Final Report
on the

European Climate Change Programme
Working Group Industry
Work Item Fluorinated Gases

Prepared on behalf of the
European Commission (DG ENV and DG ENTR)

by

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Content

1 Context, Conclusions and Recommendations

1.1 Context and Objectives

This report was produced under the European Climate Change Programme (ECCP). The purpose of the ECCP was to identify and to develop elements of a European climate change strategy that are necessary for the implementation of the Kyoto Protocol, as a basis for consideration of political decisions.
The objective of the Working Group on fluorinated gases under the ECCP was to develop the basis for a framework of an EU-policy to reduce emissions of the fluorinated greenhouse gases addressed by the Kyoto Protocol (HFCs, PFCs and SF_6) in a cost-effective way.
In line with the ECCP, **specific objectives** of the Working Group on fluorinated gases were:

- Identification of the most relevant applications that should be subject to common and co-ordinated policies of the European Community,
- Elaboration of a proposal for cost-effective instruments for each of the investigated applications.

The activities of ECCP Working Group on fluorinated gases were preceded by a stakeholder workshop on fluorinated gases, which was held in February 2000 in Luxembourg. At this workshop the approach was to identify and understand the broad variety of applications of fluorinated gases, which lead to emissions. It provided an appropriate basis for the agenda and the work of this Working Group.

The group of experts involved in the ECCP Working Group on fluorinated gases comprised about 10 permanent and 110 "revolving" participants from Industry, Environmental NGOs, Academia, Consultancy, Member States and the Commission. The majority of the 110 revolving participants represented the various sectors of industry. The large make up of the group reflects the variety and complexity of the different sectors relevant for fluorinated gas emissions. Technical expertise from each of the sectors has been proven necessary to address different sectors of fluorinated gases according to their own characteristics. Due to the high number of specialists from industry, the focus of the discussions was to seek consensus on the various technical options for emission reduction. Under the work programme of the group, all major sectors accountable for emissions of fluorinated gases have been covered in 9 full-day meetings between June 2000 and April 2001.

On behalf of the Commission and the Dutch Ministry of Environment (VROM) consultants from ECOFYS and ENVIROS have facilitated the process in proposing speakers, drafting agendas and minutes, providing information to stakeholders, and drafting the interim and final report. Stakeholders provided a wealth of factual information and position papers on policies and measures. All submitted papers are annexed to this report[1].

This final report summarises the Working Group's findings in a structured way. It builds on the interim report, which was sent out for discussion and review by the participants of the group in November 2000. Suggestions received from stakeholders have been carefully evaluated and were incorporated wherever possible.

This final report is also intended to serve as a reference document for future policy preparation by the Commission and other stakeholders. The main findings and recommendations of this report will be fed into the general report on the ECCP. In its forthcoming Communication to the Council and the Parliament, the Commission will outline the key elements of the European Union's greenhouse gas emission mitigation strategy in consideration of the ECCP-process.

It is worth reporting that the ECCP Working Group on fluorinated gases has made major advances in the discussion of opportunities to reduce emissions of fluorinated gases. At the previous international workshops held in Petten[2] in 1999 and in Luxembourg[3] in 2000 there were massive differences of opinion between different stakeholders leading to heated debates. Whilst there were still differences of opinion shown in the ECCP Working Group on fluorinated gases it was clear that a more constructive spirit evolved and strong consensus was reached in a number of areas.

To assist the ECCP-process, representatives of eleven Member States met for an informal workshop in Utrecht on the invitation of the Netherlands Government to enlarge their common view on a framework for fluorinated gases. At this meeting a four-tier approach was recommended:

- a Council statement on the future of fluorinated gases in the context of European Climate Change Policy to send a clear political signal to producers and consumers of fluorinated gases in the EU;
- a (framework) Directive on fluorinated gases, to be completed by national implementation measures;
- a call for specified voluntary actions by sectors in which regulation is not yet feasible and voluntary actions are considered as an appropriate instrument;
- Member State actions to continue existing or develop new national policies and measures

The participants at the Utrecht workshop emphasised that the different national burden sharing targets would not keep them from agreeing an appropriate joint approach to

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[1] The annexes containing all position papers are published as separate documents.

[2] Joint IPCC/TEAP Expert Meeting on Options for the Limitation of Emissions of HFCs and PFCs; Petten - 26-28 May 1999.

[3] Joining European Efforts to Limit Emissions of HFCs, PFCs and SF6; Member State Workshop - Luxembourg; February 1-2, 2000.

address fluorinated gases. However, they underlined that this joint approach should not exclude continuing existing and/or developing policies and measures to abate fluorinated gases emissions as part of the national burden-sharing target. Within the ECCP-Working-Group one of the main barriers that prevented further consensus was a great lack of reliable technical and economic data. This made it sometimes difficult to establish robust recommendations that all stakeholders could agree to. Another important issue was the possible conflict between policy measures that could be set at an EU level and those that could be set by Member States. This latter issue needs to be addressed further in preparation of any policy measures on fluorinated gases by the competent authorities on Member State and Community level.

The rest of this chapter presents the conclusions and recommendations of the Working Group on fluorinated gases. The general conclusions are set out in Section 1.2. In Section 1.3 the overall recommendations for policies that could be implemented at the EU level are presented. Section 1.4 provides recommendations in relation to specific market segments in which fluorinated gases are used.

1.2. General Conclusions

Overall Potential for Emission Reduction

Participants broadly agreed with the consultants' estimates that fluorinated gases contributed about 2% (64 MT CO_2 eq.) of overall EC greenhouse gas emissions in 1995. Views on the likely future evolution of these emissions levels varied but fell into the range of 2-4% of total emissions by 2010. The group agreed that this potential growth warrants specific action from regulators and industry to limit emissions of fluorinated gases.

As set out in further detail in chapter 2 and 4 of this report, it was clearly established that there is significant potential for the reduction of emissions of fluorinated gases from business as usual scenarios in most markets segments. It was recognised by the group that there have already been noticeable emission reductions in certain market segments.

Characteristics of Emission Sources

Emissions of fluorinated gases emanate from a wide range of sources in markets with very different characteristics. At one extreme, a handful of factories produce a significant percentage of EU emissions of fluorinated gases as a by-product of a manufacturing process (e.g. 10 plants making HCFC 22 and 21 plants smelting aluminium). At the other extreme, products containing fluorinated gases are used by millions of consumers (e.g. medical and technical aerosols, domestic refrigerators, car air-conditioning). There was a strong consensus that it is necessary to take account of these widely varying market and use conditions when making policies to reduce emissions from particular sources.

Techniques for Emission Reduction

The techniques for emission reduction can be categorised into four main areas:

a) Improved containment of fluorinated gases during the life cycle of equipment (manufacture, use and decommissioning)

b) Use of alternative fluids with a zero/low global warming potential (GWP)

c) Use of not-in-kind (NIK) technologies

d) Process modifications to avoid by-product formation or emission

Cost Effectiveness of Measures

The cost effectiveness of individual emission reduction measures varies considerably (for details see chapter 2.2). The following general findings were made:

- Very few of the measures for an emission reduction of fluorinated gases have the excellent cost effectiveness exhibited by certain energy related CO_2 reductions (i.e. emission reduction combined with cost savings).
- Many measures have good or reasonable cost effectiveness in the range of €1 to €50 per tonne CO_2 saved. It is estimated that some 30 MT CO_2 eq. per year can be reduced at less than €20 per tonne CO_2 eq. and another 20 MT CO_2 eq. per year at less than €50 per tonne of CO_2 eq.
- Some measures are much more costly, in the range of €100 to €500 per ton, and would not necessarily be the best use of resources in the first commitment period.

Confidence in Making Robust Policies

For some measures there was sufficient information available to generate a strong consensus among the Working Group to support clear recommendations for regulatory action on Community or Member State level. This particularly refers to containment opportunities of fluorinated gases, but also includes other techniques such as destruction of HFC-23 from HCFC-22 plants and elimination of certain uses of SF_6 in applications such as double-glazing and car tyres.

For other measures it was not possible to reach consensus, either because of insufficient information or because of opposing views. It became clear in the process of the Working Group that a comprehensive policy on emission reduction of fluorinated gases cannot be developed in one go. In many areas technological developments as regards the use of fluorinated gases are rapidly progressing. In various cases it was considered more appropriate to work with “soft” policy measures such as voluntary action from industry than to set stringent regulatory rules now. This was, for example, the case as regards the use of alternative fluids, where there are complex interactions that must be evaluated between parameters such as capital cost, safety, product effectiveness and energy use. However, there was a strong consensus that development of such alternatives should be vigorously encouraged in the hope that any doubts about the technical or economic effectiveness could be eliminated at some future date.

Energy Issues

It was agreed that, in certain markets, the influence of energy usage is a very important factor in selecting the best technologies to reduce emissions of fluorinated gases. If policy makers ignored the energy issue it could lead to counterproductive legislation that encourages technologies with lower emissions of fluorinated gases but higher overall greenhouse gas emissions. While the Working Group on fluorinated gases and the ECCP Working Group on energy efficiency were unable to evaluate these issues in sufficient detail to fully understand the interactions, the subgroup underlined the importance to take account of energy efficiency aspects when devising policies on fluorinated gases. In line with the Total Equivalent Warming Impact (TEWI) principles, both direct emissions and indirect CO_2 emissions related to energy usage need to be fully considered.

Monitoring and Verification of Emissions

It was agreed that current levels of monitoring and verification of emissions of fluorinated gases are insufficient and that it will be important to improve this situation if we are to effectively measure the progress of any policies to reduce emissions of fluorinated gases.

Policy Measures

As described in detail in chapter 3 and 4, the Working Group reviewed a wide range of policy instruments that could be used to reduce emissions of fluorinated gases. These included legislative measures, fiscal measures and voluntary/negotiated agreements. There was consensus that it would be necessary to implement a policy mix comprising a number of different policy instruments and measures in order to take account of:

- The enormous differences between the characteristics of the 30+ market segments.
- The large number of existing and planned measures of industries and on Member State level that are already part of the programmes being put in place in various Member States.
- The necessity to find a balance, within the limits set by the European Treaty, between the requirements of the internal market and international trade obligations and the freedom needed by Member States to accomplish their reduction targets under the Kyoto Protocol.

Existing Legislation

The Working Group was mindful of the fact that some existing or planned legislation at EU level should be used as a vehicle to deliver emission reductions of fluorinated gases.

Fiscal Measures

Although some stakeholders favoured the use of fiscal mechanisms such as taxation, there was no consensus on this issue. It was considered very difficult to implement a tax mechanism at the EU level. Some stakeholders advocated further investigations on this subject. One Member State informed that it had decided to apply fiscal measures in order to reduce the use of fluorinated gases.

Use Restrictions on Specific Applications of Fluorinated Gases

There was a general lack of consensus in the group over restricting the use of fluorinated gases in specific applications, with the exception of a small range of uses such as SF_6 in car tyres, training shoes and double glazing and the use of HFC aerosols for certain novelty products.

1.3 General Recommendations

In this section we summarise the general recommendations that could influence all or many sources of emissions of fluorinated gases. In the following section (1.4) recommendations concerning specific sectors are set out.

Recommendation 1: Make a clear statement on the importance of reducing fluorinated gas emissions

The Working Group agreed that there is significant potential to reduce fluorinated gas emissions from all sources. It is recommended that a clear political statement be made to ensure that all reasonable efforts to reduce emissions are undertaken.

Recommendation 2: Establish a regulatory framework in a "Community Directive on Fluorinated Gases"

A key recommendation of the Working Group is the elaboration and adoption of a "Community Directive on Fluorinated Gases". The key objectives of such a Directive would be:

Improved monitoring and verification of emissions of fluorinated gases. The Directive should ensure that significant improvements are made to the coverage and accuracy of emissions monitoring within the EU. The Directive should prescribe reporting obligations in a way which would enable accurate estimates of emissions from each major market segment to be established at both Member State and EU levels. The information gathered should be consistent with other obligations on reporting to other international organs (such as UNFCCC).

- **Improved containment of fluorinated gases.** The Directive should ensure that when fluorinated gases are used in products and equipment that all practicable measures are taken to minimise emissions during equipment manufacture, equipment life and at end of life. To the extent practicable, the Directive should place obligations on manufacturers, users and maintainers of equipment to achieve defined standards of performance in relation to emissions. Legislation of this type already exists on Member State level; for example the Netherlands refrigerant leakage regulations was considered by the Working Group as an important reference.

- **Marketing and use restrictions in certain applications.** The Directive (or the Community chemicals legislation) could be used to ban the use of fluorinated gases in a certain number of applications such as car tyres, double-glazing and potentially certain novelty aerosols.

The group suggested that in a number of matters (e.g. monitoring) the Directive should build on requirements and instruments created under the EC Regulation 2037/2000 on Ozone Depleting Substances.

The Working Group agreed that the primary objectives described above are best addressed via legislation at EU level. The Directive could address other issues as well, although there was less consensus about the content and scope of such provisions. In particular, it was discussed whether the Directive could provide some guidance about substitution of fluorinated gases by the use of alternative fluids and about addressing the energy efficiency issue.

However, there was general agreement that these issues were more difficult to tackle than the primary objectives and it might be more practical to concentrate on the early adoption of a Directive that successfully deals with the primary objectives.

Recommendation 3: Use existing or planned EU legislation to the extent possible for the reduction of fluorinated gases

The Commission should ensure that the findings of the ECCP on emissions of fluorinated gases are fully considered in the preparation or revision of certain pieces of EU legislation. Member States should consider recommendations of the Working Group when implementing the Directives. In particular:

- The working group noted that policies should not delay the phase-out of ozone depleting substances as mandated by the EC Regulation 2037/2000. Industry emphasises in particular, that HFCs must remain available in those applications in which they are the only technically and economically viable option.
- The IPPC Directive should minimise emissions of fluorinated gases from HCFC-22 manufacture, aluminium smelting and magnesium smelting.
- The Waste Electric and Electronic Equipment (WEEE) Directive after proper national implementation should ensure that a maximum fraction of charged HFCs is recovered from all domestic equipment such as refrigerators and freezers.
- The End of Life Vehicle Directive after proper national implementation should ensure that a maximum fraction of charged HFCs is recovered from mobile air conditioning.

Recommendation 4: Examine the appropriateness of selected voluntary agreements, primarily in the semi-conductor, switchgear and foam sectors.

In a number of sectors voluntary and/or negotiated agreements are considered to be an appropriate policy instrument, although preferably with a clear link to the recommended

Community Directive on Fluorinated Gases. It is envisaged that such agreements might be used in one of three ways:

- In some markets they could provide the primary policy mechanism to achieve emission reductions (e.g. semi-conductor industry).
- In some markets they could be used to support one or more of the other measures being implemented. (Voluntary action undertaken by the switchgear industry was found to be very suitable to support such a policy mix).
- They could be used as a temporary measure to make progress in areas of rapid technological change, where there is currently insufficient data to include specific measures in the proposed Community Directive on Fluorinated Gases (e.g. in the case of rigid foams).

A large number of stakeholders emphasised that voluntary commitments should not be a 'stand-alone-instrument'. They should be embedded in a legal framework or linked to other instruments to address non-fulfilment.

Recommendation 5: Carry out integrated, independent assessments of relevant technologies in order to facilitate a comparison between the use of fluorinated gases and alternatives

In some situations it has been difficult for the Working Group to reach robust conclusions because of either:

- A general lack of reliable information about an issue or a technology.
- A dispute over the accuracy or validity of information.

The Working Group therefore recommends that integrated assessments of relevant technologies be carried out.

These assessments should facilitate a comparison between the use of HFCs and alternatives in selected key applications. They should cover the environmental effects over the full lifecycle especially energy consumption and greenhouse gas emissions, safety issues, and the technical and economic performance. These assessments should be periodically updated. Standard methods for the assessment of energy efficiency in key applications should be developed.

Policy measures could include the creation of funding sources for further research and development and for investigation of uncertainties (such as the relative energy efficiency of different technical solutions).

Recommendation 6: Promote the Development and Appropriate Use of Alternative Fluids and Not in Kind (NIK) technologies

It was agreed within the Working Group that in many markets sectors the use of alternative fluids and NIK technologies could be the best long-term way of reducing direct emissions of fluorinated gases. However, it was also understood that a number of barriers and uncertainties make it difficult for such alternatives to be developed commercially. These uncertainties have also made it difficult for the Working Group to include definitive recommendations regarding alternatives in the proposed Directive.

The Working Group recommended that active steps be taken to maximise the appropriate uptake of alternative fluids and NIK technologies. Specific policy measures should be based on a 2-stage approach:

- Firstly, the use of ”soft” mechanisms including voluntary agreements and active EC/Member States support to ensure that development of alternatives continues. Through this process it is expected that the acceptability and cost effectiveness might be improved. Improved information dissemination and market-based initiatives should be supported to promote the commercial availability of such alternatives.
- Secondly, regular reviews of progress in each market sector should be made. If appropriate, this would lead to the use of harder mechanisms (such as inclusion in revised versions of the EC-Directive if there is more robust evidence that is the correct way to proceed.

1.4 Sector Specific Recommendations

In this section we review individual sectors and highlight selected Working Group recommendations. The background is given in chapter 4 of this report, which discusses the situation in each of the sectors.

Refrigeration and Stationary Air Conditioning

It is strongly recommended that this market sector be part of the Community Directive on Fluorinated Gases to address all containment and monitoring/verification issues.

Efforts should be made to promote the use of alternative fluids and NIK systems when they are a practical and economically viable solution.

Improved energy efficiency can provide significant levels of CO_2 emission reduction and could be addressed by means of voluntary agreements.

Mobile Air-Conditioning

Many issues are similar to the refrigeration and stationary air-conditioning market. Emissions monitoring and containment should be addressed via the recommended Community Directive on Fluorinated Gases.

The development of new technologies for mobile air conditioning systems should be supported.

Technical Aerosols

An emissions monitoring and verification system should be established via the recommended Community Directive on Fluorinated Gases.

The development of not-in-kind technologies to replace HFC propelled technical aerosols should be supported.

Restrictions on the use of HFCs in certain “non-critical” product applications could be considered.

Metered Dosed Inhalers (MDIs)

Monitoring should be addressed via the recommended Community Directive on Fluorinated Gases.
The possibility of a voluntary agreement with MDI manufacturers should be explored, including losses during production and recovery from reject MDIs.

Solvents

Emissions monitoring and containment should be addressed via the recommended Community Directive on Fluorinated Gases.

Fire-Fighting

Monitoring and containment should be addressed via the recommended Community Directive on Fluorinated Gases.

The possibility of a voluntary agreement with the fire-fighting industry should be explored.

Use of SF_6 in Windows, Tyres

Use restrictions for SF_6 in these applications should be issued either on the national or the European level.

Aluminium Production

Voluntary action by the aluminium industry has already created a monitoring system.
The group recommends an expeditious national implementation of the “Best Available Techniques” according to the BREF notes related to the IPPC-Directive.

Semiconductor Industry

Voluntary action by the semiconductor industry has already created a monitoring system.
The group recommended that the Commission give some formal recognition to the joint emission reduction commitment (Memorandum of Agreement) of the European Electronic Component Manufacturers Association (EECA) and the European Semiconductor Industry Association (ESIA).

By-Product Emissions of HFC 23 from HCFC 22 Manufacture

An emissions monitoring and verification system should be established via the recommended Community Directive on Fluorinated Gases.

Because of the magnitude of emissions from this source, the group strongly recommends accelerated voluntary action by the industry or national legislation by the affected Member States (potentially linked to the IPPC-Directive).

Magnesium Production and Die Casting

Emissions monitoring should be addressed via the recommended Community Directive on Fluorinated Gases.

For large scale operations the IPPC Directive could be used to help minimise SF_6 emissions.

For smaller operations, particularly those involved in die-casting, the viability of alternative cover gases needs to be explored.

Production and Use of SF_6 Switchgear

Voluntary action by the switchgear industry has already created a monitoring system and set standards for the handling and recycling of SF_6. It is recommended that the Commission consider the appropriateness of giving some formal recognition to this voluntary action. A link should be considered between the proposed regulatory framework with voluntary action in this sector.

Rigid Foams (XPS, PU and Phenolics)

It was agreed that it would be premature to recommend specific policies and measures on the European level in addition to some general use principles and provisions on the monitoring of HFC usage and emissions.

A voluntary commitment was proposed by the industry. Most participants welcomed the initiative and recommended a closer evaluation of the proposal and a reflection on ways of linking it to the recommended Community Directive on Fluorinated Gases.

One Component Foams

It was agreed that manufacturers should aim to minimise the mean global warming potential of its propellants. Opportunities for a voluntary agreement with this industry should be explored. Additional efforts need to be made to assess safety hazards associated with the use of flammable propellants.

Emissions monitoring can be addressed via the recommended Community Directive on Fluorinated Gases.

2 Emissions and Reduction Potentials

For setting priorities for European action a number of factors related to emission scenarios need to be taken into account. These comprise the absolute magnitude of projected emission for 2010, the associated reduction potential below a certain cost threshold, and the relative growth compared to 1995 levels.

It is worth noting that in most applications the expected rapid rise of emissions of fluorinated gases is the result of a transition away from ozone-depleting substances (mainly CFCs and HCFCs) by means of replacement substances (mainly HFCs).

2.1 Emissions

In Figures 1 it is presented how emissions[4] are estimated to evolve per sector between 1995 and 2010. These estimates were derived in the following way: the authors of this report started with the results of the respective EU studies (March, 1998; March, 1999; Ecofys, 2000). According to their expert judgement - also taking into account information presented during the ECCP process - they independently estimated what they thought would be the likely range of emissions per source in 1995 and in a reference scenario for 2010.

This reference scenario takes into account existing technological trends, and includes policies and measures already implemented[5] or under implementation[6]. It does not include any additional policies and measures discussed in this report. The values for 1995 and 2010 were calculated as average values of both experts' best estimates. The uncertainty bars included in Figure 2 in an aggregated form indicate the range of uncertainty estimated by the authors for each of the sectors.

It is important to note that all of these results are indicative and not based on new research. Estimates are based on recent studies (March, 1998; March, 1999; Ecofys, 2000) and additional information, which became available during the ECCP process.

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[4] Throughout this text emissions are quoted as million metric tonnes of CO_2 equivalents (MT CO_2 eq.) calculated according to the rules laid down in the Kyoto-Protocol.

[5] For example: The installation and operation of thermal oxidation systems in six out of ten EU plants for the manufacture of HCFC-22 is already included in the reference scenario.

[6] Considerable uncertainties of such reference scenarios result as a consequence of differing expert views about technological trends (e.g. what would be the appropriate emission factor for mobile air conditioning in 2010).

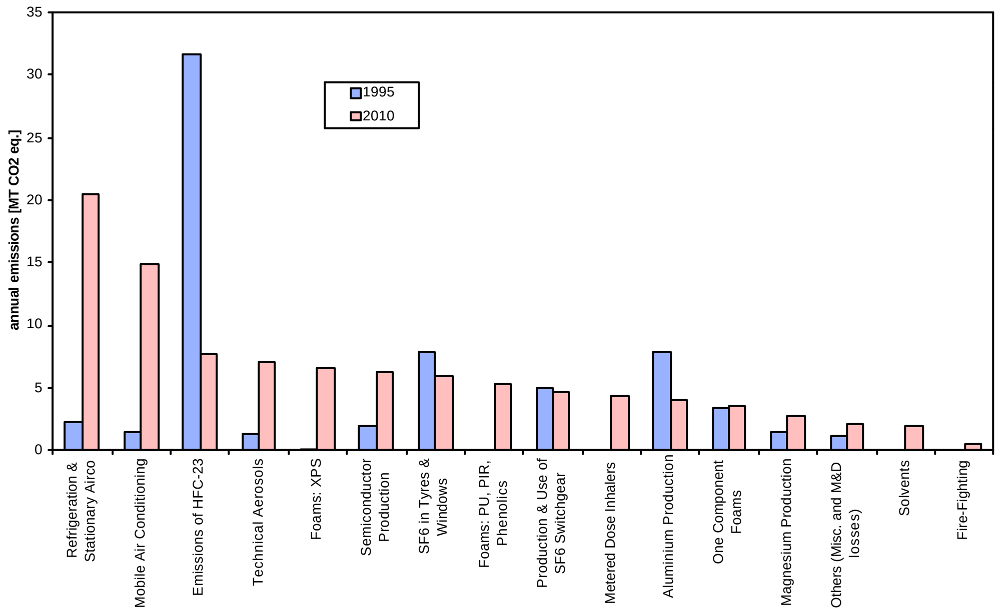

Figure 1 EU-15: Ranking of different sources[7] according to projected reference emissions of HFCs, PFC and SF_6 in 2010 in comparison to emissions in 1995.

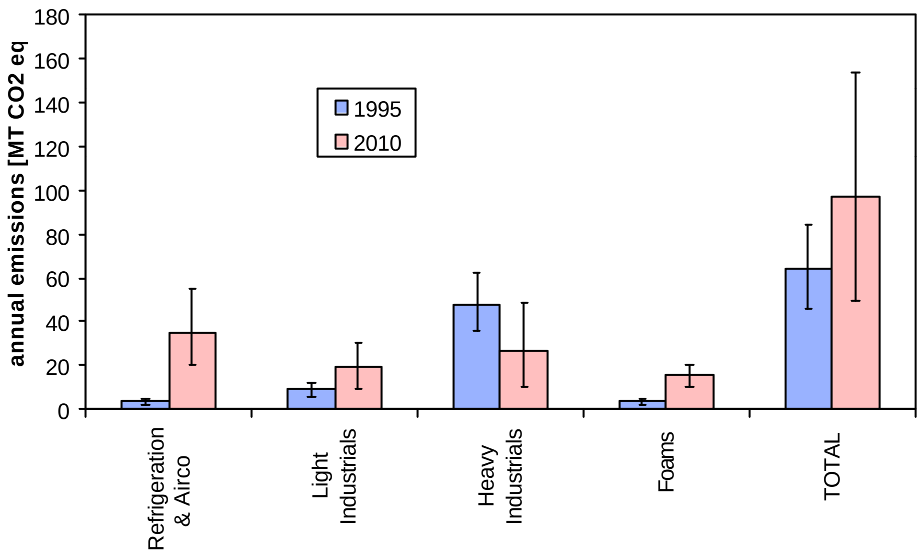

Figure 2 EU-15: Emissions of HFCs, PFC and SF_6 from different groups of sources in 1995 and projected for 2010 including uncertainty bands (see text above for details). Aggregated according to the different sessions of the ECCP process.

[7] Please refer to Table 1 and paragraph 4.3 of this report for further information on projected emissions from technical aerosols in 2010.

2.2 Reduction Potentials

As pointed out above and discussed in greater detail in VROM [2000b], there are considerable uncertainties regarding emission baseline scenarios for 2010. Estimates of reduction potentials associated with different technological options have been reported by March [1998, 1999] and Ecofys [2000] within the framework of their respective baseline scenarios. It is currently difficult to precisely quantify emission reduction potentials associated with most of the proposed policies and measures. The reduction potentials reported here refer to the best estimate of projected emissions for the year 2010 (see above) and were also calculated as mean values of both experts' independent estimates.
It is important to note that for a number of reasons it is particularly problematic to quantify reduction potentials:

- High and uncertain future growth rates of activities (e.g. Mobile Air Conditioning, Semiconductors, Magnesium).
- Base year emission levels already exhibit fairly large uncertainties.
- Technical practices vary considerably across Member States.
- A regulated transition is taking place away from ozone depleting substances (e.g. Refrigeration and Air Conditioning, Foams, Aerosols, Solvents, Fire-Fighting). Induced technological change due to this phase out of ozone depleting substances has made available a large portfolio of alternative options of similar technological performance. It is difficult to predict which options the markets, will select, also with regards to a minimisation of the system impact on the environment.
- The impact on energy efficiency connected to policies and measures to limit emissions of fluorinated gases carefully need to be taken into account.

In Table 2 and graphically in Figure 3, the authors present their joint estimates of technological reduction potentials for EU-15 in 2010 relative to their reference scenario.

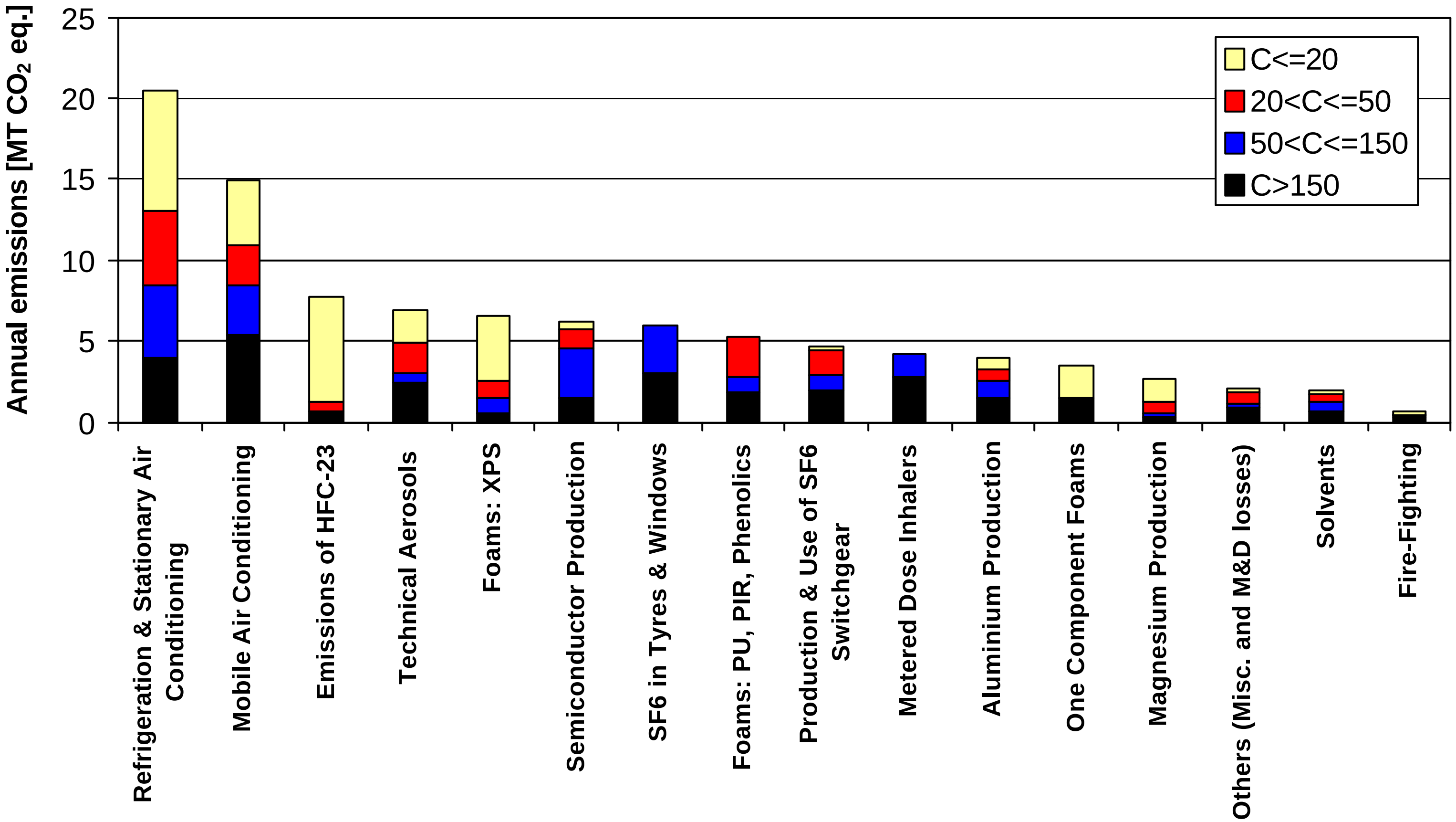

Figure 3 EU-15: Projected emissions of fluorinated gases for 2010 presented for each source as sum of reduction potentials[8] in different cost [C] intervals. Costs are reported as Euros(1999) per ton of CO_2 equivalent. Ranked by the magnitude of projected emissions in 2010.

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[8] Please refer to Table 1 and paragraph 4.3 of this report for further information on projected emissions from technical aerosols in 2010.

Table 1 EU-15: Emissions of fluorinated gases per sector estimated for 1995 and projected for 2010 with associated reduction potential per cost (C in Euros(1999) per ton of CO_2 eq.) interval – provisional estimates by R. Gluckman and J. Harnisch.

	Emissions [MT CO_2 eq./ year]		**Reduction Potential in 2010 [MT CO_2 eq./ year]**		
	1995	**2010**	**C <= €20**	**€20 < C <= €50**	**€50 < C <= €150**
Refrigeration & Stat. Air Conditioning	2.3	20.5	7.5	4.5	4.5
Mobile Air Conditioning	1.4	14.9	4.0	2.5	3.0
Emissions of HFC-23	31.6	7.7	6.5	0.5	0.0
Foams: XPS	0.1	6.6	4.0	1.0	1.0
Semiconductor Production	1.9	6.3	0.5	1.3	3.0
SF_6 in Tyres & Windows[9]	7.9	6.0	0.0	0.0	3.0
Foams: PU, PIR, Phenolics	0.0	5.3	0.0	2.5	1.0
Technical Aerosols	1.3	5.1 // 7.0[10]	2.0	2.0	0.5
Production & Use of SF_6 switchgear	5.0	4.7	0.5	1.5	1.0
Metered Dose Inhalers	0.0	4.3	0.0	0.0	1.5
Aluminium Production	7.8	4.0	0.8	0.8	1.0
One Component Foams	3.3	3.5	2.0	0.0	0.0
Magnesium Production	1.5	2.7	1.5	0.6	0.3
Others (Misc. and M&D losses)	1.1	2.1	0.3	0.8	0.3
Solvents	0.0	2.0	0.3	0.5	0.5
Fire-Fighting	0.0	0.5	0.2	0.1	0.1
TOTAL	**65.2**	**96.2 // 98.1**[10]	**30.1**	**18.6**	**20.7**

[9] Assuming that the use of SF_6 in tyres and in new windows is phased-out by 2003. Remaining emissions from installed windows will be difficult to reduce.
[10] 5.1 MT based on FEA (2000), 7.0 MT based on [March 1998] – compare chapter 4.3

3. Overview of Policy Instruments

3.1 Introduction

In this section we review the discussions about general policy instruments that could be applied to many of the market segments for fluorinated gases. Sector specific characteristics and policy instruments are discussed in Section 4.

Because of the diverse and complex nature of the various market segments for fluorinated gases it was agreed by the Working Group that a mixture of policy instruments would be required.

3.2 Policies to Improve Monitoring and Verification of Emissions

At a number of Working Group meetings it became apparent few market sectors or Member States have developed robust systems to monitor emissions. It was noted that the reporting obligations[11] under the UN Framework Convention on Climate Changes are currently not always fully met. Table 1 summarises the situation in the relevant market sectors.

It was also observed that the lack of information on import and export of products containing fluorinated gases adds uncertainty to national inventories.

The Working Group agreed that good data on emissions would be essential if the EU is to develop appropriate and effective policy measures to reduce emissions. This requirement applies to all market sectors. Requirements necessary for verifying implementation of any emission reduction policy would however have to be more detailed than that required by the reporting to UNFCC.

There was support that the best way to improve the available data on emissions would be to place legal obligations on key stakeholders to provide relevant data to Member State authorities. It was also agreed that the design of such legal obligations should minimise the administrative burden for those involved.

[11] Using the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories" and the "IPCC Report on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories"

Table 2 Existence of monitoring systems in different market sectors

SECTOR	MONITORING SYSTEM
Refrigeration & Stationary Air Conditioning	not existing*
Mobile Air Conditioning	not existing*
Technical Aerosols	being set up by FEA for the consumption of HFCs
Metered Dose Inhalers	not existing
Solvents	not existing
Fire-Fighting	not existing
SF_6 in Tyres & Windows	not existing
Aluminium Production	operated by EEA
Semiconductor Production	operated by EECA
Emissions of HFC-23	operated by EFCTC
Magnesium Production	not existing
Production & Use of SF_6 switchgear	being set up by CAPIEL / EURELECTRIC
Foams: PU, PIR, Phenolics	not existing
Foams: XPS	not existing
One Component Foams	not existing
Others (Misc. and M&D losses)	not existing

* Monitoring systems exist for systems with more than 3 kg of refrigerant in at least one Member State

3.3 Policies to Improve Containment of Fluorinated Gases

There was strong consensus that one of the most cost effective and practical ways of reducing emissions in a significant number of market sectors was improved containment during the three key stages of product life i.e.:

- Product manufacturing
- Product life
- Product disposal.

Policy measures that would improve containment in one or more of these stages would have an impact on the majority of market sectors using fluorinated gases. For many markets (such as refrigeration and gas insulated switchgear), improvements could be expected in all three of these stages. For certain "intrinsically emissive" markets (such as MDIs and technical aerosols) the impact of improved containment would be much more limited although could still be of some value (e.g. policies to ensure recovery of HFCs from used aerosols).

A number of policy instruments could be used to address containment including taxation of fluids, deposit systems, leakage regulations and voluntary agreements. There was some discussion of the advantages and disadvantages that could arise from the use of each individual instrument, and some agreement that several of the instruments, for example tax and deposit schemes, could cause practical difficulties and may not be the most effective way for ward. There was however strong consensus that the best way to proceed would be through an EU Directive that would set minimum standards for containment and that could include requirements for regular inspection and training.

The EU Regulation on ozone depleting substances (EC 2073/2000) already addresses containment of CFCs and HCFCs, but gives no legal requirements in relation to HFCs, PFCs and SF_6 (which all have a zero ODP). The Netherlands STEK system provides a wide ranging and detailed legal framework for reduction of emissions from refrigeration systems. It was agreed that legislation of this type could be developed to ensure considerably improved standards of fluorinated gas containment throughout the EU. National differences should be taken into account, as several Member States already have taken measures in this direction.

As well as addressing the 3 key stages of product life, as described above, regulations could also address a minimum technical qualification for technicians handling fluorinated gases. This training should be carried out sector specific.

3.4 Policies to Promote Alternative Technologies

In many markets fluids with zero or very low GWP are available as alternatives to the high GWP fluorinated gases (for example: HCs or ammonia used as refrigerants; CO_2 used as a blowing agent for XPS foam; SO_2 used as a cover gas in magnesium smelting). In some markets NIK (not in kind) technologies are available to replace technologies that use fluorinated gases (for example: aqueous cleaning to replace solvents; non-foam materials for use as insulants).

It was agreed within the Working Group that in many market sectors the use of alternative fluids and NIK technologies would be the best long-term way of reducing direct emissions of fluorinated gases. However, this was an area in which lack of robust data has made it difficult for the Working Group to reach consensus about the detail of policy options. Even where alternative fluids and technologies are commercially available, the following factors make development of clear policies difficult:

- Safety issues related to either product manufacture or product use.
- Product performance.
- Energy efficiency and hence indirect CO_2 emissions.
- Cost effectiveness of alternatives.
- Member State Regulations (e.g. different fire protection standards).

The development of new policies requires that these factors will be taken into account.

Some stakeholders believed that market forces would determine the uptake of alternative fluids or NIK technologies. Other stakeholders favoured strong measures such as legislation or taxation to force technology change towards these alternatives. There was no consensus on the best way forward. The majority of members of the Working Group favoured a two-stage approach as follows:

a) The use of "soft" mechanisms including voluntary agreements and active EC / Member State support to ensure that development and increased use of alternatives continues. Through this process it is expected that the cost effectiveness of alternatives might be improved and there would be considerably better understanding of the issues listed above.

b) Regular reviews to monitor and take stock of the progress and the effectiveness of political actions in each market sector with the possibility of use of "harder" mechanisms (such as inclusion in an EC Directive) once there is more robust evidence that this is the correct way to proceed.

3.5 Policies to Restrict the Use of Fluorinated Gases in Certain Applications

The Working Group discussed whether use restrictions of fluorinated gases would be appropriate. There was no agreement about broad use-bans of the type being applied in the EU to implement the Montreal Protocol for ozone depleting substances. Many Working Group members felt that such policy measures would have detrimental effects including:

- Causing a slow down in the phase out of ozone depleting substances (because of a lack of confidence in some of the most obvious alternatives).
- Unjustified financial burden, compared to other technical options for the achievement of Kyoto targets.
- Increase in overall greenhouse gas emissions because of inappropriate use of technologies with low energy efficiency.

However, there was consensus amongst the Working Group that it would be possible to implement a number of specific use restrictions in markets where there are perfectly acceptable alternatives or where the use was considered frivolous and hence unnecessary.

3.6 Policies to Improve Energy Efficiency

In some markets, especially refrigeration, air-conditioning and insulating foams there can be a strong interaction between direct and indirect emissions. Certain alternative fluids or NIK technologies lead to a reduction in direct emissions of fluorinated gases but, in some circumstances there could be an increase in indirect CO_2 emissions because of increased energy consumption. An example of this is a closed cell insulating foam manufactured using a blowing agent with inferior insulation properties, used where the foam thickness cannot be increased.

The Working Group strongly supported the need to avoid counterproductive results of policies that only address the direct emissions. It was agreed that policies in relevant markets must take into account TEWI principles to ensure that the sum of both direct and indirect emissions is minimised.

Whilst there was strong consensus that energy efficiency is very important there was less clarity about the best policy measures to use. Other ECCP Working Groups have addressed the energy efficiency issue in general terms.

Setting legal standards for energy efficiency at this stage would be very difficult because of a lack of detailed data about the enormous range of potential applications. Whilst this is the case in most markets there is good data available in a few. In the domestic refrigeration market energy labelling has been a legal requirement in the EU for some years. This has led to a clear understanding of the range of efficiencies currently on the market. The logical next step has already been taken and legislation ensures that the least efficient grades of equipment are now banned from sale.

As with discussions on use of alternatives, the majority of members of the Working Group favoured a two-stage approach as follows:

a) The use of voluntary agreements, energy efficiency labelling and active EC / Member State support to ensure that efforts are made to improve energy efficiency of products containing fluorinated gases or their alternatives. Through this process it is expected that standards and benchmarks for optimum efficiency in different market applications could be developed.

b) Regular reviews of progress in each market sector with the possibility of use of "harder" mechanisms (such as inclusion in an EC Directive) when robust efficiency standards are available – as has occurred with domestic refrigerators.

3.7 Policies to Reduce Emissions from Large Point Sources

Most of the measures described in paragraphs above are best suited for fluorinated gas emissions from "mass" markets such as refrigeration, foams, fire fighting, aerosols etc. A significant proportion of fluorinated gas emissions come from large point sources. In particular this refers to:

- HFC 23 from HCFC 22 manufacture.
- PFC emissions from aluminium smelting.
- SF_6 emissions from large scale magnesium smelting.

Such markets deserve specific policies. The Working Group agreed that the 2 best policy mechanisms for consideration are voluntary agreements and links to the EU IPPC Directive.

3.8 Voluntary Agreements in Specific Sectors

A number of stakeholders remarked that legislation is often perceived as a slow and fairly inflexible approach to environmental problems. Voluntary actions, voluntary agreements and negotiated agreements were brought forward as potentially fast, flexible and more effective responses to start addressing the long-term issue of climate change. The Working Group has discussed the pro and cons of this approach in a number of sessions on different sectors.

Provided such markets have a strong EU-wide sector trade association the Working Group supported the development of voluntary approaches that would provide challenging emission reduction targets. The group stressed that apart from ambitious targets, a transparent monitoring system and provisions for the case of non-fulfilment are essential for the success of a voluntary agreement. A majority of stakeholders emphasised that voluntary commitments are not a 'stand-alone-instrument', and that they should be embedded in a legal framework or linked to other instruments in case of non-fulfilment.

3.9 Economic Instruments

In one of its sessions the Working Group discussed economic instruments such as taxation and deposit systems. Views on the feasibility of these measures varied widely within the Working Group ranging from strong rejection to strong support. No consensus was achieved except for the point that currently the impact of such instruments cannot be quantified, that significant practical and political problems exist and that significant further thinking would be required in preparation of such instruments at EU level.

It was also noted that such economic instruments would be a reserved matter for either Member States or ECOFIN

3.10 Caps on Fluid Production or Sales

Among stakeholders diverse views prevailed regarding the instrument of caps. Support to caps depend on their level, their specificity to sectors, their dynamics and their political function (i.e. function of a safety ceiling or as a handle for phase outs). Caps on production and consumption are part of the phase-out strategy of the Montreal Protocol on Ozone Depleting Substances. The environmental NGOs and alternative industries have repeatedly proposed the use of these instruments to also control emissions of HFCs, PFCs and SF_6. A number of stakeholders rejected these concepts as not in line with the concept of a market economy. Others remarked that at some point in the future caps could become acceptable if, and only if, these caps would in return guarantee the availability of fluorinated gases. Some were of the view that such measures should first be introduced at international level to ensure an even playing field.

3.11 Information Dissemination

The group agreed in a number of sessions that information dissemination may play an important role in achieving emission reductions. Quite frequently key players are not fully aware of all technological options and their environmental performance. Member States and the Commission could play a more active role in making available information on the environmental performance of new technologies. The group did not have the time to discuss this point in any depth.

4 Sector Specific Results

This chapter presents the meeting results structured in a uniform format. Information was complemented by results from a number of recent studies and reports [March, 1998; March, 1999; Ecofys, 1999; Öko-Recherche, 1999; Ecofys, 2000; and the Background Documents to the Luxembourg Workshop VROM, 2000a-c].

4.1 Refrigeration and Stationary Air Conditioning

The Sector

A very large and complex sector:

- Numerous application areas ranging from small domestic systems to very large industrial and air-conditioning systems.
- Each application area has different characteristics in terms of technologies used and market structure.
- Historical dominance of ozone-depleting refrigerants, especially CFCs and HCFCs. Following CFC and HCFC phase-out, HFCs have become key replacements in many refrigeration and air conditioning applications.
- Relatively fragmented industry with numerous equipment manufacturers, installation contractors, service operations etc.

Emissions

- Zero emissions of HFCs and PFCs prior to 1990.
- Emissions in 1995 estimated at around 2 MT CO_2 eq. This was 3% of total 1995 emissions of fluorinated gases from the EU.
- Business as usual scenario for 2010 indicates a growth in emissions to around 19 MT CO_2 eq. This will be 17% of total 2010 emissions of fluorinated gases from the EU.
- Indirect emissions of CO_2 from refrigeration systems are considerably higher than these emissions of fluorinated gases. Estimated to be around 130 MT CO_2 eq. in 2010.

Controlling Factors

Because of the complex nature of the refrigeration and stationary air-conditioning sector there are numerous factors that influence rates of emission. Leakage rates vary considerably between different application areas and, across the EU, within single application areas. There are widely varying standards of refrigerant recovery during servicing and at end of life. Energy efficiency of systems varies considerably.

Monitoring and Verification

With the exception of Sweden, Denmark and Netherlands currently no formalised procedures are in place for the regular monitoring and verification of refrigerant emissions.

Reduction Options

There are numerous ways in which greenhouse gas emissions can be reduced from the business as usual scenario estimate. Key opportunities include:

- Reduced leakage from equipment during operational life.
- Improved recovery from equipment during servicing and at end of life.
- Use of alternative refrigerants with low or zero GWP.
- Improvements in energy efficiency.

- Where possible, avoidance of the use of refrigeration and air conditioning through alternative design of systems (e.g. buildings).

It should be carefully noted that there can be a conflict between reduction of direct emissions of HFC refrigerants and of the indirect emissions of CO_2. Care must be taken to ensure that policies do not neglect this interaction.

The Working Group considered a detailed report about the Netherlands approach to the reduction of leakage losses from refrigeration systems. The STEK system is a regulatory framework that ensures that owners of all refrigeration equipment above a certain minimum size must take active steps to minimise emissions and must keep records of refrigerant use. It was agreed that a system of this type has significant merits and could be used as a basis for the design of an overall EU approach to improved refrigerant containment.

In a number of applications users do often not collect data on the energy consumption of their installations. The group therefore discussed to what extent a mandatory monitoring system on emissions of refrigerants could be linked with a monitoring system on energy consumption in larger applications (e.g. commercial refrigeration or large stationary air conditioning).

Cost Effectiveness

Many or possibly all of the technologies described above can be implemented with good cost effectiveness *in appropriate application areas*. In particular, it should be noted that energy efficiency improvements would actually lead to savings rather than costs. Refrigerant containment options enable significant reductions in leakage to take place at low cost (< €20 per ton of CO_2 eq.). In many application areas the use of alternative refrigerants can be achieved at reasonable cost effectiveness (< €50 per ton of CO_2 eq.), although in some situations overcoming the safety problems of using ammonia or hydrocarbon refrigerants can be relatively expensive.

Reduction Options Already Under Implementation

All the important emission reduction opportunities described above (and a number of less important ones) are being implemented to a greater or lesser extent in different application areas. The refrigeration industry is well aware of the global warming issue and significant improvements in technology have been made during the last decade that have led to reduced leakage or more widespread use of alternative refrigerants. However, users of refrigeration and AC systems have not necessarily the same level of awareness. Attitudes are changing relatively quickly within the industry, so it is actually quite difficult to define a business as usual scenario, as this changes on a year to year basis.

EU vs. National Action

Representatives of the refrigeration industry were strongly in favour of an EU wide approach to policies in this area. The refrigeration market is multinational in nature and it is very difficult for the industry to operate with different standards in individual countries.

Discussed Policies and Measures

It has been generally agreed that significant reduction in emissions of fluorinated gases can be achieved by the widespread adoption of the technologies described above. Policies and measures must be aimed at maximising the effectiveness of such measures and ensuring that they are adopted by the maximum number of possible refrigeration and air conditioning users. Specific policies and measures that were discussed at the ECCP working group included:

- A Community Directive on Fluorinated Gases could address all aspects of this issue including equipment design and the skills of refrigerant handlers. It has been suggested that the STEK approach adopted in the Netherlands could be used as a basis for such legislation. Some participants representing refrigerant producers and users proposed that it should be considered applying the rules of the future to all refrigerants. However other participants underlined that the focus of such a Directive should be Fluorinated gases.
- Policies to encourage the use of alternative refrigerants with zero or low GWP.
- Policies to improve the energy efficiency of refrigeration systems.
- A cap on quantity of HFC emissions are allowed from the refrigeration and air conditioning sector.
- A tax on high GWP refrigerants.

It was noted that different policies may be required to reduce emissions from existing refrigeration and air conditioning equipment as opposed to new equipment.

Working Group Recommendation

It is strongly recommended that this market sector be part of the Community Directive on Fluorinated Gases to address all containment and monitoring/verification issues.

Efforts should be made to promote the use of alternative fluids and NIK systems when they are a practical and economically viable solution.

Improved energy efficiency can provide significant levels of CO_2 emission reduction and could be addressed by means of voluntary agreements.

4.2 Mobile Air Conditioning

The sector

A large number of different players are involved in this sector:

- Suppliers of mobile air conditioning systems (about 5)
- European and importing foreign car manufacturers (about 20)
- Servicing companies (very large number / very diverse)
- Scrapping companies (large number / decreasing diversity)
- Millions of users

Emissions

This sector is evolving into one of the major sources of HFCs (projected to account for 8-18 MT CO_2 eq. in 2010[12]). Associated indirect emissions from energy consumption are large and probably offer ample potential for cost-effective emission reductions.

Controlling factors

A number of factors have strong influence on the future level of emissions from this sector.

- Rapidly increasing penetration of mobile air conditioning in European fleets.
- Servicing procedures in this sector currently vary greatly.
- Current recovery procedures mainly cover CFCs and vary greatly.
- EC End-of-Life Vehicle Directive still needs to implemented on the national level.
- Product characteristics (leakage rate) between different suppliers and types vary greatly.
- Companies may switch to alternative systems (CO_2 or hermetic) for reasons other than climate policy (space constraints / new energy supply systems).

Monitoring and Verification

No appropriate monitoring and verification system is currently in place within the EU or one of its member states.

Reduction Options

A number of reduction options exists for the different types of mobile air conditioning systems:

All systems

- Design improvements to reduce energy consumption

HFC systems

- Improved tightness by design
- Effective recovery during servicing
- Effective recovery at end of life
- Reduce specific charge per system

Next generation systems

- Use of systems applying the CO_2-cycle (trans-critical)
- Hydrocarbon systems with secondary loop
- Hermetic systems

It was noted that the Netherlands STEK approach for the reduction of refrigerant emissions (see previous section on refrigeration and stationary air-conditioning) also had merits for the mobile air-conditioning market.

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[12] ACEA has issued a differing estimation of 9-10 MT CO_2 eq in 2010

Cost Effectiveness

Minor design modifications of HFC systems along with a successfully enforced recovery systems for the servicing and the scrapping sector currently appear to exhibit the best cost effectiveness [March, 1998; Ecofys, 2000]. However, it is currently not clear to which degree recovery will be achievable in reality. Planned fundamental modifications of current vehicle concepts may also lead manufacturers to adopt next generation systems, i.e. without costs attributable to climate policy.

Reduction Options Already Under Implementation

- Leakage rates have been reduced through design during the transition away from CFC-12.
- The infrastructure to permitting a recovery of refrigerants during servicing and at end-of-life (EC End-of-Life Vehicle Directive) is being established.
- Higher prices of refrigerant HFC-134a relative to historic prices of CFC-12 provide some economic incentive to recover fluid during servicing and at end-of-life.
- Manufacturers permanently strive to reduce failure rates of mobile air conditioning through quality control and quality assurance, i.e. reduce leakage rates.

EU vs. National Action

There seems very little scope for national action to influence the design of systems and manufacturers' choices. Procedures for servicing and scrapping, however, require strong national enforcement.

Discussed Policies and Measures

During the course of discussions a number of policies and measures were proposed:

- EU Regulations to address refrigerant containment and monitoring of emissions. The End of Life Vehicle Directive could ensure recovery of refrigerant from old vehicles. A Community Directive on Fluorinated Gases could address all other aspects of this issue.
- A voluntary agreement with ACEA, on behalf of car manufacturers, to ensure the continuing improvement of new equipment in terms of both direct emissions (improved HFC systems or use of alternative refrigerants such as CO_2) and indirect emissions (improved energy efficiency).
- A voluntary agreement with the suppliers of mobile air-conditioning equipment covering similar issues to those described in the above paragraph.
- Prohibit "blind" package sale of mobile air conditioning to end customers. Customers should need to actively choose mobile air conditioning.
- Product Labelling: consumers need to be informed by car manufacturers about associated costs and added fuel consumption of mobile air conditioning.

Working Group Recommendation

Many issues are similar to the refrigeration and stationary air-conditioning market. Emissions monitoring and containment should be addressed via the recommended Community Directive on Fluorinated Gases.

The development of new technologies for mobile air conditioning systems should be supported.

4.3 Technical Aerosols

The Sector

The technical aerosol sector represents the small percentage of the non-medical aerosol market that currently uses fluorocarbon propellants. The majority of the old CFC aerosols market has moved to alternative propellants such as hydrocarbons. In the technical aerosol sector we find aerosol applications in which it is inappropriate, usually for safety reasons, to use these alternative propellants and manufacturers have moved to HFCs as a safe alternative.
The market mostly consists of a range of industrial aerosols. It is estimated that about 70% of HFC usage in technical aerosols is for air dusters and freezing sprays. Maritime air-horns, which are also used at sports events also deserve mentioning. HFC propellants are also used in certain leisure applications and in novelty products, mainly due to non-flammability requirements set by EU-regulations.
The industry consists of a number of companies that fill relatively small quantities of these specialist technical aerosols.

Emissions

- Zero emissions of fluorinated gases under the Kyoto Protocol prior to 1990.
- Emissions in 1995 estimated at around 1.3 MT CO_2 eq. This was 2% of total 1995 emissions of HFCs, PFCs and SF_6ases from the EU.
- According to estimation[13] made in 1998, business as usual scenario for 2010 indicated a growth in emissions to around 7 MT CO_2 eq. More recent estimates from the European Aerosol Federation (FEA) suggest 5.1 MT CO_2 eq. Note, these emissions do not include aerosols for "One component foam" which are included in the discussion of foam products.

Controlling Factors

This is an area of emissions of fluorinated gases that has the potential to grow beyond the business-as-usual estimate under certain market circumstances. Currently, the use of HFCs in a wider range of applications is limited by the relatively high cost of this propellant compared to alternatives such as hydrocarbons.
Growth of emissions could occur if other environmental legislation (related to, for example, VOC emissions) restricted the use of hydrocarbon propellants. In Europe unlike the US, however, currently both hydrocarbons and HFCs are grouped as VOCs. Alternatively, growth could occur if new applications required a safe aerosol propellant in a market where cost was not critical or if new low-cost HFC propellants become available.

[13] "Opportunities to minimise emissions of HFCs from the European Union", March, 1998

Monitoring and Verification

Historically, there have been no formal monitoring and verification mechanisms. However the European Aerosol Federation is proposing to carry out annual reporting of consumption of HFCs from 2001. The statistical data (e.g. import and export of cans) to calculate emissions are currently not available.

Reduction Options

In those aerosol applications where a non-flammable propellant is critical this is a quite difficult sector to reduce emissions. Key emission reduction opportunities include:

- Use an alternative zero or low GWP propellant – this is only possible if safety issues can be addressed.
- Use new propellant mixtures with a lower GWP (e.g. HFC 152a mixtures).
- Use an alternative delivery system such as a mechanical spray or compressed gas propellant. This is technically possible in many applications, but users may find the alternative systems less convenient and more costly than aerosols.
- Avoid the use of "unnecessary" aerosol applications (e.g. silly string). However, it is hard to define "unnecessary" and some EU companies have significant exports of such products, so this option could be damaging to EU trade.
- Recovery of propellant from quality deficient new aerosol cans.

Cost Effectiveness

Little cost effectiveness data was presented to the ECCP Group. In any current application where safety issues can be overcome, alternative propellants could be used with a good cost effectiveness. However it is believed that there are few if any applications that fall into this category. Use of new propellant mixtures with a low GWP may be reasonably cost-effective, although will only reduce emissions by a small percentage. The economics of alternative delivery systems have not been studied to any extent. Recovery of propellant from used aerosols is likely to be relatively expensive, except in situations where large quantities of aerosols are used within a single organisation.

Reduction Options Already Under Implementation

The high price of HFC propellants compared to alternatives such as hydrocarbons have already restricted the use of HFC aerosols significantly.

The European aerosol Federation is currently developing a voluntary code of practice that is intended to minimise the consumption and emission of HFCs in the technical aerosol sector.

The HFC supply industry is aware that development of unnecessary new markets for HFC aerosols is damaging to the environment and therefore restricts itself to sales into specified "responsible" applications.

EU vs. National Action

Technical aerosols are heavily traded within the EU and also imported from and exported to the outside world. To avoid potential distortions of the internal market, European action could be preferable.

Discussed Policies and Measures

Specific policies and measures that were discussed at the ECCP working group included:

- Monitoring and reporting of emissions at an EU level.
- Implementation of a voluntary or negotiated agreement with the aerosol industry.

- Creation of an agreed list of currently known “critical”[14] uses.
- A ban on HFC usage for “non-critical”[14] uses.
- On-going development of alternatives, including new propellants or NIK delivery systems.
- GWP labelling of aerosol cans.

Working Group Recommendation

An emissions monitoring and verification system should be established via the recommended Community Directive on Fluorinated Gases.

The development of not-in-kind technologies to replace HFC propelled technical aerosols should be supported.

Restrictions on the use of HFCs in certain “non-critical” product applications could be considered.

[14] The appropriate definition of the terms “critical” and “non-critical” would need to be part of any such policy.

4.4 Metered Dose Inhalers (MDI)

The Sector

The MDI sector consists of a small number of major pharmaceutical companies that manufacture MDIs for use in the European market and for export. MDIs are used to treat a number of lung related illnesses including asthma and chronic obstructive pulmonary disease.

Emissions

- Zero emissions of fluorinated gases prior to 1995.
- Business as usual scenario for 2010 indicates a growth in emissions to around 4 MT CO_2 eq. This will be 4% of total 2010 emissions of fluorinated gases from the EU.

Controlling Factors

The MDI sector faces the very important challenge of phasing out CFC propellants and about half of the transition out of CFCs is now completed.
There are very long product development and testing cycles in the pharmaceutical industry. Reformulating drugs to accommodate a new delivery system (e.g. Dry Powder Inhalers (DPIs)) or to accommodate a significant redesign (e.g. modified valve design) can take up to 10 years. Approval procedures for new formulations require additional time.

Monitoring and Verification

No formalised procedures are in place for the regular monitoring and verification of MDI emissions.

Reduction Options

There are a number of ways in which greenhouse gas emissions can be reduced from the business as usual scenario estimate. Key opportunities include:

- Use of alternative drug delivery systems, in particular DPIs where appropriate.
- Modification of MDI valve design, to reduce HFC emission per dose of drug.
- Minimisation of HFC losses during manufacturing and product processing
- Development of non-propellant technologies
- Recovery of HFCs from reject MDIs
- Recovery of HFCs from used MDIs, as far as practical.
- Information and labelling

Cost Effectiveness

A recent study carried out by IPAC (International Pharmaceutical Aerosol Consortium) reported estimates of the cost effectiveness of the various emission reduction options. Although there was no disagreement on the high cost associated with several of the reduction options[15], stakeholders could not agree on the cost effectiveness of different policies and measures especially on the cost penalty of DPIs versus MDIs. The recovery of propellant from reject MDIs was identified as a clearly cost-effective measure.

[15] Such as modification of MDI valve design, of non-propellant technologies, and recovery of HFCs from used MDIs.

EU vs. National Action

MDIs, like technical aerosols, are heavily traded within the EU and also imported from and exported to the outside world. However, differences between health systems across member states are so large, that European action in this field could prove to be problematic.

Reduction Options Already Under Implementation

Several pharmaceutical companies have initiatives in place to recover HFC propellants from reject MDIs.

It was pointed out that the majority of the manufacturers of MDIs also make DPIs, which have considerable penetration rates in some Member States. Hence, the majority of the pharmaceutical industry is not against about a shift towards DPIs but recognise that the cost implications, medical prescription practices and patient needs may prohibit this. On the other hand, some participants refer to Sweden, where about 80% of the asthma patients have been treated with DPIs for years.

The industry has committed itself to explore innovative non-propellant solutions.

Discussed Policies and Measures

It was generally agreed that high costs and long development time scales make the MDI sector a difficult one to address, particularly bearing in mind the need to phase out CFC MDIs as soon as possible. It was stressed that under all circumstances consultation with all stakeholders, including heath ministries, physicians and patients is needed to avoid possible risks to human health.

Working Group Recommendation

Monitoring should be addressed via the recommended Community Directive on Fluorinated Gases.

The possibility of a voluntary agreement with MDI manufacturers should be explored.

4.5 Solvents

The Sector

For certain specialised cleaning the applications HFC or PFC solvents are considered to offer the best cleaning performance, particularly in those markets that are currently using HCFC 141 b. In addition HFCs are being considered for limited new uses in the extraction of natural products. The nature of this solvent market is relatively fragmented, with a large number of small users in a diverse range of engineering industries.

Emissions

- Zero emissions of HFCs and PFCs prior to 1995.
- Business as usual scenario for 2010 indicates a growth in emissions to around 1-2 MT CO_2 eq. This will be 1-2% of total 2010 emissions of fluorinated gases from the EU.

Controlling Factors

HFC and PFC solvents are only being considered in a few specialised markets, which currently use HCFC solvents. These include sectors such as aerospace where product testing and certification can take a long period of time. High costs for HFC solvents currently are a controlling factor.
Use of certain alternatives, especially aqueous cleaning, can reduce direct emissions but can lead to increased energy related CO_2 emissions. Care must be taken to avoid an overall increase in greenhouse gas emissions.

Monitoring and Verification

No formalised procedures are in place for the regular monitoring and verification of solvent emissions.

Reduction Options

They are a number of ways in which greenhouse gas emissions can be reduced from the business as usual scenario estimate. Key opportunities include:

- Reduction of fugitive emissions from HFC or PFC systems.
- Use of hydrofluoroethers
- Use of alternative organic solvents.
- Use of aqueous solvents.
- Use of no-clean technologies.

Cost Effectiveness

In principle the above options can be achieved at relatively low cost. The problem about applying an alternative option is not related to cost. Fluorocarbon solvents are required when very high cleaning standards are needed, when there are materials compatibility issues, when a non-flammable solvent is important and when water based cleaning is unsuitable.

Reduction Options Already Under Implementation

The solvent industry has made significant efforts to avoid use of HFC and PFC solvents. Where possible, applications that historically used CFC 113 will be addressed by non-HFC options. 50,000 tonnes of CFC 113 was used for solvents in 1990. In 2000 only 6000 tonnes of HCFC 141b will be used mainly in applications where historically CFCs were used. It is expected that in 2010 HFC solvent use will be about 1200 tonnes.
Recent EU Regulations on the use of solvents force users to minimise fugitive losses to low levels.

EU vs. National Action

Differing Member State approaches to regulate the solvent sector in response to the Montreal Protocol have led to fairly distinct developments across Europe. The choice of solvent primarily influences production processes. The trade of finished products is unlikely to be affected while trade in cleaning equipment is obviously restricted through national regulations. It is currently not evident whether European action is indicated or not.

Discussed Policies and Measures

Specific policies and measures that were discussed at the ECCP working group included:

- Further efforts to minimise fugitive losses, including a voluntary code of practice.
- Policies to encourage adoption of alternative solvents.
- Taxation for use of HFCs and PFCs in solvent markets.

Working Group Recommendation

Emissions monitoring and containment should be addressed via the recommended Community Directive on Fluorinated Gases.

4.6 Fire-Fighting

The Sector

HFC fire-fighting agents are being used in certain specialised situations that historically made use of halon fire-fighting the systems. The market consists of a reasonably large number of end-users that are supported by a small specialist fire-fighting industry.

Emissions

- Zero emissions of HFCs and PFCs prior to 1995.
- Business as usual scenario for 2010 indicates a growth in emissions to around 0.5 MT CO_2 eq.

Controlling Factors

In certain applications (e.g. aircraft fire-fighting systems) maximum effectiveness and/or minimum weight/space is critical. HFCs are the only fire-fighting agents that can meet certain specialised needs of this sort.

Monitoring and Verification

No formalised procedures are in place for the regular monitoring and verification of fire-fighting agent emissions.

Reduction Options

They are a number of ways in which greenhouse gas emissions can be reduced from the business as usual scenario estimate. Key opportunities include:

- Use of alternative systems such as inert gases.
- Improved fire detection to avoid unnecessary discharges.
- Improved design and maintenance procedures to eliminate the need for regular system testing involving gas discharge.

There was some disagreement at the ECCP meeting about whether inert gases or other non-HFC methods or agents could replace HFCs in more applications.

Cost Effectiveness

For most applications the above methods are reasonably cost effective.

Reduction Options Already Under Implementation

All the above measures are already under implementation by the industry. One Member State, Denmark, has banned the use of HFC in fire fighting equipment.

EU vs. National Action

Trade in fire-fighting equipment and associated services quite frequently cross member state boundaries. Many critical applications (e.g. in aviation and navigation) have to fulfil global performance standards and have to be dealt with in international agreements.

Discussed Policies and Measures

It was agreed that emissions from fire fighting were comparatively minor and it may be better to concentrate on other areas of Fluorinated Gas use/emissions.
It was also agreed that the ECCP should not enter the debate on the best choice of fire fighting agent.

Specific policies and measures that were discussed at the ECCP working group included:

- Good monitoring of emissions.
- A voluntary agreement with the fire-fighting industry to maximise the impact of the technical options listed above.

Working Group Recommendation

Monitoring and containment should be addressed via the recommended Community Directive on Fluorinated Gases.

The possibility of a voluntary agreement with the fire-fighting industry should be explored.

4.7 Use of SF_6 in Windows and Tyres

The Sector

These sectors are almost unique in the field of fluorinated gases in the sense that the use of SF_6 in both car tyres and double-glazing[16] is unusual or non-existent in most EU Member States. In both cases the market is dominated by the use of SF_6 in Germany.

Emissions

- Significant emissions of SF_6 prior to 1990.
- Emissions in 1995 estimated at around 10 MT CO_2 eq. This was 14% of total 1995 emissions of fluorinated gases from the EU.
- Business as usual scenario for 2010 indicates a fall in emissions to around 5 MT CO_2 eq. This will be 5% of total 2010 emissions of fluorinated gases from the EU.

Controlling Factors

Growing awareness that SF_6 is the most powerful greenhouse gas in the Kyoto basket and that these applications are considered unnecessary in most Member States.

In the case of windows, product life is very long – typically 25 years. Hence, even if production of new units stopped immediately there is a considerable SF_6 bank that will be a source of emissions for many years to come.

Monitoring and Verification

No formalised procedures are in place for the regular monitoring and verification of SF_6 emissions from tyres and double-glazing.

Reduction Options

There are options in which greenhouse gas emissions can be reduced from the business as usual scenario estimate. Key opportunities include:

- Elimination of production of new car tyres with SF_6 – cars in the EU operate in a satisfactory way with air in tyres.
- Elimination of production of double-glazing with SF_6 – the vast majority of double-glazing in the EU does not use SF_6. Alternatives such as thicker glass, extra space between panes and different types of glass can provide equally effective soundproofing.
- Recovery of SF_6 from old double-glazing units.

Cost Effectiveness

In new tyres, sport shoes and double-glazing, SF_6 can be eliminated at no costs.

The costs of removing SF_6 from old double-glazing are not known. It was mentioned that there are considerable practical difficulties carrying this out effectively.

Reduction Options Already Under Implementation

It is expected that the market for SF_6 double-glazing in new buildings will disappear by 2005.

Manufacturers expect that the filling of car tyres will drop to zero by 2002.

[16] The use of SF_6 in applications such as sports shoes and tennis balls was not specifically addressed by the working group.

EU vs. National Action

The use of SF_6 in these applications is mostly in Germany, with some smaller usage reported in Denmark and Austria (tyres and windows) and Belgium and France (windows only). It may be most appropriate for these countries to implement appropriate national policies following recommendations from the ECCP. Denmark already has a ban on installation of new tyres or windows containing SF_6 planned from 1/1/2001. The new German Climate Protection Programme also requests a phase-out of these applications.

Discussed Policies and Measures

Specific policies and measures that were discussed at the ECCP working group included:

- A ban on the use of SF_6 in these applications (National or European level).
- Efforts to investigate the options for recovery of SF_6 from old double-glazing.

Working Group Recommendation

Use restrictions for SF_6 in these applications should be issued either on the national or the European level.

4.8 Aluminium Production

The Sector

Primary aluminium is a globally traded commodity. The high consumption of energy and very high capital costs are among the key factors influencing the economic performance of a given smelter. The sector has only a small number of global producers of primary aluminium plus some smelters owned by investment groups. A total of 21 primary smelters exist in the EU and 31 in Western Europe. Within EU-15 it is unlikely that new smelters will be constructed over the next ten years. During the 1990's a several small smelters has been closed while others have been modernised and upgraded. Depending on market conditions this trend could continue over coming years.

Emissions

Emission levels most directly depend on the anode and feeding technologies used in a smelter, the degree of process automation and plant specific operating practices. Emissions have declined from 13 to 5 MT CO_2 eq. by almost 60 % since 1990.

Controlling Factors

- Prospects for inert anodes.
- Energy availability and price
- Decommissioning or modernisation of old smelters.
- Speed of implementation of the IPPC-Directive

Monitoring and Verification

The European Aluminium Association has established a monitoring system in which emission data are collected according to the IPCC inventory methodology.

Reduction Options

The main short-to-mid term emission reduction option is to retrofit smelters in respect to their anode, feeding and process technology. A number of site-specific factors need to be considered in order to assess the feasibility and costs of such measures.

Cost Effectiveness

A fairly large number of smelters in Europe have recently been retrofitted to modernise production and respond to environmental concerns. In the past abatement costs of PFCs have been negative. For remaining smelter and further upgrades of technology it is currently not clear to what extent a potential for cost-effective reductions exists.

Reduction Options Already Under Implementation

Much of the existing emission reduction potential has been realised mainly as part of capacity expansions and retrofitting during the last 15 years.

EU vs. National Action

Aluminium is a global commodity with comparatively small transport costs. Unilateral national action could lead to distortions of the internal market. European action under the EC-IPPC Directive could thus be indicated.

Discussed Policies and Measures

- Expeditious implementation of the BAT according to IPPC BREF notes.

- Continuation and expansion of voluntary agreements on the national level.
- Concerted research on improved production technologies, e.g. inert anodes.

Working Group Recommendation

Voluntary action by the aluminium industry has already created a monitoring system.
The group recommends an expeditious national implementation of the “Best Available Techniques” according to the BREF notes related to the IPPC-Directive.

4.9 Semiconductor Production

The Sector

The sector comprises a limited number (roughly 25) of fairly large companies with often globally spread operations. Most of these companies have a number of production sites in Europe. In addition there are a larger number of smaller emitters in research and development that probably do not contribute significantly to EU emissions.

Emissions

According to industry projections emissions were close to 2.0 MT CO_2 eq. in 1995. Due to the continuing rapid growth of the industry emissions are projected to grow to about 16 MT CO_2 eq. if uncontrolled [Ecofys, 2000]. The World Semiconductor Council comprising all major producers has committed itself to a global emission reduction of minus 10% relative to 1995 levels.

Controlling Factors

The rapid growth of the sector and the specific choice of technology for chamber cleaning and etching processes and the added waste gas treatment fully determine future emission levels. The concept of best-available-technology is difficult to define in this highly dynamic industry with its very differentiated application pattern.

Monitoring and Verification

EECA has established a monitoring system in which companies report uses and estimated emissions of fluorinated gases to an accountant who produces European aggregates.

Reduction Options

A number of different technological options exists in order to reduce emissions:

- Integrated solutions for new equipment like NF_3 in Chemical Vapour Deposition (CVD) including waste gas treatment.
- Switching to alternative chemistry for CVD-chambers (e.g. C_3F_8) and for etching processes (e.g. C_4F_8 and C_5F_{10}) with higher destruction efficiency and adding thermal oxidation equipment including waste gas treatment.

Cost Effectiveness

The cost effectiveness of integrated abatement options is difficult to assess as improved process performance (e.g. in terms of increased throughput) can easily offset increased equipment costs. For most retrofit situations a poor cost effectiveness is found as costly re-certification procedures and interruptions of production are involved, especially for etching processes. In many cases plants may simply lack the space to add abatement equipment close to chemical vapour deposition chambers and etching equipment.

Reduction Options Already Under Implementation

The industry has started to install abatement technologies when erecting new fabrication sites.

EU vs. National Action

Voluntary agreements on the European level would provide greatly more flexibility to industry than national solutions and would thus be far more effective. European action thus seems warranted.

Discussed Policies and Measures

- Formal recognition of the European voluntary action of the industry
- Research on new methods for etching and cleaning in the semiconductor industry.

Working Group Recommendation

Voluntary action by the semiconductor industry has already created a monitoring system.
The group recommended that the Commission give some formal recognition to the joint emission reduction commitment (Memorandum of Agreement) of the European Electronic Component Manufacturers Association (EECA) and the European Semiconductor Industry Association (ESIA).

4.10 By-Product Emissions of HFC-23 from HCFC 22 Manufacture

The Sector

The sector comprises a small number of companies that operate production plants of HCFC-22 at ten different sites within EU-15. Most of the companies have multi-national operations and own more than one plant in EU-15.

Emissions

With roughly 30 MT CO_2 per year this source was the only significant emitter of HFCs in 1990 and the major one in 1995 (representing about 50% of HFC emissions in 1995). This sector contributed roughly 40% of 1995 EU emissions of all fluorinated gases regulated under the Kyoto protocol. Emissions have significantly declined in the meantime.

Controlling Factors

The key factors controlling emissions from this source comprise:

- Evolution of non-feedstock production of HCFC-22 under the new EC Regulation 2037/2000 on ozone depleting substances.
- Growth of demand for feedstock-applications of HCFC-22 like production of poly-tetrafluoroethene.
- Rate of installation and appropriate operation of thermal oxidation equipment (or collection) of HFC-23 and disposal at production plants (e.g. influenced by IPPC).
- Destruction efficiency and down times for maintenance of thermal oxidation equipment (e.g. influenced by IPPC).

Monitoring and Verification

Manufacturers are collecting data on emission factors for each production plant. Production data of HCFC-22 are estimated according to plant capacity.

Reduction Options

- Process optimisation.
- Thermal oxidation of by-product HFC-23 on site.
- Collection of HFC-23 at the production site and disposal in facilities elsewhere.

Cost Effectiveness

Process optimisation measures are likely to save money. The remaining potential for this measure is believed to be small. Thermal oxidation is an option with well established low abatement costs (< 1 Euro per ton of CO_2 eq.). The cost-effectiveness of collection of HFC-23 at a production site with subsequent transport to a destruction facility elsewhere has not been studied. There could be cases where manufacturers are planning to soon close a plant under the HCFC phase-out scheme and would consequently not want to make new investments.

Reduction Options Already Under Implementation

Manufacturers have installed and successfully operate thermal oxidation facilities at six plants within EU-15. This has been accomplished as part of voluntary agreements or by unilateral action of manufacturers.

EU vs. National Action

HCFCs are widely traded within the EU and imported from and exported to the outside world. National action could lead to distortions of the internal market. European action under the EC-IPPC Directive could thus be indicated.

Discussed Policies and Measures

It was proposed that the main instrument to reduce emissions from the four remaining plants would be the appropriate national implementation of the EC-IPPC Directive.

Two important objectives could be achieved either through IPPC or through voluntary agreement with the industry:

- Maximising the utilisation and efficiency of thermal oxidation facilities once installed.
- Ensuring that all production facilities have thermal oxidation systems.

Working Group Recommendation

An emissions monitoring and verification system should be established via the recommended Community Directive on Fluorinated Gases.

Because of the magnitude of emissions from this source, the group strongly recommends accelerated voluntary action by the industry or national legislation by the affected Member States (potentially linked to the IPPC-Directive).

4.11 Magnesium Production and Casting

The Sector

There is currently only one primary magnesium producer and one large secondary smelter in EU-15. The number of die-casters in EU-15 is significantly larger (about 120). Most of them are SMEs and located close to their main customers in the automotive industry.

Emissions

It is estimated that EU-wide emissions from this sector were in the order of 1.5 MT CO_2 eq. in 1990/95. Due to growth in automotive applications these emissions are projected to grow if specific usage values cannot be reduced.

Controlling Factors

A number of factors will influence the future magnitude of SF_6 emissions within EU-15:

- Specific usage of SF_6 per mass unit of magnesium
- Growth of demand for casted magnesium, particularly in the automotive industry
- Commissioning / de-commissioning of primary / secondary smelters within EU-15
- Penetration of alternative cover technologies
- Penetration of alternative casting / moulding technologies

Monitoring and Verification

Currently no European system for monitoring and verification exists. Some member states are continuously collecting respective data from gas vendors.

Reduction Options

In the short term an improvement of operations in smelters and casting houses leading to reduced specific usage of SF_6 is the only available option. This would involve a further dissemination of information and benchmarking efforts between competitors.

In the mid term many companies could switch from SF_6 to SO_2. Apart from the significant problems arising from its toxicity and corrosiveness, SO_2 provides an equivalent technical performance at low gas costs. Investment costs for health and safety issues could be significant but would not necessarily be prohibitive.

In the long term other cover gases are likely to evolve as preferred options in magnesium casting. The industry is currently devoting significant resources to this investigation. Alternative cover gases would probably be non-toxic and non-corrosive and exhibit lower GWP values than SF_6. Investments for a conversion could be significantly lower than for SO_2.

Cost Effectiveness

Ecofys [2000] estimates that a substitution of SF_6 by SO_2 exhibits a cost effectiveness of less than 1 Euro per ton of CO_2 equivalent in most applications. Costs can however be expected to vary greatly depending on local circumstances.

Reduction Options Already Under Implementation

A producer and a number of casters of magnesium have demonstrated that very substantial reductions of specific use values of SF_6 can be achieved through minor changes of operating practises.

EU vs. National Action

Primary and secondary magnesium have to compete with imported material. Cast magnesium products are mostly produced in great proximity to customers within the automotive industry. However, in some instances there may be competition against imported cast products. For ingot magnesium as well as cast products European action could be indicated.

Discussed Policies and Measures

- Potentially, regulation of larger enterprises under EC-IPPC Directive
- Definition of best practice maximum emission values
- EU support for research into alternative cover gases (performance & toxicity)
- Establishing an EU monitoring and verification system
- Benchmarking exercises for die casters
- Information dissemination
- Schedule for phase out of SF_6

Working Group Recommendation

Emissions monitoring should be addressed via the recommended Community Directive on Fluorinated Gases.

For large scale operations the IPPC Directive could be used to help minimise SF_6 emissions.

For smaller operations, particularly those involved in die-casting, the viability of alternative cover gases needs to explored

4.12 Production & Use of SF_6 Switchgear

The Sector

Producers: All European producers of switchgear applying SF_6 are organised in the industry association CAPIEL. Five large manufacturers cover the main relevant market for high voltage switchgear.
Users: Users of SF_6 switchgear are mainly the large operators of electricity grids, in particular in the case of high-voltage equipment. However, large industrial companies will often directly purchase mid-voltage switchgear from manufacturers.

Emissions

Emissions from this sector are estimated to be 5 MT CO_2 eq. in 1995. Emissions are projected to remain constant, or slightly decrease, despite a projected increase of 50% in the population of switchgear.

Controlling Factors

Three main factors have been identified as drivers of future emissions:

- Handling practices for SF_6 during production, erection, maintenance and decommissioning of equipment
- The amount of new equipment manufactured within EU-15
- The rate of replacement of old equipment (oil insulated) systems with SF_6 switchgear

Monitoring and Verification

Manufacturers and the main users of SF_6 switchgear have completed the test phase of a monitoring system for emissions from production and use by the end of the year 2000. Data for the base year 1995 were derived by an earlier enquiry carried out by CAPIEL/EURELECTRIC.

Reduction Options

- Permanent improvements in switchgear design for minimal leakage and simplified handling in service as well as at End of Life
- Reduction of emission during manufacture
- Improved Gas Handling Equipment (for reduction of gas losses at gas removal)
- Improved filling procedures on site
- Better monitoring in service (for larger equipment)
- Use of "sealed-for-life" techniques in in particular smaller equipment
- Target older existing equipment with known leakage problem for repair/replacement
- Improved maintenance procedures including RCM (Reliability Centered Maintenance)
- Improved end-of-life recovery and recycling
- Ensure re-use of SF_6 in the relevant IEC Standards and promote the re-use concept
- Alternative arc quenching technologies in some mid-voltage applications (limited potential)

Cost Effectiveness

Thorough estimates of the cost effectiveness of different emission reduction options are scarce.

Reduction Options Already Under Implementation

Producers and many users of SF_6 switchgear have made significant progress in reducing their emissions of SF_6 since the early 1990's. Changes away from historical handling practices towards current best practice are generally believed to be very cost-effective in manufacturing and use and have often been implemented through changes to quality management.

A working group on SF_6 recycling has been established within CIGRÉ. The establishment of a monitoring system has made it possible to benchmark producers' and utilities' performance against that of their competitors.

EU vs. National Action

A target on the European level would provide a higher flexibility to producers and users of SF_6 switchgear. It would thus be more effective than national solutions. European action could thus be indicated.

Discussed Policies and Measures

- Consolidation of monitoring system.
- Formal recognition of voluntary European action to provide a framework for flexible national targets.

Working Group Recommendation

Voluntary action by the switchgear industry has already created a monitoring system and set standards for the handling and recycling of SF_6. It is recommended that the Commission give some formal recognition to this voluntary action. A link should be considered between the proposed regulatory framework with voluntary action in this sector.

4.13 Rigid Foams (XPS, PU & Phenolics)

The Sector

This sector comprises a number of technologically distinct ways of producing rigid foams based on different polymers. The main application of rigid foams in which HFCs are of interest, is thermal insulation with only minor other uses e.g. for integral foams. A common feature of this sector is that a large part of the blowing agent (HFC or alternative) stays in the foam product over the lifecycle of the product ("closed cell foams"). Emissions occur during the production of the foam, during its product life and at the end of life. The choice of blowing agent has a significant impact on the insulation properties of the foam and hence of the energy related CO_2 emissions of the insulated installation.

Based on the different polymers the following three sectors are commonly differentiated:
A) Extruded Polystyrene (XPS) – made by a small number of large producers
B) Polyurethane [17] (PU) – made by a few large producers and many SMEs
C) Phenolic Foams – made by a small number of producers

An important characteristic of the sector is that HCFC blowing agents are currently in widespread use and are due for phase out between 2001 –and the end of 2003.

Emissions

HFC emissions from this sector were close to zero in 1995. As a consequence of the phase-out of HCFCs, emissions are projected to rapidly increase starting in 2003. The authors of this report estimate that emissions (production and life) of HFCs from this sector will account to about 6 MT CO_2 eq. from XPS and about 5 MT CO_2 eq. from PU and Phenolics in 2010 if no further actions are taken.

Controlling Factors

The key factors influencing the evolution of HFC emissions from this sector are the following:

- Choice of blowing agent (including availability and costs)
- Growth of individual market segments (partly driven through regulation)
- Evolution of technology to re-capture blowing agent at production sites
- End-of-Life treatment of foam products

Monitoring and Verification

While it is fairly simple to track the consumption of HFCs in different market segments of the foam industry, it becomes more difficult to monitor emissions. This is mainly due to uncertainties of emissions factors and fairly complex trade flows within the EU and across its borders. The situation is comparable with a number of applications from the refrigeration and air conditioning sector. The foam industry has offered to report consumption data on an annual basis to the Commission. Further action by the Community and its Member States will be required to comply with the reporting obligations under the UN Framework Convention on Climate Change.

Reduction Options

The main emission reduction options for this sector comprise:

[17] Not including one component foams which are covered separately.

- Choice of low GWP-blowing agent (pure HFCs, HFC blend, alternatives such as CO_2 and HCs, blends of HFC with an alternative)
- Minimisation of emissions from reject
- Re-capture of emitted blowing agent at production sites
- End-of-Life treatment of foams
- Use of alternative insulation materials

For each of the above options a number of caveats exist. Often one or several of the following factors could prevent a minimisation of HFC emissions by means of the reduction options.
- Required thermal insulation properties
- Required technical performance of the foams
- Safety at the production site (flammable hydrocarbon blowing agents)
- Required fire resistance of the foam product
- Investment Costs

Cost Effectiveness
The cost effectiveness of different emission reduction options can vary significantly between different applications and manufacturers. To date mainly a switch between blowing agents has been assessed. The technology and economics of systems for a re-capture of blowing agents are unproven. Because a considerable part of the emissions take place at the end of life for many types of foam, the comparison between different emission reduction options therefore becomes uncertain.
- XPS - It is estimated that a large part of the market (thin boards) can convert to CO_2 or CO_2/ethanol at moderate abatement costs of less €20 / ton of CO2 eq.
- PU - The cost effectiveness of switching from HCFCs to pentane instead of HFCs depends on the size of the enterprise and the technical requirements of the specific application. Specific abatement costs range from negative to above €50 per ton of CO_2 eq. A detailed assessment of individual market sectors is indicated.
- Phenolics – Except for recapture/recovery during preparation of cut products and at end of life, there is little potential to reduce HFC emissions other than through substitution with other insulation products. Phenolics are used primarily because of their flame resistance, which is, in part, dependent on their fluorocarbon use.

Reduction Options Already Under Implementation
- XPS: A number of production lines for XPS board stock have been converted from HCFCs to CO_2/ethanol.
- PU: A significant number of larger producers of PU foams (e.g. appliances, continuous panels, pipe in pipe) have converted their production lines from HCFCs to pentane.

EU vs. National Action
Many foam products are widely traded within the Community and also imported and exported. National differences regarding building codes, insulation standards and fire classifications have led to a significant differentiation of products in the building sector today found in Europe. In a number of applications European action is preferable to avoid potential distortions of the internal market.

Discussed Policies and Measures
The potential effects of taxes on fluids and use restrictions of HFCs in specific applications have been discussed. Some Member States are examining the use of taxes, and Denmark has introduced a tax from March 2001. Industry has made clear that it strongly rejects these

concepts and favours voluntary action. The industry has subsequently proposed a voluntary commitment in which it sets emission targets for emissions from manufacturing for the years 2005 and 2010. It was also discussed whether targets could be set for emissions from products during their life-time and at end-of life. It was concluded that little information about feasibility for recovery and costs for it were available and therefore further studies would be needed.

The Working Group agreed that at this stage it would be premature in the foam sector to prescribe specific technologies or set specific quota for use of alternatives in a Directive on fluorinated gases. However, it was discussed how monitoring and verification could be included and whether some general principles on the use of HFCs in the foam sector should be outlined in the Directive.

The technical requirements for HFC blowing agents are restricted to rigid insulating foam and integral skin foams for automotive safety applications. It was suggested that a ban on the use of HFCs for the blowing of open cell flexible foams could be included in a Directive.

Working Group Recommendation

It was agreed that it would be premature to recommend specific policies and measures on the European level in addition to some general use principles and provisions on the monitoring of HFC usage and emissions.

A voluntary commitment was proposed by the industry. Participants welcomed the initiative and recommended a closer evaluation of the proposal and a reflection on ways of linking it to the recommended Community Directive on Fluorinated Gases.

4.14 One Component Foams (OCF)

The Sector

Thirtyfive fillers of one component foam cans are operating their businesses in the whole of Europe, of which 12 are within the EU. Cans are used by several tens of thousands of small enterprises and a very large number of end consumers. The total European market has a size of annually about 120 million cans, including 30-40 millions cans in Eastern Europe. Germany with about 30 million cans is the single largest market within the EU. Exports out of the EU account for less than 1 million cans per year. Imports from Eastern Europe into the EU are in the order of 10 million cans per year. Typical can sizes vary between 300 and 750 millilitres containing in average about 660 grams of filling of which propellants account for about 18%. OCFs differ from the rest of the foam applications discussed above in that propellant / blowing agent is not retained in the foam for any significant amount of time.

Emissions

After completing the phase-out of CFCs in 1991 and of HCFCs in 1995 the industry has switched to HFC-134a, HFC-152a, propane, butane and dimethylether. Emissions of HFCs in 1995 are estimated to have been about 3 MT CO_2 eq. Despite some growth in this sector HFC emissions are unlikely to increase above this level as industry is moving towards propellants with lower GWPs. Industry itself is projecting to achieve emissions below 1 MT CO_2 eq. in 2010.

It is important to note that OCFs are primarily used to fill gaps and crevices in the building sector in order to avoid undue to heat losses. OCFs thus contribute very significantly to reduce the energy consumption in the building sector. Associated saved CO_2 emissions are very large.

Controlling Factors

Future levels of emissions are mainly influenced:

- Evolving standards on safety requirements regarding the use of flammable propellants
- The growth of the market

Monitoring and Verification

Fairly reliable emission estimates for the whole of Europe were presented by the industry for 1999 and 2000. Without excessive effort a monitoring system could be set up within a short timeframe. Data reported by the fillers should be complemented through data on sales of HFCs into this sector from the manufacturers of HFCs.

Reduction Options

Basically the choice of propellant and recovery of propellant from used cans are the two main ways to influence emission levels of HFCs from this application:

- The most evident reduction options in this field involve the choice of propellant. After the phase-out of ozone depleting substances the main alternatives are HFC-134a, HFC-152a, propane, butane and dimethylether. Currently, blends of these compounds are used to provide satisfactory technical performance and comply with safety standards at minimum costs. Significant potential for further development and use of low GWP blends exists.
- Used OCF cans still contain about 10% of its initial content including the propellant. This amount can be recovered if a recycling system exists. Provided that a European system for the recycling of these cans is established and high return quota are achieved, additional

emission reductions can be achieved. However, increased emissions of CO_2 through additional transport has to be considered.

Cost Effectiveness

Under the constraints of safety and technical performance, moves towards propellants with lower GWP are likely to be associated with negative costs through savings for the purchase of the substance.

Reduction Options Already Under Implementation

After the phase-out of CFCs and HCFCs there is now a strong move away from HFC-134a towards propellants with lower GWPs (HFC-152a, propane, butane, dimethylether). Significant reductions of HFC emissions have occurred from 1995/96 levels. Fillers of foam cans anticipate a continuation of this trend.
In Germany - accounting for 1/3 of the EU market - has established a recycling system for used OCF-cans. It currently has a return quota of 40%. The remaining filling including the propellant is recycled.

EU vs. National Action

Differing risk perceptions across Europe have led to some fragmentation of the EU market for OCFs. However, OCFs are heavily traded within the EU and also imported from and exported to the outside world. To avoid potential distortions of the internal market, European action could be preferable.

Discussed Policies and Measures

Stakeholders within the Working Group could not agree on the actual safety risk involved in switching to propellants with lower GWP and higher flammability. Recommendations on policies and measures would strongly depend on the assessment of this risk. Further research is clearly needed. A voluntary commitment by the OCF industry to limit its HFC emissions to a certain level was seen as a promising way forward by many participants of the Working Group. Monitoring and verification obligations should also be part of such a commitment and / or an EC Directive on Fluorinated Gases. Some participants favoured use restrictions, except in applications where flammability would be a major concern (e.g. in the mining industry and in other closed places).

Working Group Recommendation

It was agreed that manufacturers should aim to minimise the mean global warming potential of its propellants. Opportunities for a voluntary agreement with this industry should be explored. Additional efforts need to be made to assess safety hazards associated with the use of flammable propellants.
Emissions monitoring can be addressed via the recommended Community Directive on Fluorinated Gases.

5 References

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6 Annex I – Position Papers (2000)

The annex is distributed as a separate document containing the following position papers submitted by different stakeholders.

Positions submitted in 2000

Co-ordinated Member State Positions

1. Refrigeration and Stationary and Mobile Air Conditioning
2. Light Industrial Applications
3. Metered Dose Inhalers
4. Heavy Industrial Sources
5. Foams

Climate Network Europe

6. Refrigeration and Stationary and Mobile Air Conditioning
7. Light Industrial Applications
8. Heavy Industrial Sources
9. Foams

Industry Associations and other Non-Governmental Organisations

10. Refrigeration and Stationary Air Conditioning (EUCRAR)
11. Refrigeration (CECED)
12. Mobile Refrigeration (ACEA)
13. General Aerosols (FEA)
14. Metered Dose Inhalers (IPAC)
15. Metered Dose Inhalers (EFA)
16. Solvents (EFCTC)
17. Fire-Fighting (Eurofeu)
18. Use of SF_6 in Tyres and Windows (Solvay)
19. Primary Aluminium (EEA)
20. Semiconductors (EECA)
21. By-Product Emission of HFC-23 (EFCTC)
22. Magnesium Production and Casting (Hydro Magnesium)
23. Production and Use of SF_6 Switchgear (CAPIEL / UNIPEDE)
24. Insulation Foam Industry (ISOPA, EXIBA, BING)
25. One Component Foams (European OCF Producers)

7 Annex II – Position Papers (2001)

The annex is distributed as a separate document containing the following position papers submitted by different stakeholders.

1. Member States - Report on Utrecht Workshop
2. EPEE / EUCRAR
3. Calorgas
4. Earthcare
5. EECA/ESIA
6. EXIBA / ISOPA / EPFA
7. FEA
8. IPAC