

Reduction of the emissions
of HFC's, PFC's and SF₆ in
the European Union

Final report

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FOREWORD

Herewith we present the report on the reduction options of the emissions of HFC's, PFC's and SF₆ in the European Union. This report is a revised version of the report of October 1998. In this Revised Version, recent comments from industry and DG XI have been taken into account. In this revised report also reference is being made to emission projections given in a recent report for the European Commission (DG III) by March Consulting Group (September 1998).

Main focus of the study is the description of potential reduction measures of HFC's, PFC's and SF₆ in the European Union. It aims at giving a framework to deal with emission reduction options in a structured way. Given the relatively small size of the study, only preliminary emission estimates, emission projections and breakdowns could be given. Despite this preliminary character some robust conclusions can already be drawn on some of the reduction options.

The work for this study was mainly carried out in the first half of 1998. In the meantime, more information has become available. We are grateful for the useful comments provided for the update of the report. Other comments concerning the data in this study and the white spots that we inevitably left, are welcome and can be a useful input for follow-up research that is under way at present.

The authors

SUMMARY

Background

Within the activities to develop the Commission' Communication on a Post-Kyoto Climate Strategy analysis is made to identify the least-cost package of specific policies and measures for meeting the Community's proposed quantitative reduction for 6 (groups of) greenhouse gases under the Kyoto Protocol for the period 2008-2012. Work is already in progress for 3 of the 6 gases (CO₂, CH₄ and N₂O). This needs to be complemented by an analysis of the costs of options to reduce emissions of the remaining group of 3 gases (HFC's, PFC's and SF₆, hereafter also indicated as "halogenated gases") to identify cost-effective and effective policies.

Aim of this study

The aim of this work is to make a preliminary assessment of the options and costs of controlling the three gases HFC's, PFC's and SF₆ as well as the barriers for implementing reduction policies for these gases.

This report provides a first estimate of the development of the EU wide use and emissions of HFC's, PFC's and SF₆ in 2005 and 2010 (compared to 1990/1995) with existing (current) national and Community policies, presents existing estimates of the (capital and operating) costs and associated emission reductions (in 2010) of options to control HFC, PFC and SF₆ emissions in the EU 15, and identifies and elaborates on the barriers for implementing the identified emission reduction options.

Emission sources

In this study the following emission sources are distinguished:

Table 1 Emission sources

HFC	PFC	SF ₆
<ul style="list-style-type: none"> • HFC production/ handling • HCFC-22 production • Refrigeration (Industrial, Commercial, Transport, Households, Stationary airco, Heat pumps) • Mobile airco • Foam • Solvents • Aerosols, Fire extinguishing, Other 	<ul style="list-style-type: none"> • Primary aluminium production • Semiconductor manufacturing • Other 	<ul style="list-style-type: none"> • Electricity distribution • Magnesium production • Semiconductor manufacturing • Noise isolating windows • Tyres • Other

Process emissions are responsible for a large part of emissions in countries locating these production processes: HFC-23 emissions during HCFC-22 production, PFC emissions from primary aluminium production, SF₆ emissions from magnesium production

In the future, other emission sources become relatively more important, due to achieved emission reduction in those production processes on the one hand, and increasing demand for certain applications on the other (c.f. stationary and mobile airco, specific applications for SF₆).

Emission data supplied by member states

Within the framework of the setting of the Community targets for the extra greenhouse gases resulting from the Kyoto protocol, emission estimates and projections on halogenated gases have been collected from Member States and discussed during the Expert Group meeting of February 24, 1998.

Table 2 gives emission estimates based on these reported data from member states. *Note that the emission data in this table give a preliminary breakdown based on a number of assumptions. Further improvement of these estimates is necessary.*

Some remarks should be made with regard to these estimates.

First, so far no national data have been collected from Greece, Ireland, Luxembourg, Portugal and Spain. Other countries like Austria, Belgium and Denmark do not (or only partly) give emission projections for the years 2000 and 2010.

Second, comparability of data is insufficient. Most countries, among them Austria, Belgium and Finland report *potential* emissions, referring to emissions that could occur if all halocarbons used were emitted into the atmosphere. Other countries provide *actual* emissions, differing from potential emissions because there may be a time lag between use and emission and emission could be avoided by emission prevention. Countries reporting partly actual emissions are Germany (actual emissions for 1990/1995, potential for 2000/2010) and The Netherlands. There are several methodologies for estimating actual emissions (see for example RIVM 1995, app. 5-1). Within the scope of this study it is not possible to go into more detail concerning these methodologies and resulting emission estimates. Here only ranges in emission projections are presented.

Another aspect of comparability is whether emission projections refer to the situation with or without control. For example, scenario's for the years 2000 and 2010 for The Netherlands do not include (additional) emission control. On the other hand, Germany reports scenario's with measures.

Third, there are several uncertainties concerning the emission data. It is not clear whether national reported data include all possible emission sources (for example certain specific applications of PFC and SF₆) and to what extent these gases are used in those applications.

Also projections concerning future emissions and availability of reduction measures probably differ among countries. Besides, different mixes of HFC's with different average GWP values are assumed.

Table 2 Preliminary emission data set for cost calculations, emission projections for 2010, EU-15, Mt CO₂-equivalents (business as usual)

Total halogenated gases¹⁾ 2010: 82 Mt		
HFC's²⁾ 2010: 65 Mt	PFC's 2010: 5 Mt	SF₆ 2010: 12 Mt
<i>HCFC-22 production</i> 2010: 10 Mt <i>Refrigeration</i> 2010: 25 Mt <i>of which:³⁾</i> Industrial: 1 Mt Commercial: 11 Mt Transport: 3 Mt Stationary airco: 1 Mt Mobile airco: 8 Mt Households: 0.2 Mt <i>Foam</i> 2010: 25 Mt ⁵⁾ <i>Other</i> 2010: 5 Mt ⁶⁾	<i>Aluminium production</i> 2010: 5 Mt <i>Other</i> 2010: pm	<i>Electricity distribution</i> 2010: 6 Mt <i>Other⁴⁾</i> 2010: 6 Mt

- 1) Source: Expert Group 1998a. First country comments included (Expert Group 1998b).
- 2) Conservative (low) estimate of HFC emissions per emission source deducted from the emission ranges in table 2.1, par. 2.2.
- 3) Own preliminary estimation of distribution emissions refrigeration, based on emission rates per application and estimations of numbers of installations.
- 4) Assumption: of which 3 Mt related to noise isolating windows.
- 5) Emissions might be lower as it could be argued that emissions from the foam bank will not yet have reached this level in the year 2010.
- 6) This should be considered as a minimum figure.

Abatement options HFC's, PFC's, SF₆

The report gives an inventory of abatement options, cost and emission reduction potentials, for all emission sources distinguished in table 1.

These abatement options are ranked by type of technology, using the following categories:

- A. Reduction and prevention of leakage during use (by better installations/materials, preventive maintenance) and during installation, maintenance, refill
- B. Recycling/reuse of discarded agents
- C. Application of alternative agents
- D. Development of modified (components of) installations, using less or no HFC's, PFC's, SF₆
- E. Miscellaneous (e.g. incineration)

Table 3 summarises the abatement options, reduction potentials and cost. Note that this table gives typical figures but that in fact (wider) ranges are possible depending on size of equipment and local circumstances. Note that the effects on energy cost and energy-related CO₂-emissions are **not** included in the figures in this table.

Total abatement cost

In table 4 total abatement cost for the EU-15 are summarised. Two variants have been indicated: i) maximum use of alternatives and ii) maximum leakage reduction. Where results for those variants differ - and that is mainly the case within refrigeration - cost and emission reduction of both variants have been indicated (i/ii). Table 0.3 shows that maximum substitution of HFC's by alternatives results in higher reduction and lower cost than in case of maximum leakage control.

If measures above 100 ECU/tonne CO₂-eq. are excluded (for commercial refrigeration and stationary airco), total abatement cost will be 1000/3400 mln ECU and emission reduction 62/58 Mt CO₂-eq.

Table 4 Summary of total abatement cost estimate for 2010, EU-15

	Cost (mln ECU)	Reduction (Mt)
HFC	4200/5500	63/48
PFC	24	4
SF ₆	8	7
Total	4200/5500	74/69

This first rough estimate of total abatement cost and emission reduction for the EU-15 in 2010 shows that with maximum application of abatement measures mentioned in this report an emission reduction of about 85% of total emissions in EU 15 for these three gases together can be reached for about 5000 mln ECU.

Considering the measures included in this report, HFC reduction accounts for 85% of emission reduction and 99% of abatement cost. Also relative cost are largest for HFC emission reduction, with average abatement cost of 60-90 ECU/t CO₂-eq. (or 20 ECU/t CO₂-eq. when measures > 100 ECU/ t CO₂-eq. are excluded). For PFC and SF₆ average abatement cost are about 1 - 6 ECU/t CO₂-eq.

Conclusions

It should be noted that these results have a preliminary character and that further elaboration is necessary. However some conclusions may be drawn at this stage:

- There is a substantial potential for reducing emissions of HFC's, PFC's and SF₆.
- There are a number of low-cost options, including emission reduction at HCFC-22 manufacturing (HFC-23 incineration) and at primary aluminium production (process modifications) and leakage reduction and recycling of SF₆.

Recommendations

Further development of the emission data set and check of by national experts of emissions per application is needed. Differences in data and methodologies between countries should be identified. Furthermore, more data on measures and cost are needed to complete and check the information currently available. A workshop with main stake holders and experts may accelerate the information gathering (and reviewing) process.

This report can be considered as a basis for further elaboration in the directions mentioned above. With a more detailed and consistent emission data set for EU-15 countries and with further completed and differentiated cost data, these first rough cost estimates can be refined.

Table 3 Marginal cost and reduction potentials abatement options

Source	Measure	Marginal emission reduction	Estimated emissions EU-15 in 2010 (Mt CO ₂ -eq.)	Maximum reduction potential EU-15 (Mt CO ₂ -eq.)	Marginal cost (ECU/t CO ₂ -eq.)			
					< 0	0 - 50	50 - 100	>100
HFC								
HCFC-22 production	Incineration	90%	10	9		0.40		
Refrigeration general	Recycling	?	25	?		2		
Industrial refrigeration	Leakage reduction	67%	1	0.67		16		
	Alternatives	100%	1	1			50	
	Process modifications		1			?		
Commercial refrigeration	Leakage reduction	80%	11	8.8				170
	Alternatives	100%	11	11				200
	Process modifications	90%	11	9.9				110
Transport refrigeration	Leakage reduction	80%	3	2.4			70	
	Alternatives	100%	3	3			70	
Stationary airco	Alternatives	100%	1	1				1000
Household refrigeration	Recollection	100%	0.2	0.2				150
Mobile airco	Alternatives	100%	8	8		25		
Solvents, other	Process optimisations	100%	5	5		0-100		
Foam	Alternatives	100%	25	25		?		

Source	Measure	Marginal emission reduction	Estimated emissions EU-15 in 2010 (Mt CO ₂ -eq.)	Maximum reduction potential EU-15 (Mt CO ₂ -eq.)	Marginal cost (ECU/t CO ₂ -eq.)			
					< 0	0 - 50	50 - 100	> 100
PFC								
Aluminium production:	Process modifications	85%	5	4.3		5.6		
Semiconductor industry	Alternatives, process optimisations	100%	pm			?		
SF₆								
High (and mid) voltage switches	Leakage reduction modifications	90%	6	5.4		1		
	Recycling	100%	6	6		0.04		
Magnesium production	Leakage red., alternatives, process mod.	90%	pm			?		
Semiconductor industry	Process modifications	100%	3	3		0-100		
Tyres	Alternatives	100%	pm			0		
Windows	Leakage reduction	50%	3	1.5		2		
	Recycling	75%	3	2.3		0.04		
All substances								
Other/new uses	pm							