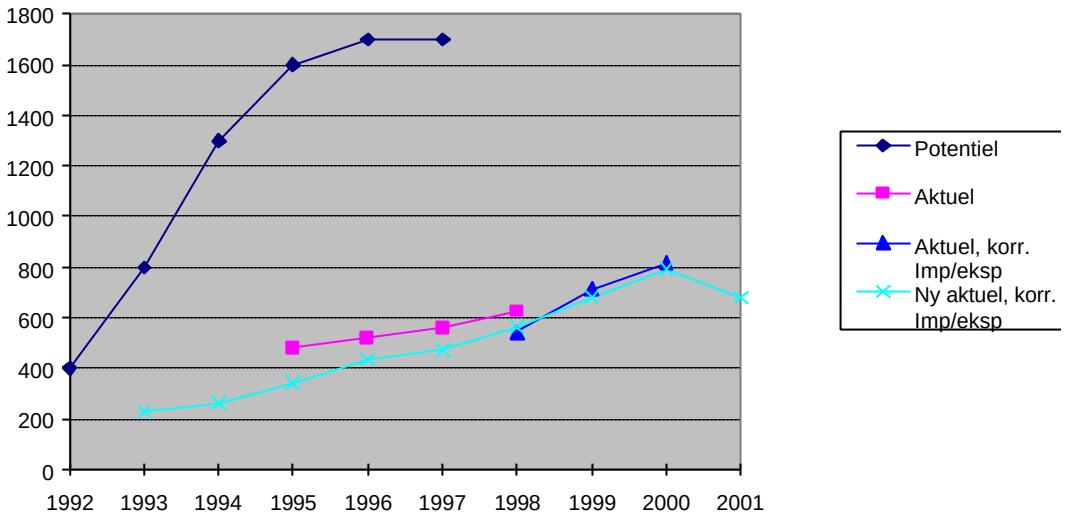


Figure 1.4 The change in the GWP-weighted potential, actual, and new actual emission 1992-2000, '000 tonnes CO_2 equivalents.

(translation of box – potential – actual – actual adjusted for imports and exports – new actual corrected for imports and exports)

The figure shows that for the year 2001 a reduction in the total GWP contribution can be seen for the first time.

The trend in the GWP contribution 1992-2001 can also be seen in table 1.4 below.

Table 1.4 Total GWP-contribution from HFC, PFC, SF_6 000 tonnes CO_2 eq. The total GWP-contribution has been determined using four different methods during this period.[1]

	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

[1] Due to new information, emissions determined for actual, adjusted import/export GWP emission have been changed for 1998 and 1999 compared to last year's evaluation /13/.

2 Introduction

On behalf of the Danish Environmental Protection Agency, COWI has conducted an assessment of the Danish consumption and emissions of ozone-depleting substances and the greenhouse gases HFCs, PFCs, and SF_6 for 2001. The evaluation survey has been carried out in continuation of previous assessments, refer to /13/ and references in this report.

The report provides an evaluation of the actual emissions of HFCs, PFCs, and SF_6. This method of determination was first used in the 1998 evaluation /2/. The determination of the actual emissions takes into account the emissions from stock contained in products and adjustments have been made for the import and export of the substances contained in products.

In 2001, the method of determination underwent further development and now defines Danish emission factors for certain primary areas of application such as commercial refrigerators and mobile refrigerator units. In order to ensure consistency of the determination, the new basis of determination has been used in the 2001 evaluation for all historical data back to 1990.

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

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

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

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

The Danish Environmental Protection Agency has published a booklet on the ozone layer and the greenhouse effect /5/, and in cooperation with the other Nordic countries the Agency has published a booklet on the protection of the ozone layer – Nordic Perspective /6/. The Danish

Environmental Protection Agency has also published a report on substitutes for the greenhouse gases HFCs, PFCs and SF_6 /10/.

2.1 Monitoring Group

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

- Frank Jensen, Danish Environmental Protection Agency
- Erik Lyck, National Environmental Research Institute, Denmark (DMU)
- Confederation of Danish Industries (DI)
- Statistics Denmark
- Tomas Sander Poulsen, COWI

2.2 Objective

The objective of the project is to evaluate the 2001 consumption of recently produced ozone-depleting substances and the consumption and the actual emission of the greenhouse gases HFCs, PFCs, and SF_6. The evaluation has been made partly in accordance with the IPCC guidelines, the Intergovernmental Panel on Climate Change /4/, and partly following the methods employed in previous evaluations.

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

2.3 Scope and definition

Ozone-depleting substances

This evaluation survey covers the net consumption of ozone-depleting substances. The term net consumption is understood as the amount of imported goods in bulk or drums, not counting any re-export of substances as raw materials.

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

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

The information on consumption has been gathered from importers, suppliers and user enterprises (usually the purchasing departments), and

Statistics Denmark. The method of data gathering used ensures that the information collected corresponds to the quantities of substances that are traded. The purchase and sales figures are utilised in this evaluation as an expression synonymous with the level of consumption. This approach is considered to be suitable and adequate for the present purpose, since experience from previous projects shows that a levelling out occurs with time and the substances sold/bought are consumed within a relatively small time horizon.

None of the substances covered here are produced in Denmark. Furthermore, ozone-depleting substances in Denmark are transported for treatment at chemical waste processing plants in Denmark. This data is included in the evaluation, but is not offset in the consumption figures, as was the case in all previous surveys.

Greenhouse gases

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

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

2.4 Methods

Consumption and emissions

The evaluation of consumption and determination of emissions and stock have been carried out based on information from six sources:

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

Information for evaluation is firstly gathered by means of a questionnaire survey. The responses to the questionnaires are supplemented where necessary with information gathered by telephone.

The results of the project are primarily based on the information received from enterprise and importer respondents etc.

The information gathered from importers and suppliers is recorded with information on consumer enterprises in order to monitor any disagreements between purchase and sales information and application of the substances. In some cases the application of individual substances can be estimated on the basis of two sources, given that the majority of the consuming enterprises are known. In cases where not all the user enterprises specify the application of substances, the consumption of individual substances is estimated from the information provided by importers, suppliers, and any industry-related organisations, such as the Danish Refrigeration Installers' Environmental Scheme (KMO).

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

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

The evaluation has been conducted using two different methods /2/:

- The potential emission (ozone-depleting substances)
- The actual emission (HFCs, PFCs and SF_6)

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

Potential emission = import + production - export - destruction/treatment.

The evaluation of greenhouse gas emissions is based on a calculation of the *actual emission*. The actual emission is the emission in the evaluation year, accounting for the time lapse between consumption and emission. The actual emission includes Danish emissions from production, from products during their lifetimes, and from waste products. The 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 the emission is determined on the basis of information on consumption in the various areas of application and calculated or estimated emissions in the area of application (emission factors).

Tier 2 – Bottom-up analysis.
In the bottom-up analysis an estimation is made of the emission from a specific application area based on information from producers using substances in production and products; information on import and export of products; information on the technological developments within the application areas; information on the average amount of greenhouse gases contained in products; and information on the lifetime of products and the actual emission during the consumption phase and disposal phase.

The Tier 2 – Bottom-up analysis was first employed in the evaluation of emissions from HFCs, PFCs, and SF_6 in 1998, and it covered the following activities /2/:

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

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

Consumption and emissions of greenhouse gases are wherever possible carried out for individual substances, even though the consumption of certain HFCs has been very limited. This has been done to ensure transparency of evaluation in the determination of GWP values. However, the continued use of a category for "Other HFCs" has been necessary since not all importers and suppliers have specified records of sales for individual substances.

Uncertainty varies from substance to substance. Uncertainty is greatest for HFC-134a due to its widespread application in products that are imported and exported. The greatest uncertainty in the distribution of substances in the areas of application is judged to arise from the consumption of HFC-404a and HFC-134a in commercial refrigerators and mobile refrigerators. The distribution is significant in the differences in the emission determinations in the short term (approx. five years), but balances out in the long term. This is because the distribution is only significant for the rate at which emissions are released.

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

2.5 Explanation of terminology

The following terms and abbreviations are used throughout this report.

- *User enterprise:* A producer that uses ozone-depleting substances or strong greenhouse gases in connection with production processes in the enterprise.

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

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

- *Importer:* Trade 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 Denmark.

3 Ozone-depleting substances

All known importers of ODS's responded to the questionnaire survey. The responses provide information on import/export, sales/purchase, and areas of application relating to relevant substances (including both mixed and pure substances). All ODS's reported by the importers are new ODS's.

The information from importers is supplemented with statistical information from Statistics Denmark for 2001. Information on CFC-11, CFC-12, CFC-113, tetrachloromethane, 1,1,1-trichloroethane, and methylbromide is available from Statistics Denmark, but for HCFCs, halons and other CFCs the statistics are provided only for groups of substances and not for individual substances. Statistical data is used for cross-checking information on imports. The statistics do not distinguish between new and re-used substances, and thus imports could in principle consist of new and re-used substances. It is therefore assumed that in the import of CFC-113 the difference between data from importers and data from Statistics Denmark derives from the import of re-used ODS.

There is no import for feedstock except for methylbromide.

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

The foreign trade statistics for 2001 assign the following ozone-depleting substances to the following separate positions:

- CFC-11 (position nr. 2903.41.00)
- CFC-12 (position nr. 2903.42.00)
- CFC-113 (position nr. 2903.43.00)
- CFC-115 (position nr. 2903.44.90)
- Tetrachloromethane (carbontetrachloride) (position nr. 2903.14.00)
- 1,1,1-trichloroethane (methyl chloroform) (position nr. 2903.19.00)

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

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

3.1 Import and export

The following sections describe the import of individual ozone-depleting substances.

3.1.1 CFCs

The import of new CFCs in 2001, based on information on imports, was 2.6 tonnes. In 2000 the import was 4.8 tonnes. The considerable fall is mostly due to a particular importer reporting a very limited import in 2001.

Four importers report imports of 2.6 tonnes of CFC-113 for use as a trace gas for laboratory purposes. There is no other information available for the import of other CFCs.

Statistics Denmark registered an import of 3.7 tonnes of CFC-113 in 2001, of which it is assumed 0.9 tonnes has been imported in the form of regenerated CFC-113. This accounts for the difference between 2.6 tonnes of new gas and 3.7 tonnes imported altogether.

3.1.2 Tetrachloromethane

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

3.1.3 Trichloroethane

In 2001, two importers reported combined imports and sales of < 50 kg of 1,1,1-trichloroethane.

3.1.4 Halons

No information has been received regarding the import of halons in 2001.

3.1.5 Methylbromide

Approx. 180 tonnes of methylbromide have been imported for feedstock in chemical production.

3.1.6 HCFCs

Six enterprises have imported HCFCs in 2001. The consumption of HCFC-22 has fallen, while the consumption of HCFC-141b has risen, and the consumption of HCFC-142b has remained almost the same as in 2000. HCFC-123 has also been imported.

Import of pure HCFC-22 totals 329.3 tonnes in 2001. Of this, re-export to the rest of Scandinavia and Greenland measures 80.2 tonnes. Thus the Danish consumption amounts to 249.1 tonnes. In 2000 the consumption of HCFC-22 after re-export was 347 tonnes.

In addition, approx. 13.8 tonnes of pure HCFC-22 from HFC mixtures has been imported.

The import of HCFC-141b has increased to 609.3 tonnes in 2001. The import measured 538.8 tonnes in 2000. There was a small re-export of 0.3 tonnes of HCFC-141b in 2001, giving a final consumption of 609 tonnes.

There was no import of HCFC-142b in 2001. In 2000 this import amounted to 15.8 tonnes.

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

Substance	1987	1989	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CFC-11	3,046	2,300	1,307	593	54	0	0	0	0	0	0	0
	3,046	*2,300*	*1,307*	*593*	*54*							
CFC-12	1,378	825	612	495	243	0	0	0	0	0	0	0
	1,378	*825*	*612*	*495*	*243*							
CFC-113	469	327	253	162	70	3	5	2	1.4	3.3	4.8	2.6
	375.2	*261.6*	*202.4*	*129.6*	*56*	*2.4*	*4*	*1.6*	*1.12*	*2.64*	*3.84*	*2.08*
CFC-115	83	68	56	50	26	0	0	0	0	0	0	
	49.8	*40.8*	*33.6*	*30*	*15.6*							
All CFCs	4,976	3,520	2,228	1,300	393	3	5	2	1.4	3.3	4.8	2.6
ODP-weighted consumption	*4,846*	*3,427.4*	*2,155*	1247.6	*368.6*	*2.4*	*4*	*1.6*	*1.12*	*2.64*	*3.84*	*2.08*
Tetrachloro-methane	4	2	3	<1	0.7	1.7	1.5	2.0	0.7	1.3	0.6	1.25
ODP-weighted consumption	*4.4*	*2.2*	*3.3*	*1*	*0.77*	*1.87*	*1.65*	*2.2*	*0.77*	*1.43*	*0.66*	*1.26*
1,1,1-trichloroethane	686	396	1,015	940	569	104	0	0.9	0.2	0.03	0	0.05
ODP-weighted consumption	*68.6*	*39.6*	*101.5*	*94*	*56.9*	*10.4*	*0*	*0.09*	*0.02*	*0.003*	*0*	*0.005*
Halon 1302	n.i.	105	45	14	5	0	0	0	0	0	0	0
		1050	*450*	*140*	*50*							
Halon 1211	n.i.	15	4	1	0	0	0	0	0	0	0	0
		45	*12*	*3*								
Halon 2402	n.i.	0	0	0	0.7	0	0	0	0	0	0	0
					4.2							
All halons	100	120	44	15	6	0	0	0	0	0	0	0
ODP-weighted consumption	n.s.	*1095*	*462*	*143*	*54.2*	0	0	0	0	0	0	0
Methylbromide[1)]	40	51	31	17	12	9	8	5	0	0	0	(179.5)
ODP-weighted consumption	*24*	*30.6*	*18.6*	*10.2*	*7.2*	*5.4*	*4.8*	*3*	*0*	*0*	*0*	-
HCFC-22	374	455	1,005	813	750	748	610	600	534	566	347	249.1
	20.6	*25*	*55.3*	*44.7*	*41.2*	*41.1*	*33.5*	*33*	*29.4*	*31.1*	*19.1*	*13.7*
HCFC-141b	0	0	90	340	510	410	440	585	621	447.1	538.8	609
			9.9	*37.4*	*56.1*	*45.1*	*48.4*	*64.3*	*68.3*	*49.2*	*59.3*	*66.99*
HCFC-142b	0	0	130	326	145	195	160	17	17	15.8	15.8	0
			8.45	*21.2*	*9.4*	*12.7*	*10.4*	*1.1*	*1.1*	*1*	*1*	*0*
Other HCFCs	0	0	0	0	0	5	<5	20	0	0	0	18
						n.s.	*n.s.*	*n.s.*				*n.s.*
HCFC-22 from HFC mixture												13.8
												0.76
All HCFCs	374	455	1,203	1,479	1,410	1,302	1,215	1,222	1,172	1,029	901.6	889.9
ODP-weighted consumption	*20.6*	*25*	*73.65*	*103.3*	*106.7*	*98.9*	*92.3*	*98.4*	*98.8*	*81.3*	*79.4*	*81.45*
Total ODP-weighted consumption	***6 020***	***5 150***	***2 758***	***1 593***	***590***	***121***	***108***	***111***	***101.5***	***85.3***	***83.9***	***84.8***

1)Information from the Danish Environmental Protection Agency's Environmental Statistics. n.i. = no information available
n.s. = no specified information available for individual substances

Importers and consumers report that HCPC-22 is only used as a refrigerant and HCFC-123, HCFC-141b and -142b are used exclusively for foam systems in foam production.

Table 3.2 shows an overview of the Danish consumption of HCFCs by application areas, using information provided by importers and producers.

Table 3.2 HCFC consumption distribution in application areas for 2001, based on information from importers and producers, tonnes.

Application area	HCFC-22	HCFC-123	HCFC-141b	HCFC-142b
System foam (for panels and insulation)		18	609	0
Refrigerant	249.1		0	0
Total	249.1	18	609	0

3.1.7 Treatment

Denmark has two treatment facilities for the processing of ODS's - Kommune Kemi (KK) and Århus Genindvinding. All ODS's to be treated are sent to these plants.
The Kommune Kemi plant does not operate a registration system for individual substances because it receives and treats all substances in mixed tanks. Consequently it is not possible to quantify the amounts of substances collected for treatment based on what the plants receive. Therefore information is used from importers that receive and send on used ODS's for treatment at the Kommune Kemi plant.
The Århus Genindvinding plant has the capacity to document specific annual quantities of individual substances processed at the plant.

The quantities of treated ODS in 2001:

ODS	Quantity, tonnes
HCFC-22	15.1
CFC-12	7.5
CFC-11	16.1

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

4 Greenhouse gases

4.1 Import of substances

An overall picture of the trends in the import of greenhouse gases is given in Table 4.1, based on information from importers for the years 1987, 1989, 1992, and 1994-2001.

4.1.1 HFCs

HFCs were imported by nine enterprises in 2001, of which five are Danish suppliers and four are user enterprises, importing directly from other EU countries.

The total import (minus re-export) for all HFCs, according to the importers, has fallen from 1,027 tonnes in 2000 to 676 tonnes in 2001. This is a reduction of about 34% compared to 2000.

The import of HFC-134a has fallen from 711.1 tonnes in 2000 to 472.8 tonnes in 2001. In particular it has been possible to ascertain a reduction in consumption by manufacturers of fridges, as there has been a significant reduction in production by one manufacturer.

The import of HFC-152a has been reduced from 16.4 tonnes in 2000 to 11.1 tonnes in 2001.The import of HFC-404a has been reduced from 193.1 tonnes in 2000 to 126.3 tonnes in 2001. The reduction in the consumption of HFC-404a is to a large degree due to lower consumption by commercial refrigerators. It is not possible to explain this development, but it is clear that the refrigerator industry had a lower turnover in 2001 than in the year before. Therefore it can be assumed that there were fewer refillings in 2001 than in 2000.

The import of HFC-407c has been reduced from 44.7 tonnes in 2000 to 40.3 tonnes in 2001. HFC-407c is a substitute refrigerant for HCFC-22 in stationary A/C systems.

The import of other HFCs (HFC-408a, HFC-409a, HFC-410a, HFC-227, HFC-365 and HFC-23) measures 18.4 in 2001 compared with 24.1 tonnes in 2000. The year 2001 is the first year where an import of the new substance HFC-365 has been registered. The import of HFC-365 amounts to approx. 3.5-4 tonnes. HFC-365 has been developed by Solvey as a substitute for HFC-134a and other blowing agents for foam plastics. HFC-227 is often used as a substitute for CFC blowing agents, but the consumption for 2001 has not been ascertained.

The import of HFC-507a has been reduced to 2.2 tonnes in 2001. In 2000 the import totalled 23.9 tonnes. The import of HFC-401a measures 4.1

tonnes and HFC-402a measures 0.8 tonnes. The consumption of these was also relatively small in 2000.

4.1.2 Sulphurhexafluoride

Three importers report imports and sales of 2.7 tonnes of sulphurhexafluoride in 2001. The areas of application concerned are the glass industry, high-voltage plants, and a small amount as trace gas for laboratory purposes. Use of SF_6 in the metal industry was phased out in 2000.

In addition, a supplier of GIS plants (power switches in high-voltage plant) imported 2 tonnes of SF_6 in 2001 from another EU country.

4.1.3 Perfluorinated hydrocarbons

Two importers report imports of mixture products containing perfluorinated substances. The substance in this case is perfluoropropane, C_3F_8, for refrigerant application in commercial refrigerators. Imports of this substance amount to approx. 3.2 tonnes.

One producer reports imports and sales of detergent for electronics, containing approx. 0.5 tonnes of perfluoropropane.

Table 4 Developments in the import of greenhouse gases, tonnes.

Substance	1987	1989	1992	1994	1995	1996	1997	1998	1999	2000	2001
HFC-134a	0	0	20	524	565	740	700	884	644.6	711.1	472.8
HFC-152a	0	0	4	51	47	32	15	14	35.8	16.4	11.1
HFC-401a	-	-	-	-	-	-	-	15	15	9.5	4.1
HFC-402a	-	-	-	-	-	-	-	10	10	4.2	0.8
HFC-404a	0	0	0	36	119	110	110	146	193.7	193.1	126.2
HFC-407c	-	-	-	-	-	-	-	17	40	44.7	40.3
HFC-507a	-	-	-	-	-	-	-	10	10	23.85	2.2
Other HFCs	0	0	0	1	14	20	65	15 [1)]	29.2[1)]	24.14[1)]	18.4[1)]
All HFCs	0	0	24	612	745	902	890	1112	978.3	1026.9	676
Sulphurhexafluoride	n.i.	n.i.	15	21	17	11	13	9	12.1	9	4.7
Perfluorinated hydrocarbons	0	0	0	0	1.5	3	8	6	7.9	6.9	3.7

[1)] The category 'other' includes HFC -408a, -409a, -410a + HFC-365, HFC-23 and HFC-227 (in the emission calculation a worst-case figure is used on the grounds of the GWP value for HFC-410a)
n.i. = no information available
n.e. = not evaluated

4.2 Consumption distributed among application areas

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

Table 4.2 Distribution of HFC consumption shown by application area in 2001, tonnes.

Application area	HFC-134a	HFC-152a	HFC-401a	HFC-402a	HFC-404a	HFC-407c	HFC 507a	HFC-365, 227	Other HFCs
Insulation foam (fridges, freezers etc.)	158.9	0	0	0	0	0	0	0	0
Refrigerant (household and commercial fridges, freezers etc.)	130.1	0	0	0	6.5	0	0	0	0
Refrigerant (commercial stationary refrigerators and A/C systems)[1)]	102.4	0	4.1	0.8	113.7	40.3	2.2	0	11
Transport refrigerators[2)]	2.4	0	0	0	5.9	0		0	0
Refrigerants in mobile A/C [2)]	30.9	0	0	0		0	0	0	0
Other (including aerosol sprays and soft foam)	48	11.1	0	0	0	0	0	7.4	0
Total	472.8	11.1	4.1	0.8	126.2	40.3	2.2	7.4	11

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

2) Danish Refrigeration Installers' Environmental Scheme statistics (KMO), 2001

4.2.1 Consumption of HFC as refrigerant

The general trend in Danish consumption of HFCs for refrigerants is falling in all areas. Refrigerant consumption for production of refrigerators/freezers is falling because of a lower production of appliances based on HFCs. A similar consumption to 2001 is expected in future years. Similarly, there is a falling trend for refrigerant consumption for stationary refrigeration units. Due to new legislation banning construction of new HFC units after 2007, and generally better units, the trend is expected to continue to fall. For use of HFCs in mobile climate equipment there is a clear increase in consumption for refilling mobile equipment.

The consumption distributed according to application area is based on information from producers and importers and on data from the Danish Refrigeration Installers' Environmental Scheme (KMO), which receives

records of the sales of substances from refrigerator installers and automobile garages, and so forth.

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

The consumer figures for refrigerants in commercial and stationary A/C systems, and mobile A/C systems and refrigerators are estimated using data from the Danish Refrigeration Installers' Environmental Scheme (KMO) and import information.

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

Table 4.3 The relative consumption of refrigerants according to refrigerant application, tonnes.

Substance HFC	Fridge/ freezer (commercial & household)	Commercial refrigerators and A/C systems	Mobile A/C systems	Refrigerated vans and lorries	Total	%
-134a	130.2	102.4	30.9	2.4	**265.9**	59%
-401a	-	4.1	-	-	**4.1**	1%
-402a	-	0.8	-	-	**0.8**	0%
-404a	6.5	113.7	-	5.9	**126.2**	27%
-407c	-	40.3	-	-	**40.3**	9%
-507a	-	2.2	-	-	**2.2**	0%
Others	-	16.3	-	-	**16.3**	4%
Total	136.7	279.8	30.9	8.3	**455.7**	100%
	30%	61%	7%	2%		100%

The largest consumption of HFC refrigerant is related to commercial stationary refrigerators, which account for 61% of the total consumption of refrigerants. The second highest consumption is 30% for fridges/freezers and 7% for mobile A/C systems. Refrigerated vans and lorries make up 2% of the consumption (only includes refrigerators on lorries).

The consumption of HFC-134a accounts for 59% of the overall consumption and the consumption of HFC-404a accounts for 27%. This distribution is comparable to that of the previous year.

4.2.2 Consumption of HFC for foam production

There are no significant changes in Danish consumption of HFC for foam production since last year. However, over the past 5 years there has been a significant fall in consumption, partly because there is no longer any production of filler foam in Denmark. In the future it is expected that HFC consumption will fall within all foaming applications. With regard to the use of HFC as a propellant it is assumed that 2002 will be the last year in which HFC-134a is used as a propellant in the production of aerosol containers.

The consumption of HFC-134a utilised in insulation foam in fridges, freezers and similar products amounts to 158.9 tonnes in 2001, which is a reduction compared to 2000. It is only HFC-134a that is used in this type of foam production.

The consumption of HFC-134a and HFC-152a for other purposes, such as soft foam production and for use as a propellant, is approximately the same as the previous year. The consumption of HFC-134a amounts to 48 tonnes in 2001 compared to 50.4 tonnes in 2000.

HFC-152a consumption has fallen from 15.4 tonnes in 2000 to 11.1 tonnes in 2001.

In addition, consumption of HFC-365 and HFC-227 for foam production purposes measures 7.4 tonnes in total. HFC-365 is used as a substitute for HFC-134a and HFC-227 is typically a substitute for CFC. The information forms returned only state the sum total and therefore the calculations in other parts of this report assume a 50/50 consumption of these substances.

4.2.3 Consumption of SF_6

The overall consumption of SF_6 in 2001 was 4.7 tonnes. The distribution of the consumption is shown in the table below.

Table 4.4 Consumption of SF_6 distributed by application area.

Application	Danish consumption, tonnes
Sealed glazing units for window panes	0.16
Power switches in high-voltage plant	4.37
Laboratory purposes	0.2
Total	4.7

4.2.4 Consumption of PFCs

The total consumption of perfluoropropane in 2001 amounts to approx. 3.7 tonnes, of which approx. 3.2 tonnes is used in refrigerant products; perfluoropropane is contained in two different mixture products comprising either 9 % or 39 % (weight) of the product. The remaining approx. 0.5 tonnes of perfluoropropane is employed in detergent for electrical and electronic components.

Other applications of PFCs have not been reported in Denmark.

4.3 Emissions of HFCs, PFCs and SF_6

This section describes the actual emission of the greenhouse gases HFCs, PFCs, and SF_6 for 2001. The determinations are based on the aforementioned reports on consumption of these substances distributed by application areas (section 4.2). In the case of the current product groups adjustments have been made for the import and export of the substances in products.

It should be noted in the emission evaluation that an improvement in last year's basis of determination has been made regarding leakage rates in commercial refrigerators, and mobile A/C systems and refrigerators. The IPCC guidelines recommend that consistency is maintained throughout the period of evaluations when making such changes, i.e. 1990-2020. Thus the subtotals for actual emissions and for the affected application areas contain changes in the historical data.

In the present report the historical emissions are listed in brackets. These are based on determinations employing the old basis of determination.

Appendix 5 shows the leakage rates employed, the Tier method etc, in relation to individual substance and application area. The scheme in Appendix 5 provides an overview of the IPCC methods that have been employed. It also shows the extent to which the IPCC default values and specific default values for Denmark have been used /4, 16/.

4.4 The actual emissions of strong greenhouse gases in 2001

The total actual emission of HFCs, PFCs, and SF_6 in 2001 has been calculated at approx. 699,000 tonnes CO_2 equivalents. The equivalent emission was approx. 793,000 tonnes CO_2 equivalents (818,000 tonnes CO_2 equivalents using the old basis of determination) in 2000, which is equivalent to a total reduction of approx. 94,000 tonnes CO_2 equivalents. This is a reduction of about 13% and this survey is the first time that a reduction can be seen in the actual emission of strong greenhouse gases in Denmark.

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

Table 4.5 GWP contribution from substance groups

Substance group	DK consumption, tonnes	GWP contribution, tonnes
HFCs		646 400
PFCs		22 130
SF_6		30 400
Total		**698 900**

4.4.1 Emissions of HFCs from refrigerants

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

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

The actual emission from these sources occurs in connection with:

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

Release resulting from *disposal* does not count as emission in Denmark since Danish legislation ensures that management and treatment of refrigerants prevents such emissions. The release is defined as the writing-off of stock (the quantity of refrigerant contained in a product).

Table 4.6 shows the emission factors used in the determination of the emission from refrigerants in household and commercial fridges/freezers, commercial stationary refrigerators, and refrigerated vans and lorries.

Table 4.6 Factors in the determination of the emission from refrigerants in household and commercial fridges/freezers, refrigerators, stationary A/C and (transport refrigerators) /4/

	Fridges/freezers	Commercial refrigerators and stationary A/C	Transport refrigerators
Filling	2%	1.5%	0.5%
Operation	1%	10%	17%
Disposal	0%	0%	0%
Lifetime	15 years	15 years	15 years

Commercial refrigerators and stationary A/C systems

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

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

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

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

Table 4.7 shows the actual emission evaluated for specific HFCs. The total emission of all HFCs is given in CO_2 equivalents to take into account the different GWP values of the substances.

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

Table 4.7 Actual emission and GWP contribution from commercial refrigerators 2001 and 2010, tonnes

Source	Substance	Consumption, DK	Stock	Actual emission	GWP contribution 2001	GWP contribution 2010[2)]
Commercial refrigerators and stationary A/C	HFC-134a	102.4	650	62.6	81 300	95 000
	HFC-401a	4.1	39.4	4.5	0.1	0
	HFC-402a	0.8	42	4.7	7 80	2 700
	HFC-404a	113.7	705.7	67.7	220 600	282 500
	HFC-407c	40.3	132.5	10.9	16 60	24 000
	HFC-507a	2.2	43.5	4.6	14 30	6 300
	Other HFCs [1)]	16.3	100.5	9.6	16 60	13 600
	All substances				**357 30**	**424 100**

[1)] The category 'other' includes HFC -408a, -409a, -410a (in the emission calculation a worst-case assumption is used on the grounds of the GWP value for HFC-410a).
[2)] The possible future scenario takes account of the effect of an implemented phasing-out of HFCs and other substances, and the effect of an implemented charge scheme. Conditions relating to the substitution of HCFC-22 with HFC-134a and HFC-404a are also taken into account.

In the projection of emissions in 2010, in which concrete phase out dates are taken into account, as established in the Statutory Order on regulation of certain industrial greenhouse gases, it is estimated that the GWP contribution from commercial refrigerators in 2010 would be approx. 424,100 tonnes.

Fridges/freezers

The actual emission from refrigerants in fridges and freezers is determined on the basis of consumption corrected for import and export of HFCs. The determination assumes that the refrigerant is removed and treated upon disposal so that no emission occurs.

After adjusting for import and export, estimations based on values calculated in /3/ show that export accounts for 50 % of consumption. Only fridges containing HFC-134a are imported/exported. The determination is made on the basis of Denmark's foreign trade statistics of average figures for the amount of HFC-134a in a standard fridge/freezer manufactured in 1999. The statistical background data for this is given in Appendix 2.

In addition, the effect of charges in the reduction in consumption is taken into account in the case of HFC-134a fridges. This is not accounted for in the case of HFC-404a refrigerators because these products are an exception.

Table 4.8 shows the actual emission from fridges/freezers in 2001 and 2010.

Table 4.8 Emission of refrigerants from fridges/freezers 2000 and 2010, tonnes

	2001–134a	2010 -134a	2001–404a	2010 –404a
Consumption	130.1	106	6.5	6.5
Emission during production	2.6	2.1	<1	<1
Export	65.1	53	-	-
Stock	678.4	1 027	64.6	112.3
Emission from stock	6.2	10.1	0.6	1.2
Emission from treatment	0	0	0	0
Actual emission	8.8	12.2	<1	<1.5
GWP contribution, '000 tonnes of CO_2 equivalents	11.5	15.9	2.4	4.3

The total emission of HFC refrigerants from fridges/freezers in 2001 measures 13,900 tonnes CO_2 equivalents. In the projections of the actual emissions a small increase is expected to approx. 20,000 tonnes CO_2 equivalents in 2010.

Mobile A/C

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

The determination has been corrected for import and export of HFC-134a, which is the only HFC imported in A/C systems in cars and trucks. In Denmark filling is only carried out after import. Initial filling is carried out by car manufactures.

The total filling (stock) in Denmark in A/C systems in cars and trucks is determined using statistical information about annual imports and re-exports of cars, vans, and trucks. The statistical figures for imported units are multiplied by an estimated percentage that expresses the proportion of cars and trucks with air conditioning. In 1998 an evaluation was made of the stock for 1998 and the projections since then have accounted for a 20% proportion of cars and a 50% proportion of trucks.

In the present year, this estimate has been revised and the total stock figure has been updated. The conditions employed in the final evaluation are shown in the table below. The conditions have been grouped according to individual statistical categories for types of transport and they represent estimated values based on information from car importers and refrigerator service enterprises.

Table 4.9. Conditions used in the calculation of stock in mobile A/C systems

	Percentage 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 up to 6 t	50%	1.2	50 %
Trucks over 6 t	50%	1.5	40 %

The Danish Automobile Dealers Association (DAF) publishes annual statistics of the number of vehicles in Denmark /17/. This data forms the basis for evaluating the HFC-134a stock in vehicles in Denmark below. Determinations are also provided for the percentage of installed A/C systems that are currently undergoing servicing and are thus refilled with refrigerant upon leakage and other repairs. This forms the basis for determining the amount of refilling of HFC-134a in vehicles in Denmark in 2001.

The results are shown in the table below.

Table 4.10. Determination of Danish stock in mobile A/C systems in 2001 grouped by vehicle type

		2001	Stock, kg	Filling undergoing maintenance	Refrigerant (HFC-134a) refilled in Danish vehicles 2001, tonnes
Cars		1 854 060	139 055	69 527	23.2
Buses		13 968	25 142	5 028	1.7
Vans		335 990	13 440	6 720	2.2
Trucks up to 6 t		4 628	2 777	1388	0.5
Trucks over 6 t		32 975	2 4731	9 892	3.3
TOTAL			**205 145**	**92 556**	**30.9**

The figures shown in the table have been determined using various assumptions, such as the estimated percentage of the various types of vehicles with A/C systems. The total stock of HFC-134a in mobile A/C systems in Denmark has been calculated as 203 tonnes in 2001. This increase is expected to increase further in coming years since there is a continuing trend of more vehicles and new vehicles with more A/C systems. The filled amount of HFC-134a refrigerant in mobile A/C systems in 2001 has been calculated as 30.9 tonnes. This alone accounts for usage in refilling during maintenance of existing systems /16/.

Actual emissions from mobile A/C systems have been calculated on the basis of the following emission factors.

Table 4.11 Emission factors for mobile A/C systems

	Emission factor
Filling	4.5 %
Operation	30 %
Destruction	0 %

The table below shows the actual emissions from mobile A/C systems in Denmark. The table has been prepared on the basis of a steady-state assumption where consumption for refilling in 2010 is assumed to be the same as in 2001. This assumption is very conservative as all signs indicate continued increases in vehicles with A/C systems.

Table 4.12 Calculated emissions of HFC-134a from mobile A/C systems in 2001 and 2010

	2001, tonnes	2010, tonnes
Imported via vehicles	27.8	27.8
Consumption with refilling	30.9	30.9
Total addition to stock	58.7	58.7
Emission from filling	1.4	1.4
Emission from operation of stock	44.8	57.5
Total reduction in stock	46.2	58.9
Stock	205.1	191.5
Actual emission	46.2	58.9
GWP contribution	60 000	76 600

Refrigerated vans and lorries
The evaluation of refrigerated vans and lorries employs the following Danish emission factors, which are based on a study of the servicing of Danish transport refrigerators /17/.

	Emission factor
Filling	0.5 %
Operation	17 % per year
Destruction	0 %

There are an estimated 5,500-6,000 refrigerated vans and lorries in Denmark /16/. These refrigerators require an average filling of approx. 8 kg, equivalent to 44-49 tonnes of refrigerant altogether, either HFC-134a, HFC-404a or HCFC-22. An estimated one third of the refrigerators utilise HCFC-22 and for HFC refrigerators 75 % of the HFC stock consists of HFC-404a. The remaining 25 % use HFC-134a. This results in the following stock distribution for 2000:

- Stock in refrigerated vans and lorries containing HFC-404a = 22-24.5 (23.2 tonnes)
- Stock in refrigerated vans and lorries containing HFC-134a = 7.3-8.1 (7.7 tonnes)
- Stock in refrigerated vans and lorries containing HCFC-22 = 14.6-16.3 (15.5 tonnes)

The actual emission from refrigerated vans and lorries is stated in the table below.

4.4.2 Emission of HFCs from foam plastic products and propellants

The HFC emission determination used for foam plastic products employs two determination principles, depending on the type of product:

1) Hard PUR foam plastics (closed cell)

2) Soft PUR foam plastics (open cell)

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

Table 4.13 Factors in the determination of emission from foam plastic products.

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

Insulating foam

Hard foam plastics produced with HFC-134a are mainly used in insulating foam in fridges/freezers. The emission determinations for insulating foam in fridges/freezers are adjusted for the import and export of fridges /freezers. The determinations are carried out on the basis of 1998 figures for the average quantity contained in fridges/freezers for household use. Based on manufacturer information the average content has been estimated at 240 grams per product, and in 1998 there was a net export of two tonnes of HFC-134a (see Appendix 3).

Usage of HFC-134a in insulating foam in industrial and commercial refrigerators is very limited. Insulating foam for such purposes is usually produced using HCFC-141b.

The actual emission of HFC-134a from insulating foam is summarised in Table 4.12.

Table 4.14 Emission of HFCs from insulating foam, tonnes

	2001 HFC-134a	2010 HFC-134a
Consumption	158.9	0
Emission during production	15.9	0
Export	2	0
Stock	1462	1138
Emission from stock	68.9	89.2
Actual emission	84.8	89.2
GWP contribution, '000 tonnes of CO_2 equivalents	110.2	115.9

In the projections for 2010, it is estimated that the stock will reduce as a result of the phase out of HFC-134a in foam production by 1/1 2006 in compliance with regulations on the phase out of strong greenhouse gases.

Foam polyether

There is only one Danish producer of foam polyether and the firm concerned in this specialised area of production did not wish to provide any information again on their consumption for 2001. Therefore the firm's consumption of HFC-134a in 1999 is taken in their polyether-based shoe production in 2001. The consumption in 1999 was reported as approx. 5 tonnes and the actual emission is estimated at 2.1 tonnes, equivalent to 2,800 tonnes CO_2 equivalents. The determination makes the assumption that no emission is released upon disposal since the gases are destroyed during incineration.

Evaluations from 1998 are used for the export adjustments. In the evaluation it is estimated that 5 % of all shoes with plastic, rubber, or leather soles contain polyether. In 1998 approx. 12.8 million pairs of shoes were exported (Statistics Denmark, Foreign Trade) and it is estimated that a single pair of shoes contains an average of 8 grams HFC-134a. Based on these figures the export is estimated at 0.3 tonnes of HFC-134a.

Joint foam/soft foam/aerosol sprays

The emission of HFCs from joint foam and soft foam (open cell foam) accounts for 100% of the consumption in the year of application /4/. The emission from soft foam occurs during production and it is thus not necessary to correct for import/export.

Joint foam is no longer produced in Denmark, leaving only emissions from imported joint foam products to be accounted for. The determination of joint foam imports is based on previous information made available by the producers /2/. An estimated average of 100 grams of HFC-134a and 25 grams of HFC-152 per can of joint foam is considered reasonable. The emission calculation assumes that the joint foam is used in the same year as the production year.

It is estimated by the producers that in 1998 the amount of imported HFC-based joint foam was equivalent to 10 tonnes of HFC-134a and 1 ton of HFC-152a. This import quantity is also assumed for 2001, following which the consumption will be phased-out. This is equivalent to a GWP contribution from *joint foam* in 2001 of 13,140 tonnes CO_2 equivalents.

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 used in aerosol sprays is equal to the consumption of HFC-based aerosol sprays in Denmark after adjusting for import and export. The total emission from these two areas is 43.1 tonnes of HFC-134a, equivalent to 57,000 tonnes CO_2 equivalents, and 11.1 tonnes of HFC-152a, equivalent to 1,600 tonnes CO_2 equivalents, which is a small decrease compared with 2000.

Medical supplies

Due to marginal emissions the HFC emission from medical supplies has not been evaluated this year.

4.4.3 Emission of sulphur hexafluoride

The total emission of SF_6 in 2001 has been determined at approx. 1.3 tonnes, equivalent to a GWP contribution of approx. 30,400 tonnes CO_2 equivalents. The net consumption was 4.7 tonnes.

The emissions derive from four sources, of which power switches and sealed glazing units for windowpanes are the main sources, contributing approx. 41 % and 34 %.

Sealed glazing units for windowpanes. The emission determination for SF_6 from sealed glazing units for windowpanes has been evaluated using information from producers and industry experts. The emission factors below are employed in the determination. The emission of SF_6 in the life cycle of a sealed glazing units for windowpanes consists of three phases:

- Production, 15% resulting from filling.
- Ongoing release following installation, 1% per year.
- Emission during disposal of windows, equivalent to the remaining quantity of SF_6. Based on an average expected lifetime of 20 years this gives an emission of 66 % during treatment. The determination assumes that the gas is not released from the windows prior to disposal.

The determination of import and export of sealed glazing units for window panes filled with SF_6 takes into account an estimated net export of 50 %.

Table 4.15.Emission of SF_6 from sealed glazing units for windowpanes, tonnes

	2001	2010	2015
Consumption	0.2	0	0
Emission from production	0	0	0
Release from installed sealed glazing units for window panes	0.4	0.4	0.2
Export	0.1	0	0
Emission during disposal	0	0	3.7
Stock	39.9	36.5	18.5
Actual emission	0.4	0.4	3.9
GWP contribution, '000 tonnes CO_2 equivalents	10.2	8.8	94.5

The projections assume that the consumption will be zero in 2003. In subsequent years the emission will rise again due to the start of disposal /substitution of windows with SF_6 thermal glass and in 2015 it is estimated that the GWP contribution from thermal glass will be 94,500 tonnes CO_2 equivalents.

Metal work

Metal workers in Denmark no longer use sulphurhexafluoride in magnesium smelting.

Power switches in high-voltage plant

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

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

- release of 5 % on filling with new gas
- ongoing release of 0.5 % of the stock
- release of 5 % on drawing off and recycling of used gas

No emission is assumed to result from disposal since the used SF_6 is drawn off from the power switches and is either re-used internally by the power enterprise concerned or is re-used externally through means of a collection scheme. The emission resulting from external re-use is determined on the assumption that 0.5 % of the annual stock is sent for external re-use.

Table 4.14 shows the evaluated actual emission from SF_6 power switches.

Table .14 Emission of SF_6 from power switches in high-voltage plant 2000, 2010, and 2015, tonnes

	2001	2010	2015
Consumption	4.4	3	3
Emission during service	0.2	0.15	0.15
Emission from re-use	0.02	0.02	0.03
Emission from stock	0.28	0.4	0.46
Stock	61.2	83.5	95.4
Actual emission	0.50	0.6	0.6
GWP contribution, '000 tonnes of CO_2 equivalents	12.5	13.7	15.2

Laboratories

In 2001 the consumption for laboratory purposes measures 0.2 tonnes and the actual emission amounts to 5,000 tonnes CO_2 equivalents.

Running shoes

Information provided by importers shows that the quantity of SF_6 contained in imported running shoes totals approx. 1 tonne, imported during the period 1990-1998. The emission of SF_6 occurs as a result of the disposal of the shoes. The emission from running shoes in 2001 is estimated at 0.11 tonnes as in previous years, which is equivalent to a GWP contribution of approx. 2,650 tonnes CO_2 equivalents. The consumption of SF_6 for use in running shoes will end in 2003.

4.4.4 Emission of perfluorinated hydrocarbons

The actual emission of perfluoropropane has been calculated at 22,000 tonnes CO_2 equivalents in 2001 and the total consumption measures approx. 3.7 tonnes. Perfluoropropane is the only known perfluorinated hydrocarbon used in Denmark. The emission is released from refrigerants in commercial refrigerators and from cleaning liquids for electronics.

The consumption of perfluoropropane in refrigerants for commercial refrigerators in 2001 was 3.2 tonnes and the stock in commercial refrigerators was evaluated at approx. 26.5 tonnes. The emission in 2001 has been determined as approx. 2.6 tonnes, equivalent to a GWP contribution of 18,500 tonnes of CO_2 equivalents. Since mixture products containing PFC are used in stationary refrigerators adjustments have not been made for the import and export of the substance in products.

The consumption of perfluoropropane in liquid cleaners for electronics has been reported as 0.5 tonnes in 2001 and the actual emission amounts to 3,600 tonnes of CO_2 equivalents.

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/17/ D.A.F prepare statistics of registered vehicles, analysed into various categosries of vehicle. These statistics are updated annaully and used to calculate Danish filling of HFC-134a in vehicles.

Appendix 1

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

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

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

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

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

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

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

Appendix 2

Statistical data for import/export calculations

Table 1. Statistical data concerning import and export calculated as net export of fridges and freezers (commercial + household).

Import/export of fridges/freezers

Key figures, refrigerant + foam:	grams 134a
Fridges/freezers	351
Fridges	305
Chest freezers	404
Freezers	367

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

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

Table 2. Average content of HFC refrigerant in household refrigerators and commercial refrigerators/freezers.

Category	Fridge/freezer	Fridge	Chest freezer	Freezer
HFC-134a	111 g	65 g	164 g	127 g

Table 3. Statistical data on the import and export of cars and trucks.

Air conditioning	Cars	Trucks	In total, tons
Net import, 1998	151 385	26 249	
Proportion with A/C	151 38.5	13 124	
Quantity of HFC 134a, kg	11 353.	16 405	27.8

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

Table 4. Projection, with 30% in 2005

Air conditioning	Cars	Trucks	In total, tons
Net import, 1998	151 385	26 249	
Proportion with A/C	45 415.5	13 124.5	
Quantity of HFC 134a, kg	34 061.625	16 405.625	50.5

Table 5. Projection, with 50% in 2005, cars

Air conditioning	Cars	Trucks	I alt, tons
Net import, 1998	151 385	26 249	
Proportion with A/C	75 692.5	13 124.5	
Quantity of HFC 134a, kg	56 769.375	16 405.625	73.2

Appendix 3

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 to Greenland during the period 1990 to 2001 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
CFC-11	5.5	0.1	4.5	0	2.2	1.6	0	0	2.1	1.9	<0.3	0
CFC-12	6.0	0	0.1	0	0.7	6.7	10.3	0	1.2	0	0	0
CFC-113	-	-	-	-	-	-	-	-	0	0	<0.2	0
CFC-115	-	-	-	31	5.5	0	0	0.2	0.4	0	0	0
All CFCs	13	7	6	31	8	8	10	0.2	3.7	1.9	<0.5	0

Based on the statistics available it was not possible to evaluate the consumption of substances other than those shown in the table, as these are the only substances specified individually. The export substance group “Halogen derivatives of methane, ethane or propane”, which is assumed to contain substances such as HFCs and HCFCs, represented an export to Greenland of 10.1 tonnes in 2001. In 2000 the export was 0 tonnes and in 1999 it was 29.3 tonnes.

There is no information registered on imports of CFCs to Greenland in 2001. In 2000 the import was <0.5 tonnes and in 1999 it was 1.9 tonnes. The import of HCFC-22 cannot be quantified on the basis of information on foreign trade from Statistics Denmark.

The above data does not provide an ODP-weighted consumption for 2001.

Appendix 4

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

The table below shows determined GWP contributions.

The emission projections are determined by starting with a 'steady state' consumption using 2001 as the reference year and employing a series of dates for the phasing-out of specific substances in accordance with the phasing-out process of strong greenhouse gases. A charge effect is also included in the relevant areas of application and expected increases in several application areas are taken into account as much as possible, as are reductions in several of the applications areas.

The calculated GWP contribution expresses the actual emission, corrected for import and export (the latest basis of determination).

Table 1. GWP contribution, '000 tonnes from HFCs, PFCs and SF_6 1993-2020[2]

	HFC-134a	HFC-152a	HFC-404a	HFC-401a	HFC-402	HFC-407c	HFC-507a	Other HFCs	PFCs	SF6	Total per annum
1993	91.5	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	134.6	230.3
1994	131.6	6.4	2.9	0.0	0.1	0.0	0.0	0.0	0.1	122.1	263.2
1995	200.9	6.1	27.3	0.0	1.2	0.0	0.0	0.4	0.9	107.3	344.1
1996	271.6	4.5	88.2	0.0	3.7	0.0	0.0	2.9	2.9	61.0	434.7
1997	244.5	2.1	132.2	0.0	6.6	0.3	0.4	6.0	7.2	73.1	472.5
1998	295.1	1.3	171.7	0.1	7.6	2.5	2.9	8.1	15.0	59.4	563.7
1999	330.8	5.3	231.4	0.1	8.7	5.4	5.7	10.2	19.8	65.4	682.8
2000	353.6	2.3	306.4	0.1	9.5	11.0	8.9	14.1	28.3	59.2	793.3
2001	338.2	1.8	236.8	0.1	9.0	16.6	14.3	29.4	22.1	30.4	698.9
2002	354.0	1.7	253.0	0.1	8.1	21.1	13.6	30.6	21.5	29.1	732.7
2003	361.0	1.6	267.4	0.1	7.1	25.2	12.9	31.3	20.0	28.8	755.4
2004	372.9	1.6	280.4	0.1	6.1	28.8	12.3	31.9	19.2	27.2	780.5
2005	384.7	1.6	292.1	0.1	5.3	31.8	11.5	32.5	18.9	27.4	805.9
2006	329.2	0.1	302.6	0.1	4.7	34.5	10.7	20.2	18.8	27.6	748.5
2007	331.7	0.1	311.2	0.0	4.2	35.6	9.8	20.0	18.6	27.8	759.1
2008	331.4	0.1	314.0	0.0	3.7	31.2	8.0	17.5	18.5	28.1	752.5
2009	318.6	0.1	312.0	0.0	3.3	27.4	7.1	15.5	18.7	28.3	730.9
2010	306.2	0.1	305.0	0.0	2.9	24.0	6.3	13.6	18.8	28.5	705.3
2011	297.1	0.0	268.7	0.0	2.6	20.9	5.6	11.9	18.9	60.8	686.6
2012	266.4	0.0	239.8	0.0	2.3	18.1	5.0	10.4	19.0	106.9	668.0
2013	252.4	0.0	215.2	0.0	2.1	15.6	4.4	9.0	19.1	116.9	634.8
2014	209.4	0.0	183.4	0.0	1.8	13.3	3.9	7.8	19.2	129.4	568.3
2015	188.0	0.0	142.5	0.0	1.6	12.0	3.5	7.0	19.3	114.7	488.7
2016	161.4	0.0	101.7	0.0	1.5	10.8	3.2	6.3	19.4	87.0	391.2
2017	144.8	0.0	78.5	0.0	1.3	9.7	2.8	5.7	19.4	72.1	334.5
2018	129.8	0.0	59.3	0.0	1.2	8.8	2.6	5.1	19.5	102.0	328.3
2019	116.1	0.0	43.4	0.0	1.1	7.9	2.3	4.6	19.5	71.3	266.2
2020	103.3	0.0	30.2	0.0	1.0	7.1	2.1	4.2	19.6	50.8	218.2
Total	**7 215.9**	**41.3**	**5197.2**	**0.9**	**108.2**	**419.6**	**159.8**	**356.4**	**462.5**	**1877.1**	**15 838.9**

[2] In light of new knowledge, the determinations of the GWP contributions have been altered in relation to last year's evaluation /13/.

Appendix 5

Specification of methods and assumptions for 2001 determination of GWP emissions in accordance with *IPCC Good Practise Guidance and Uncertainty Management in National Greenhouse Gas Inventory*

ID	Source	Substance	Method	Emission factor	Remarks	Projection assumptions
	EMISSION OF SUBSTITUTES FOR OZONE-DEPLETING SUBSTANCES (ODS-SUBSTITUTES)					
	Refrigerant					
K1	Household fridges and freezers	HFC-134a	Top-down Tier 2 approach: - information on refrigerant consumption provided by reports from the main producers of household fridges and freezers in DK, accounting for an estimated 95 % of the market at least. Bottom-up Tier 2 approach: - information on import and export of refrigerants in products based on the average quantity contained per unit and Danish statistics.	2 % release on filling (IPCC default) 1 % release from stock per year (IPCC default) Lifetime = 15 years (IPCC default) 0 % release upon disposal (DK default). Up to and including 2000, the quantity remaining upon disposal was included as emission (IPCC default). Legislation in Denmark ensures drawing-off of refrigerant, and consequently the IPCC default is misleading in the Danish context.	Stock determined in 1998 for the period 1990-1998 based on information from Danish producers and estimates based on import/export statistics and average quantity of HFC contained in refrigerant and foam per unit (source: consumption and emissions 1998, Danish Environmental Protection Agency). For the updating of stock import/export data from 1998 is used, as well as information on annual HFC consumption among Danish producers. 1998 import/export data is equal to net export of 1.6 tons of HFC-134a in foam (note: Denmark's largest exporter does not use HFC in foam.	From 2001 the net export of refrigerant in household fridges is assumed to account for 50 % 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% in the period 2001-2005

					Therefore the export of HFC in foam is less than the export of refrigerant).	
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, HFC others, PFCs (C_3F_8)	Top-down Tier 2 approach: - information on refrigerant consumption provided by importers/suppliers of refrigerants to commercial refrigerators in Denmark - information on distribution of refrigerant consumption at different sites is estimated using information from user enterprises, the the KMO and estimates from suppliers	1.5 % release on filling (DK default) 10 % release from operation and accident (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 the sales and import.	In 2001/2002 an assessment was made of the national Danish leakage rate from commercial plant. The work was conducted by COWI for the Danish Environmental Protection Agency. The results have lead to a decrease in the evaluated leakage rates for filling, operation and disposal in compliance with IPCC guidelines (Source: reassessment of emissions from commercial refrigerators, Danish Environmental Protection Agency, 2002).	From 2007 the consumption of refrigerant is accounted for entirely by the amount needed for refilling of existing stock. It is assumed that the consumption of refrigerant for refilling of stock will be reduced by 15 % in 2007 and will then diminish by 5 % per year until 2014. From 2015 the consumption is assumed to account for only 10 % per year.
	Fridge transporters	HFC-134a, HFC-404a	Top down Tier 2 approach - information on refrigerant consumption in rrefridgerated vans and lorries is based on consumption information from fridge transporting enterprises and data from the KMO	0.5 % release on filling (DK default) 17 % release from operation annually (DK default, same as IPCC) 2% release from re-use (DK default) Lifetime 6-8 years 0 % upon destruction; all refrigerant is drawn off and is either recycled or destroyed at the Kommune Kemi plant	In 2001/2002 an assessment was made of the national Danish leakage rate from refridgerated vans and lorries. The study was conducted by COWI for the Danish Environmental Protection Agency. The results have lead to a decrease in the evaluated leakage rates for filling and disposal in compliance with IPCC guidelines. The leakage rate during operation remains at 17%, the same the stated in the IPCC guidelines (Source:	Charge effect not accounted for since refridgerated vans and lorries are exempt. Stock is defined as 7.7 tons of HFC-134a and 23.2 tons of HFC-404a in 2000 (Source: reassessment of EF for mobile plant…, Danish environmental Protection Agency). Consumption is projected as steady state for 2001

					reassessment of emissions from mobile A/C and refridgerated vans and lorries).	
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 import. Top-down approach used for gathering of consumption data from importers to refilling of mobile A/C systems.	0.5 % on refilling (DK default) 33 % annual release per during operation (complete refilling every third year) (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 % release on destruction. Gas is collected and re-used/cleaned, or treated at Kommune Kemi (DK default). The emission is calculated as 1/3 of stock from the previous year (n-1). This means the stock is the crucial determination parameter. The stock is calculated using DAF annual statistics in relation to a number of conditions defined in (source: reassessment of emission factors from mobile A/C and transporter refrigerators. Consumption per annum gives the quantity used in refilling of units which undergo servicing (max. 50% of existing units).	In 2001/2002 an assessment was made of the national Danish leakage rate from mobile A/C. The work was carried out by COWI for the Danish Environmental Protection Agency. The results have lead to a slight increase in the evaluated leakage rate from operation and a decrease from filling and disposal in accordance with IPCC guidelines (Source: reassessment of emissions from mobile A/C and refridgerated vans and lorries). The stock figures are updated using statistics on vehicles in Denmark from the Danish green consumer organisation Active Consumers (DAF). The average expected stock for cars and vans is 750 gms, 1.2 kg for trucks under 6 tons, 1.5 kg trucks over 6 tons, and 9 kg for buses. For information on other evaluation conditions see (Source: reassessment of emissions from mobile A/C and refridgerated vans and lorries).	The projection is based on a steady state stock (203 tons).

	Foaming processes					
S1	Foam in household fridges and freezers (closed cells)	HFC-134a	Top down + bottom up Tier 2 approach: - information on foam blowing agents is derived from reports provided by the main producers of household fridges/freezers in Denmark, thought to represent at least 95 % of the market.	10 % release during foaming processes (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 emission (DK default).	HFC stock contained in foam is defined for the period 1990-1998 using information about consumption from Danish producers and estimates based on import/export statistics and the average quantity of HFC in refrigerants and foam per unit (Source: consumption and emissions 1998, Danish Environmental Protection Agency). The stock figures are updated using import/export statistics from 1998 and information on annual HFC consumption among Danish producers. Import/export figures for 1998: 141 tons net export of HFC-134a in refrigerants and 1.6 tons net export of HFC-134a in foam (note: Denmark's largest exporter does not use HFC for foaming processes. Consequently the export of HFC in foam is less than in the export of refrigerants).	
S2	Soft foam (open cells)	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	Emission = 100 % of the HFC quantity sold in the sold in the current (IPCC default)		

			thought to represent approx. 80 % of the Danish soft foam consumption.			
S3	Joint filler (open cells)	HFC-134a HFC-152a	Tier 2, top down approach. - There are no longer any Danish producers of joint filler employing HFC as a foam blowing agent. Emissions are due to previous estimates by producers of imported joint filler products.	Emission = 100 % of imported quantity contained in joint filler in the current year (IPCC default).	The estimated import in 1998 by a joint filler producer was 10 tons of HFC-134a and 1 ton of HFC-152a. This estimate was based on the assumption that there is an average of 100 gms of HFC-134a and 25 gms of HFC-152a per tin of joint filler imported.	
	Foaming of polyether (for shoe soles)	HFC-134a HFC-152a	Top down Tier 2 approach Information regarding consumption is identical to the consumption reported by producer in 1999 + an estimate of import/export of HFC in shoe soles, 1998. Bottom up Tier 2 approach: - Import of HFC contained in shoes is based on the average amount per shoe and on Danish statistics.	Emission (Danish default): - Production = 15 % - Use = 4.5 % - Lifetime = 3 years - Disposal = 71.5 %, destroyed in incineration and thereby is not released as emission.	The determination of the HFC stock in shoe soles is based on the following conditions: it is assumed that 5% of all shoes with plastic, rubber and leather soles contain polyether holding 8 gms of HFC-134a per shoe. The net export with the same consumption in Danish production is 0.3 tons of HFC-134a.	
	Aerosols					
	Aerosol sprays (industrial products)	HFC-134a	Tier 2. - information on propellant consumption is derived from reports on consumption from the only major producers of HFC-containing aerosol sprays in Denmark. It is estimated that these producers account for 100 % of the market.	Emission = 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 import/export are based on the producer's assessment of imports equivalent to 20 % of Danish production in the current year. The export is quantified by the producer.	
	MDI (Metered Dose Inhalers)	HFC-134a	Tier 2, bottom up approach - consumption was studied in 1999 and was			Due to minimal emissions this class of products is no longer

			evaluated as minimal.			included in Denmark's national inventory.
	Solvents					
R1	Liquid cleaners	PFC (C_3F_8 Perfluoropropane)	Tier 2. - information on consumption of PFC in liquid cleaners is derived from sales reports of two importers. This information is estimated to cover 100 % of Danish consumption of PFC in liquid cleaners.	Emission = 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 Undergoing phase-out starting 1/9 2002. It is assumed that the consumption is equally distributed over all months.
	EMISSIONS OF SF_6 FROM ELECTRICAL EQUIPMENT AND OTHER SOURCES					
	Insulating gas in thermal windows	SF_6	Tier 2 - information on consumption of SF_6 in thermal windows is derived from importers' sales reports to the application area. The importers account for 100 % of the Danish sales of SF_6 for thermal windows. 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 thermal windows - 1 % per year during the lifetime of the window - Lifetime = 20 years - Disposable - 66 % of the filled content of a window in the production year. - Net export = 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 (source: consumption and emissions 1998, Danish Environmental Protection Agency). The stock is determined on the basis of consumption information provided by importers back to 1990. The first Danish consumption was registered in 1991. In the projection of emissions it is assumed that the consumption of SF_6 in Danish window production will be

						phased out by 2003. Hereafter the only emissions will be those released from stock.
	Insulating glass and 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 sales reports from importers of gas or products containing gas. The importers account for 100 % of the Danish sales of SF_6. The power and electricity sector also provide information the installation of new plant and thus whether the stock increases.	Emission (DK default): - release on filling = 5 % - release during operation = 0.5 % per year - release from re-use/drawing-off = 5 %. - release from disposal = 0 %		There is one supplier (Siemens) that imports its own gas for filling in Denmark. Suppliers (AAB, Siemens, Alstom) report on new installations. The stock in 2000 was 57.6 tons 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 (source: Collection and recycling of SF_6 from high-voltage plant, Danish Environmental Protection Agency, 2000).
	Shock absorbing gas in Nike Air running footwear	SF_6	Tier 2 - top-down approach. Importer has estimated import to Denmark of SF_6 in running shoes.	Emission (DK default): - release from use and disposal = 100 % of filled amount - Lifetime of running shoes = 5 years		Importer/wholesaler reports that the import for the period 1990-1998 amounts to approx. 1 ton, equivalent to an emission of 0.11 tons per year in the period 1995-2003. For the period 1999-2005 the

						importer estimates the import at approx. one third of this, equivalent to 0.037 tons per year for the period 2004-2010.