SIA | SEMICONDUCTOR INDUSTRY ASSOCIATION

VIA EMAIL

Barbara Fry
Chief, Measures Assessment Branch, Stationary Source Division
California Air Resources Board
Headquarters Building
1001 "I" Street
P.O. Box 2815
Sacramento, CA 95812
bfry@arb.ca.gov

May 30, 2007

Re: Semiconductor Industry PFC Emissions White Paper

Dear Ms. Fry:

The Semiconductor Industry Association (SIA) is pleased to submit the attached White Paper describing perfluorocarbon use, emissions and stewardship in semiconductor manufacturing. This White Paper is intended to support the California Air Resources Board's (CARB)'s Global Warming Solutions Act of 2006 implementation efforts. We look forward to working with CARB as those efforts proceed.

A hard copy of the White Paper will follow in the mail. Please do not hesitate to contact me if you have any questions.

Very Truly Yours,

Charles I. Fraust

Charles Fraust, Ph.D.
Director, Environmental, Health and Safety
SIA

Attachment

cc: Diana Schwyzer, dschwyze@energy.state.ca.us

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PERFLUOROCARBON EMISSIONS
BY THE SEMICONDUCTOR INDUSTRY

A White Paper Submitted
To The
CALIFORNIA AIR RESOURCES BOARD
By The
SEMICONDUCTOR INDUSTRY ASSOCIATION
May 30, 2007

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I. INTRODUCTION AND SUMMARY

The Semiconductor Industry Association (SIA) has prepared this White Paper describing perfluorocarbon (PFC) use, emissions and stewardship in semiconductor manufacturing to support the California Air Resources Board (CARB)'s Global Warming Solutions Act of 2006 implementation efforts. SIA is a trade association representing the U.S. semiconductor industry, uniting companies responsible for more than 85 percent of semiconductor production in the U.S.[1] SIA is dedicated to maintaining the nation's world leadership in semiconductor technology while at the same time providing safe working conditions in production facilities and protecting the environment.

As detailed below, PFCs have been serving a critical function in semiconductor manufacturing since the phase-out of ozone depleting chlorofluorocarbons in the early 1990s. In recognition of PFCs' global warming potential, SIA member companies have long been proactive in emissions control and reduction.

A number of our members formalized an early voluntary commitment for PFC stewardship in a 1996 memorandum of understanding (MOU) with the U.S. Environmental Protection Agency (EPA). That commitment entailed data gathering and emissions reduction efforts. Upon expiration of this MOU, SIA member companies agreed in 2000 to a second MOU with EPA that imposes a hard target of 10% PFC emissions reduction relative to 1995 levels by the year 2010. This second MOU has been embraced in other regions around the world as part of an international effort by the industry to reduce PFC emissions from semiconductor manufacturing.

Notably, the most recent data demonstrate that semiconductor manufacturers -- including at facilities in California -- remain on track to meet the substantial 10% emission reduction target. The PFC emissions in California by MOU-participating SIA members have declined dramatically -- almost 70% -- since the 1996 inception of the voluntary reduction effort. These reductions stem not only from the MOU commitments, but also from a semiconductor manufacturing decline in California. This decline -- which has occurred over the last decade -- grows out of various economic factors and marketplace realities that have shifted manufacturing to other states and overseas, and semiconductor manufacturing capacity will not likely return to the state. As a consequence, the semiconductor manufacturing PFC emissions decline in California should continue into the future.

In SIA's view, the semiconductor industry's longstanding PFC stewardship and emissions reduction achievements render regulation under the Global Warming Solutions Act unnecessary. Notably, the European Union's fluorinated gases Directive 2006/40/EC does not impose specific emissions limitations or reduction requirements on the semiconductor industry. As a Working Group report prepared as part of the Directive development process recognized, "formal recognition" should be given to the voluntary reduction efforts by the semiconductor industry at a European level "to provide greatly more flexibility to industry" and to avoid overlapping government-imposed requirements. The semiconductor manufacturing decline in California further underscores the lack of a need for regulation.

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[1] See the SIA's website at: http://www.sia-online.org.

SIA understands that the reduction commitments -- and achievements -- by our members in California under the U.S. EPA MOU do not address a question that has been raised for CARB by several public information sources: The possibility that non-SIA member companies not participating in these commitments may operate in California and use PFCs. As described in this White Paper, SIA has initiated an information gathering effort designed to reach all facilities in California -- whether SIA member facilities or not. This effort -- although not complete -- already indicates that a number of facilities identified by these information sources do not currently engage in semiconductor manufacturing and/or do not use PFCs. SIA hopes to complete the information gathering within the next several months and will submit a final report with the results to CARB.

II. PFC USE IN THE SEMICONDUCTOR INDUSTRY

A. Nature of PFC Use

The semiconductor industry has used perfluorocarbons and hydrofluorocarbons (collectively referred to as "PFCs") in the fabrication of semiconductor silicon wafers since their predecessors, chlorofluorocarbons (CFCs), were phased out as ozone depleting substances. PFCs are used in two processes essential to semiconductor production: 1) cleaning of chemical vapor deposition (CVD) tool chambers, which are used to lay down thin films of chemicals onto the surface of silicon wafers; and 2) dry etching of integrated circuits into those thin films. The PFCs used in semiconductor fabrication are:

- hexafluoroethane (C_2F_6);
- octofluoropropane (C_3F_8);
- nitrogen trifluoride (NF_3);
- tetrafluoromethane (CF_4);
- sulfur hexafluoride (SF_6);
- trifluoromethane (CHF_3); and
- octofluorocyclobutane (C_4F_8).

Generally, C_2F_6, C_3F_8 and NF_3 are used for chamber cleaning, and account for about 50–70% of PFC usage at a semiconductor wafer fabrication site (or "FAB"). The remaining PFCs -- CF_4, SF_6, CHF_3 and C_4F_8 -- are used primarily in etching.

B. The Criticality of PFCs to Semiconductor Manufacturing

PFCs possess characteristics that cannot be duplicated by currently available alternative chemicals, and hence, are critical to the manufacturing of semiconductors and to the semiconductor industry. The fluoride atom in PFCs is highly effective in etching silicon and silicon oxide thin films on the surface of silicon wafers and the stable nature of PFCs allows unmatched precision in etching – a requirement for modern semiconductor manufacturing, which is dependant on the ability to produce ever smaller, and therefore faster, circuits. In addition to their high etching performance, PFCs also clean (CVD) tool chambers quickly and exceptionally well, which allows the deposition of high-purity thin films onto silicon wafers, another requirement of semiconductor manufacture. PFCs also are non-toxic, so they present little health risk to workers.

Because of these properties, PFCs are of unmatched performance in the fabrication of semiconductors. Indeed, without these gases, it simply would not be possible to etch circuits to the extreme limits required in the manufacture of leading edge integrated circuits. Furthermore, unless and until suitable substitutes are found, PFCs undoubtedly will play a critical role in the manufacture of the next generation of nano-devices.

III. THE SEMICONDUCTOR INDUSTRY HAS A LONGSTANDING COMMITMENT TO REDUCING PFC EMISSIONS IN THE U.S. AND GLOBALLY

A. First EPA Memorandum of Understanding

Almost immediately after substituting PFCs for CFCs in the early 1990s, SIA member companies began to consider approaches for stewardship, recognizing world concern that PFCs have global warming potential. After engaging in dialogue with U.S. EPA over a number of months, SIA member companies joined with EPA to form the "PFC Emission Reduction Partnership for the Semiconductor Industry." This Partnership was formalized in a 1996 Memorandum of Understanding (MOU) under which the participating companies agreed to: (1) endeavor to reduce the absolute and normalized rate of PFC emissions from U.S. semiconductor manufacturing operations; (2) share non-confidential information about technologies for reducing PFC emissions; (3) implement a comprehensive system for reporting their PFC emissions to EPA; and (4) undertake a research and development effort to determine whether it would be appropriate for the industry to set specific goals for PFC reduction.

B. World Semiconductor Council Voluntary Agreement

About the time the 1996 MOU with EPA was being finalized, the U.S. semiconductor manufacturers also entered into discussions with manufacturers worldwide, which led to the formation of the World Semiconductor Council (WSC) in 1996.[2] Initially, the WSC included the semiconductor industry associations of the United States (SIA) and Japan (JSIA), Europe (ESIA) and Korea (KSIA), with Taiwan (TSIA) and China (CSIA) joining later. The WSC's member associations currently represent about 85% of the world's semiconductor manufacturing capacity.

The WSC was established to promote cooperative semiconductor industry activities and to expand international cooperation in the semiconductor sector in order to facilitate the healthy growth of the industry from a long-term, global perspective. In furtherance of these goals, the WSC makes recommendations to the governments of member countries and discusses issues of common concern, including: environmental safety and health; e-commerce; tracking semiconductor trends; intellectual property protection; and developing trade rules.

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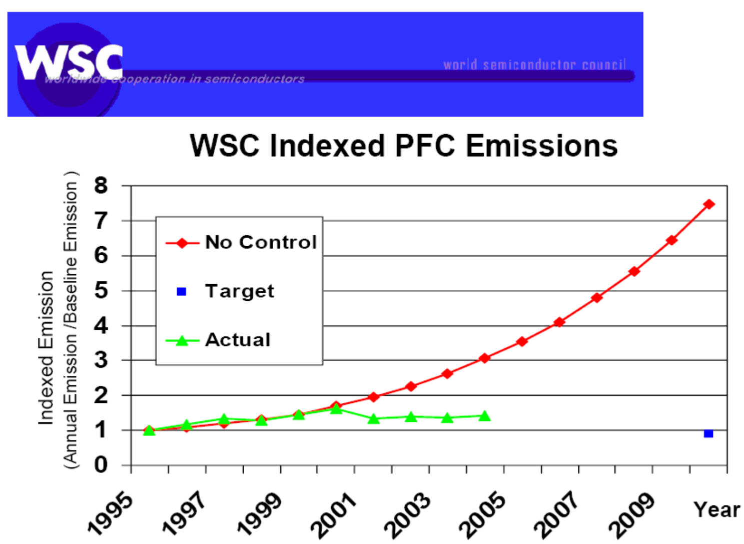
2 The WSC's website is available at: http://www.semiconductorcouncil.org.

One of the first cooperative projects undertaken by the WSC was the adoption, in 1999, of a voluntary global PFC emission reduction program with a goal of reducing absolute emissions to 10% below each association's baseline emission level by the year 2010.[3] The WSC voluntary agreement represented the first time that an international industry sector had joined together in a cooperative effort to address a global environmental problem. Figure 1 below presents the indexed, or relative, global PFC emissions reported by the WSC member associations since 1995. As shown by the red line in this graph, with no controls, global PFC emissions were projected to increase by a factor of more than seven between 1995 and 2010, due to worldwide increases in semiconductor manufacturing to meet the demands of today's technology-driven economy. However, as a result of the global emission reduction program, current worldwide emissions are instead only slightly above baseline levels, and the WSC expects the 10% reduction goal to be achieved by 2010. Furthermore, it is expected that new programs will be developed within the WSC to continue this effort into the next decade.

Figure 1: WSC Voluntary Agreement Participant Indexed PFC Emissions from 1995 to Present



C. Second EPA Memorandum of Understanding

In the wake of WSC voluntary agreement, the SIA entered into a second MOU with EPA in 2000.[4] Under the second MOU, participating SIA member companies commit to reducing total U.S. PFC emissions to 10% below 1995 levels (the SIA's baseline year) by the year 2010. These hard targets are to be achieved through a combination of strategies including: process optimization; development of alternative chemistries; recycling; and emissions abatement.

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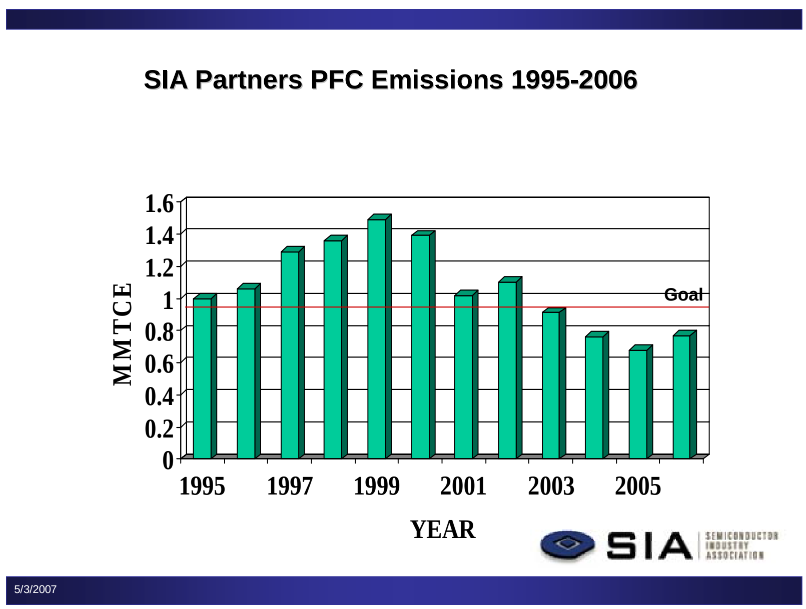
[3] The WSC's April 26, 1999 Announcement and Position Paper Regarding PFC Emissions Reduction Goal are included as Attachment A to this document.

[4] The 2000 MOU between SIA and EPA is Attachment B to this document.

MOU participants submit a yearly report to EPA documenting estimated total PFC emissions. Emissions are estimated using standard 2001 Intergovernmental Panel on Climate Change (IPCC) methodology. Figure 2 below presents total estimated PFC emissions by MOU participants since 1995, as reported to EPA under the MOU. The graph demonstrates that since the signing of the first MOU in 1996, total U.S. PFC emissions have been reduced substantially – from a maximum of about 1.4 MMTCE (5.1 $MMTCO_2$)[5] in 1999 to less than 0.8 MMTCE (2.9 $MMTCO_2$) in 2006. In addition, MOU participants are currently on track to meet the target of a 10% reduction in PFC emissions relative to 1995 levels by the year 2010 (about 09. MMTCE, or 3.3 $MMTCO_2$, as signified by the horizontal red line).

Figure 2: SIA MOU Participant PFC Emissions from 1995 to Present as MMTCE (Million Metric Tons of Carbon Equivalent)



While the data for California are not complete, PFC emissions from California MOU participants mirror the reductions seen for all MOU participants. Emission estimates for all California MOU facilities are presented in Table 1 and Figure 3, below. These data show that emissions from California MOU facilities have declined dramatically from 0.076 MMTCE (0.279 $MMTCO_2$) in 1995 to 0.023 MMTCE (0.084 $MMTCO_2$) in 2006 – an overall reduction of 69.7%. Although part of this is due to a decline in semiconductor manufacturing facilities in California -- e.g., a decline from six to three facilities among MOU participants -- the great majority of the overall reduction is the result of the stewardship efforts of the MOU participants.

As the data show, PFC emissions for the three MOU companies in continuous operation in California since 1995 account for most of the overall reduction. Their emissions fell from 0.061 MMTCE (0.224 $MMTCO_2$) to 0.023 MMTCE (0.084 $MMTCO_2$) – a reduction of 62.3% on their own, or 89% of the overall reduction. Moreover, since 1995, the percentage of total U.S.

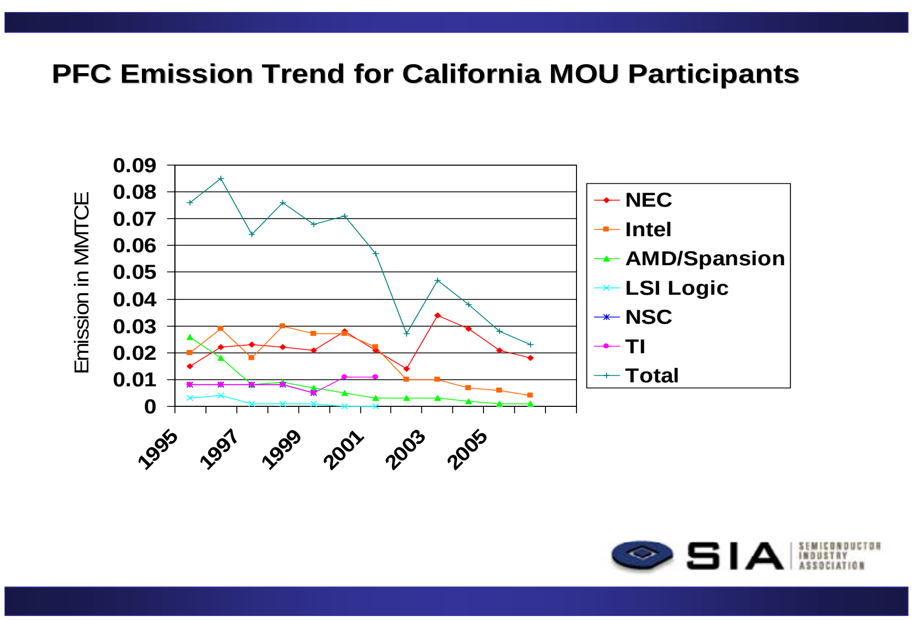
[5] Million Metric Tons of CO_2: 1.0 MMTCE = 3.67 $MMTCO_2$.

emissions versus California emissions among MOU participants has dropped from 7.6 % to about 3%. Given that U.S. emissions have dropped overall, this relative decrease in the California proportion of total U.S. emissions likely reflects diminished manufacturing capacity in California. SIA expects the decline in California PFC emissions to continue as a result of both MOU participant stewardship efforts and, as discussed below, a declining semiconductor manufacturing industry in California.

Table 1: Historical PFC Emissions for California MOU Participants (MMTCE)

Company	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
NEC	0.015	0.022	0.023	0.022	0.021	0.028	0.021	0.014	0.034	0.029	0.021	0.018
Intel	0.020	0.029	0.018	0.030	0.027	0.027	0.022	0.010	0.010	0.007	0.006	0.004
Spansion/AMD	0.026	0.018	0.008	0.009	0.007	0.005	0.003	0.003	0.003	0.002	0.001	0.001
Total for NEC/Intel/Spansion	**0.061**	**0.069**	**0.049**	**0.061**	**0.055**	**0.06**	**0.046**	**0.027**	**0.047**	**0.038**	**0.028**	**0.023**
LSI Logic	0.003	0.004	0.001	0.001	0.001	--	--	--	--	--	--	--
National Semiconductor	0.004	0.004	0.006	0.006	0.007	--	--	--	--	--	--	--
Texas Instruments	0.008	0.008	0.008	0.008	0.005	0.011	0.011	--	--	--	--	--
Overall Total	**0.076**	**0.085**	**0.064**	**0.076**	**0.068**	**0.071**	**0.057**	**0.027**	**0.047**	**0.038**	**0.028**	**0.023**
Overall Total as $MMTCO_2$	**0.279**	**0.312**	**0.235**	**0.279**	**0.25**	**0.261**	**0.21**	**0.099**	**0.172**	**0.14**	**0.103**	**0.084**
% of US total	**7.60**	**8.02**	**4.96**	**5.59**	**4.56**	**5.11**	**5.59**	**2.45**	**5.16**	**5.00**	**4.12**	**2.99**

Figure 3: PFC Emissions for California MOU Participants (MMTCE)



D. Emission Reduction Strategies

Much of the decrease in PFC emissions in California, as well as the decrease nationwide and globally, results from the application of a combination of emission reduction strategies outlined in the MOU. As described below, these strategies, which include process optimization, development of alternative chemistries, emissions abatement, and recover/recycling, have proven to be of varying effectiveness.

1. Process Optimization

Initial reductions in PFC emissions were achieved through process optimization. Process optimization is used primarily in the chamber clean process for two reasons: 1) most of PFC gas usage is for chamber clean; and 2) the chamber clean process, in general, has less impact on wafer fabrication. Within the scope of chamber clean, process optimization can reduce PFC emissions through the use of endpoint detectors and/or process parameter variation to find the point optimum for PFC utilization. In some cases, chamber clean optimization can yield emission reductions on the order of 10–50%.

2. Alternative Chemistry Development

The largest portion of the emission reductions achieved to date stem from substituting NF_3 for C_2F_6 in the chamber clean process. NF_3 is more effectively destroyed in this process, resulting in lower emissions. As with process optimization, chemical substitution in the chamber clean process is less likely to affect wafer fabrication as compared to the etching process. Some work has been done, however, to identify alternative etch chemicals. But, etch substitution necessitates an expensive, time-consuming requalification process to ensure that the new chemistry performance is equivalent to that of the original etch gas.

3. Emissions Abatement

One of the greatest successes of the EPA MOU program has been the rapid development and commercialization of abatement equipment. At the beginning of the MOU, companies had little or no access to abatement equipment specifically designed to reduce PFC emissions. Now, abatement equipment is readily available to semiconductor manufacturers to meet most any need. Abatement technology can be applied to PFC emissions from both chamber cleans and etch processes. Certain abatement technologies may be better suited for one or the other. Abatement systems can be applied locally as point-of-use (POU) devices or FAB-wide as end-of-pipe (EOP) devices. The most common technologies used to abate PFCs are high temperature and catalytic oxidation, and plasma destruction. Some include post treatment to remove byproducts produced during the abatement process, such as F_2 and HF. Typically, these systems are capable of removing more than 90% of the PFCs in the process waste stream.

4. Recovery/Recycling

To date, recovery/recycling methods have not achieved the same level of success as other forms of abatement. A number of systems have been proposed and evaluated, but several issues remain to be resolved. In particular, recovery systems generally require extensive pre-treatment and a considerable amount of maintenance. Additionally, recovered product typically has more impurities than virgin chemicals, but will cost more to use. Therefore the reuse of recovered materials from chamber clean and etch in not likely to contribute significantly to a reduction in PFC emissions.

IV. STATE CONTROLS ARE UNNECESSARY AND REDUNDANT IN LIGHT OF THE VOLUNTARY EMISSIONS REDUCTION FRAMEWORK

Based on its own analysis, the European Union has concluded that industry voluntary controls are preferable to government controls of PFC emissions. SIA believes the same holds true for California.

The first phase of the European Climate Change Programme (ECCP) established a Working Group on fluorinated gases (Working Group) whose purpose was to develop the framework of an EU policy to reduce emissions of the fluorinated greenhouse gases addressed by the Kyoto Protocol, including PFCs, in a cost effective way. The specific objectives of the Working Group were to: 1) identify the most relevant applications that should be subject to common and coordinated policies of the European Community; and 2) elaborate a proposal for cost-effective instruments for each of the investigated applications.[6] After reviewing several industry sectors in which fluorinated gases are used, the Working Group determined that "[i]n a number of sectors voluntary and/or negotiated agreements are considered to be an appropriate policy instrument . . ." and that "[i]n some markets they could provide the primary policy mechanism to achieve emission reductions (e.g. semi-conductor industry)."[7]

When addressing sector-specific recommendations, and in particular semiconductor production, the Working Group stated that "[v]oluntary 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)."[8] Moreover, in considering EU-wide versus national action, the Working Group stated that "[v]oluntary agreements on the European level would provide greatly more flexibility to industry than national solutions and would thus be far more effective."[9] Likewise, SIA believes the semiconductor industry's nationwide voluntary PFC emission reduction effort in the U.S. is a more effective method of controlling PFC emissions than would be state-level regulations.

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[6] See Final Report on the European Climate Change Programme, Working Group Industry, Work Item Fluorinated Gases (June 18, 2001) at p. 3, which is Attachment C to this document. Also, available at: http://ec.europa.eu/environment/climat/pdf/eccp_wg_final_report.pdf.

[7] *Id.* at pp. 8-9.

[8] *Id.* at p. 43.

[9] *Id.*

The Working Group's recommendations for the semiconductor industry were in contrast to its recommendations for other sectors. For example, for the PFC solvents, fire fighting, and magnesium production and casting sectors, the Working Group stated "[m]onitoring and containment should be addressed via the recommended Community Directive on Fluorinated Gases." Similarly, for the refrigeration and stationary air conditioning sector, the Working Group concluded "[i]t is strongly recommended that this market sector be part of the Community Directive on Fluorinated Gases to address all containment and Monitoring/verification issues." Thus, where for certain sectors the Working Group recommended that PFC emissions be addressed by EU-wide legislation (i.e., the Community Directive on Fluorinated Gases), for the semiconductor industry it explicitly acknowledged the effectiveness of its voluntary emission reduction program, and recommended no further legislative emission controls. The Working Group's recommendations were endorsed by the European Commission.[10]

Ultimately, the EU enacted Directive 2006/40/EC,[11] which creates explicit fluorinated gas containment and recovery requirements for certain sectors, such as refrigeration and air conditioning, solvents and fire protection systems.[12] However, while the Directive did include certain generally-applicable recovery requirements that could be applied to the semiconductor industry -- such as recovery and disposal of residual fluorinated gases in spent cylinders or contained in "other equipment"[13] -- it created no requirements specific to the semiconductor manufacturing sector other than reporting of the volumes of gases produced or imported for use in the sector.[14] As such, the EU's final fluorinated gas control law did not impose any specific emission reduction measures on the semiconductor sector beyond the industry's voluntary emission reduction program.

The EU's conclusions with respect to the European semiconductor industry apply equally to California. The significant reductions accomplished through the MOU initiative, both nationally and in California, demonstrate the effectiveness of the industry's voluntary initiative. Consequently, SIA believes that the semiconductor industry's voluntary and effective PFC stewardship is preferable to state-imposed requirements.

V. CALIFORNIA-BASED SEMICONDUCTOR MANUFACTURING

A. Decline in Semiconductor Manufacturing

California, and in particular Silicon Valley in Santa Clara County, is generally perceived to be the center of the U.S. semiconductor industry, but in reality, California semiconductor

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[10] See, Second ECCP Progress Report: Can we meet our Kyoto targets? at p. 44, available at: http://ec.europa.eu/environment/climat/pdf/second_eccp_report.pdf.

[11] Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated gases, included as Attachment D to this document and available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:161:0001:0011:EN:PDF.

[12] See *Id.* at Articles 3 and 4.

[13] *Id.* at Article 4.

[14] See *Id.* at Article 6.

manufacturing has been in decline. This decline -- which has occurred over the last decade -- grows out of various economic factors and marketplace realities that have shifted manufacturing to other states and overseas. For these same reasons, semiconductor manufacturing capacity will not likely return to the state.

Many semiconductor companies historically manufacturing in California have elected to cease doing so in favor of other states such as Arizona and Oregon, or altogether by going "FAB-less" in the U.S. (*i.e.*, utilizing overseas foundry companies that manufacture semiconductors for multiple customers). The reasons for this trend are numerous and include: the high capital costs associated with the production of leading edge semiconductors in California; tax and other advantages offered by state and foreign governments; and the lower financial risk involved in foundry manufacturing compared to self manufacture, especially for smaller companies.

As an illustration of the decline in California semiconductor manufacturing, in 1995, six of the companies participating in the first EPA MOU operated FABs in California; by 2006, that number had fallen to three. (See Table 1 above). Of the three remaining MOU participant FABs in California, only one is a true manufacturing facility, or IDM (integrated device manufacturer), while the other two are Research and Development (R&D) facilities, and therefore use only small quantities of PFCs. (See Attachment E).

B. <u>SIA Information-Gathering Underscores Decline</u>

To obtain a clearer picture of statewide semiconductor manufacturing, SIA is currently working to gather additional information on California semiconductor manufacturing and PFC emissions beyond the data submitted by the California MOU participants. To date, we have been able to obtain an estimate of emission data from four non-MOU semiconductor manufacturers, including the three largest non-MOU companies. The total estimated 2006 emission from these sites was calculated to be 0.0432 MMTCE (0.15 $MMTCO_2$). Combined with the data for the existing MOU sites in California, total emissions are 0.078 MMTCE (0.28 $MMTCO_2$), which is significantly less than the 0.137 MMTCE (0.5 $MMTCO_2$) reduction that California identified in the "Early Action Report."

In addition, in a report by the California Energy Commission, total California greenhouse gas emissions in 2002 were estimated at about 115.1 MMTCE (422 $MMTCO_2$).[15] Based on this estimate, semiconductor manufacturing in California represents only about 0.07% of the California greenhouse gas inventory. SIA intends to provide additional emission information to CARB as it is made available. In the meantime, other information is available that can be used to characterize the extent of semiconductor manufacturing in California.

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[15] See California Energy Commission, Inventory of California Greenhouse Gas Emissions and Sinks: 1990-2004, CEC-600-2006-013-SF, (December 2006), available at: http://www.energy.ca.gov/2006publications/CEC-600-2006-013/CEC-600-2006-013-SF.PDF

1. **Industry Employment Figures**

Employment figures for the semiconductor industry also illustrate the recent decline in California semiconductor manufacturing. Figure 3 below shows the most recent available statewide monthly employment data obtained from The California Employment Development Department (EDD) for the semiconductor industry. The employment data show a 20% decline in overall semiconductor industry employment from 2001 to 2003, with slight fluctuations in employment since 2003. The general decrease in California semiconductor industry employment also can be observed by comparing the State trend with that of Santa Clara County, as presented in Figure 4 below. According to the latest statistics from the State, semiconductor employment in Silicon Valley has exhibited a steady decline since 2001.

Figure 3: California Employment Patterns for Semiconductor Industry (1983-2003)

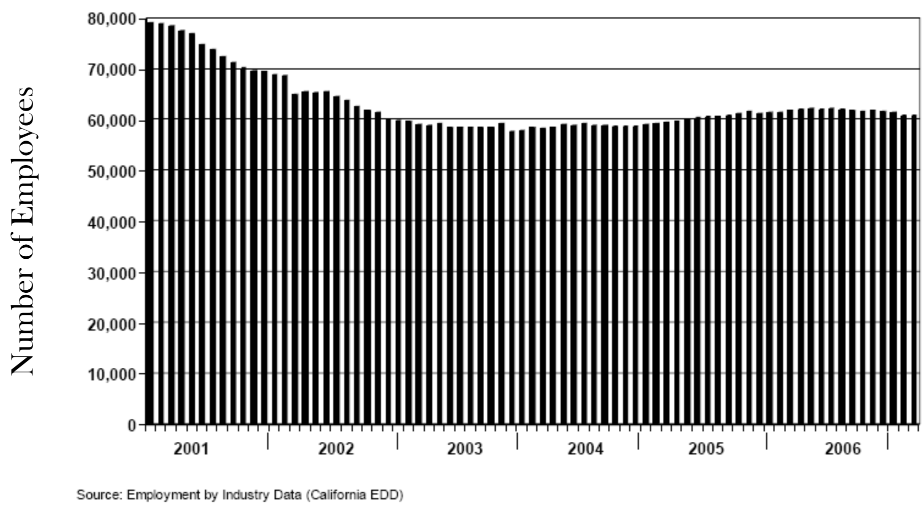
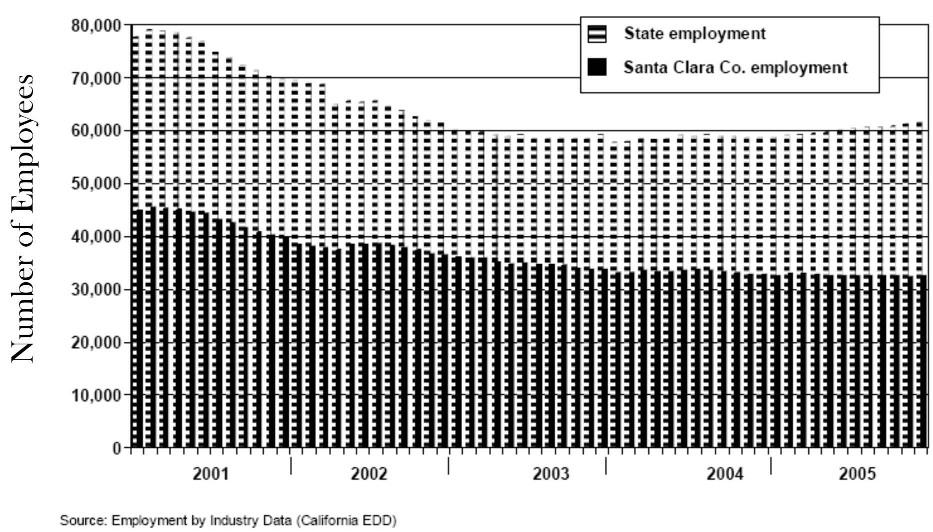


Figure 4: Employment Estimates for California Semiconductor Industry State & Santa Clara County: 2001-2005



In addition, the semiconductor industry employment statistics shown above do not reflect the fact that most "semiconductor industry" employees in the state are not directly associated with semiconductor manufacturing and instead work in administrative, sales, training, distribution and various support activities. In fact, according to the latest (2005) U.S. Department of Labor occupational employment statistics for California, employees classified as "Semiconductor Processors" (by Standard Occupational Classification code 51-9141) number only 11,400, as compared to the industry total of 59,206.[16] Thus, less than 20% of semiconductor industry employees are actually involved in the manufacture of semiconductors.

Finally, the decreasing trend in California semiconductor industry employment has been acknowledged by the State, itself. The publication "Manufacturing Careers," published online by the California EDD in March, 2007, included a section on "Semiconductor Processors."[17] The EDD's projection for this occupation was an increase of only 300 employees over the next decade (i.e., 2004 to 2014), with a projected number of 11,400 "Semiconductor Processors" in 2014. As stated by the EDD in this section: "Growth of the occupation, Semiconductor Processors, will be slower than average compared to all California occupations. Many companies in the United States are building plants overseas where costs are lower and downsizing their operations in our country."[18]

As recognized by EDD, the California agency responsible for analyzing State occupational and industry employment statistics, the primary occupation associated with the manufacture of semiconductors in the California has stagnated and is not expected to grow in numbers over the next decade. This corroborates the SIA's experience and expectations that employment in the California semiconductor manufacturing sector will continue to decline along with semiconductor manufacturing activities in the State.

2. World Fab Watch Data

SIA understands that CARB has reviewed information obtained from World Fab Watch (WFW), an online database of worldwide semiconductor FAB locations, suggesting there are about 75 active semiconductor manufacturing sites in California.[19] Because SIA was only aware of the three MOU participants' FAB sites and a few additional sites operated by SIA member companies that are not MOU participants, SIA asked Dr. Don Lassiter, a consultant who has worked extensively with semiconductor industry demographic data, to review and characterize the WFW database for California sites. A brief summary of the WFW data for California facilities is included as Attachment E to this document.

Dr. Lassiter's review indicates that the WFW database indeed lists 75 sites as California semiconductor facilities, including the three active SIA MOU participant sites. These sites are

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16 See Attachment F for online employment statistic resources utilized for this document.

17 Available at: http://www.calmis.ca.gov/file/Manuf/Mfg-Semiconductor-Processors.pdf.

18 *Id.* at p. 199.

19 World Fab Watch, though not a freely-available database, is available at: http://www.scfab.com/index.php?p=view_product&product_id=6.

operated by 57 different companies. However, not all of the FABs in the WFW database are active manufacturing sites, and not all of the active FABs necessarily use or emit PFCs in significant amounts. Dr. Lassiter found that, among the 75 California sites:

- one is closed;
- two are universities, and not manufacturers;
- two are operated by an equipment supplier, and likewise not engaged in manufacture of semiconductors;
- twenty-nine sites were listed as R&D and/or pilot facilities, which also would use only small quantities of PFCs;
- thirty-two sites processed less than 1000 wafers/month (8" equiv.), a very small number that would require only small quantities of PFCs;[20]
- in all, sixty-two sites each processed less than 10,000 wafers/month (8"equiv.), also a relatively small quantity;
- only one site processed more than 21,000 wafers/month (8"equiv.); and
- only 3 sites had clean room space in excess of 100,000 sq ft, which would indicate that even the potential for substantial semiconductor manufacturing and PFC use was limited.

Thus, further inspection of the WFW data indicate that about half (34)[21] of the listed FABs are pilot facilities or engage in R&D and hence do not engage in commercial wafer fabrication, and therefore are likely to use very small amounts of PFCs. In addition, most of the FABs listed (62) do not process a large quantity of semiconductors, with maximum production of less than 10,000 wafers per month (8" equivalent), and only four sites process a maximum of more than 21,000 wafers per month. Furthermore, as shown in the attached summary, not all of the information contained in the WFW database is up-to-date; information for 20 facilities has not been updated since 2002, and most (at least 47, but perhaps more because 14 list no date) have not been updated since 2005. Given the economic and marketplace trends discussed above, it is not likely that the number of FABs, particularly manufacturing sites, has increased since 2002.

C. <u>EPA Toxic Release Inventory Data</u>

Dr. Lassiter also reviewed EPA's Toxic Release Inventory (TRI) established under the federal Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA). Under the TRI, facilities with more than 10 full-time employees that use more than 10,000 pounds of any reportable chemical on the TRI list must report environmental releases and media transfers of such chemicals to the EPA, annually. TRI reporting is accomplished using EPA Form-R, which

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[20] Note: in general, $<$ 1000 wafer starts/month is considered small, 1000-10,000 wafer starts/month moderate, and $>$ 10,000 wafer starts/ month large

[21] The sum of 1 closed site + 2 universities + 2 equipment suppliers +29 R&D sites = 34 non-manufacturing sites.

identifies the quantities of these chemicals that are released into the air, water and soil, or transferred off-site for disposal, further treatment or to sewage systems (i.e., publicly-owned treatment works).

Although none of the PFCs used in semiconductor manufacturing, and addressed in the MOU, are listed as reportable TRI chemicals (because they are not toxic), a number of chemicals essential to most semiconductor manufacturing activities are listed, including: hydrogen fluoride; hydrochloric acid; sulfuric acid; nitric acid; ammonia; and n-methyl-2-pyrrolidone. Because the use of more than 10,000 pounds of any one of these chemicals -- a small amount for a manufacturer -- would "trigger" the TRI reporting requirement, it can be assumed that even small semiconductor manufacturing facilities could be identified in EPA's annual public TRI database publication.

The most recent TRI data available are for calendar year 2005. Dr. Lassiter downloaded the 2005 public TRI database for the State of California, and extracted data records for all facilities that reported use of the above chemicals. This included all data elements provided on EPA's reporting form (Form-R), which also requires facilities to list U.S. Department of Labor Standard Industrial Classification (SIC) codes relevant for the facility, one of which is for "Semiconductors & Related Devices." Using the SIC codes, Dr. Lassiter identified 30 California Semiconductor facilities, three of which are operated by MOU participants (Intel, NEC & Spansion/AMD).

Dr.Lassiter also retrieved primary contacts and telephone numbers for each of the non-MOU reporting facilities. He then contacted these facilities and conducted a telephone survey to determine answers to the following questions:

Is the facility actually manufacturing semiconductor devices at the present time?

If so, does the facility use any of the 7 PFCs addressed in the MOU?

If so, does the facility maintain purchase, use or emission records for these chemicals?

If so, would the facility provide such data to be used confidentially in deriving estimates of emissions for the facility?

Based on discussions with the facility contacts, two facilities were determined to be too small to warrant further consideration as contributors of PFC emissions. The 25 remaining non-MOU facilities responded to the initial questions (above) as follows:

- ten facilities were not involved in the manufacture of semiconductor devices;
- fifteen facilities were involved in the manufacture of semiconductor devices (including solar arrays and X-ray sensor arrays) and used one or more of the PFCs;
  - of those 15, four facilities provided PFC use data to SIA (confidentially), from which emissions were estimated and noted earlier; and
  - of the remaining 11 companies, nine are known to use some PFCs but have not as yet provided usage information

In summary, publicly available TRI reporting data indicate that only 30 facilities in California self-identify as semiconductor facilities, and of those, only 18 (including the three MOU companies) are actually involved in the manufacture of semiconductors. This number is significantly below the number of California FABs suggested by the WFW database. SIA is working to determine whether the 11 facilities it has not yet been able to contact in fact use PFCs, and if so, whether those facilities would be willing to share their PFC use information with SIA, which SIA would then provide to CARB along with MOU participant data.

VI. CONCLUSION

PFCs are chemicals that are critical to both the present and foreseeable future of semiconductor manufacturing. Because PFC emissions contribute to global warming, the semiconductor industry, through various industry associations, has committed to a worldwide voluntary program to reduce PFC emissions. This program has, over the course of its 12 years, been very successful at reducing PFC emissions internationally, nationally and in California; currently both the global and U.S. initiatives are expected to meet their goal of reducing PFC emissions to at least 10% below baseline levels by the year 2010.

While SIA recognizes that some information sources suggest the possibility that non-SIA member companies not participating in the MOU commitment currently operate semiconductor manufacturing facilities in California, SIA has initiated an information gathering effort designed to reach all facilities in California. This effort -- although not complete -- already indicates that a number of facilities identified by these information sources do not currently engage in semiconductor manufacturing and/or do not use PFCs. SIA hopes to complete the information gathering within the next several months and will submit a final report with the results to CARB.

Given the small proportion (0.07%) of California's overall greenhouse emissions accounted for by the semiconductor industry, the successes achieved through the semiconductor industry's voluntary efforts, and the decline in California semiconductor manufacturing -- a trend that both SIA and the State believe is not likely to reverse -- SIA believes that additional state regulation of PFC emissions under the Global Warming Solutions Act are unwarranted. Such regulations would impose additional and unnecessary burdens on an already declining industry in California.

In SIA's view, responsible and effective industry action is preferable to additional state regulatory requirements that may overlap and conflict with existing voluntary emission reduction goals. For this reason, the SIA recommends that CARB, like the EU, recognize that a proactive voluntary approach to PFC emission reduction is the most appropriate solution for the semiconductor industry.

ATTACHMENTS

A. The WSC's April 26, 1999 Announcement and Position Paper Regarding PFC Emissions Reduction Goal

B. 2000 MOU between SIA and EPA

C. Final Report on the European Climate Change Programme, Working Group Industry, Work Item Fluorinated Gases (June 18, 2001)

D. Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated gases

E. Summary of World Fab Watch Data for California FABs

F. Summary of Online Employment Statistic Resources

DC\990707.5

ATTACHMENT A:
The WSC's April 26, 1999 Announcement and Position Paper Regarding
PFC Emissions Reduction Goal

Contact: Daven Oswalt
Molly Marr

www.semichips.org

For Immediate Release:
April 26, 1999 #11

Successful World Semiconductor Council Concludes in Italy

-Trade Associations Agree to Reduce Emissions-

San Jose - Several key decisions were made at the third annual meeting of the World Semiconductor Council (WSC), held in Fiuggi, Italy, on April 23 – among them was a commitment to work together to reduce emissions of PFCs.

The membership of the WSC includes the Semiconductor Industry Association (SIA), the Electronic Industries Association of Japan (EIAJ), the European Electronic Component Manufacturers Association (EECA), the Korea Semiconductor Industry Association (KSIA) and the Taiwan Semiconductor Industry Association (TSIA). The WSC was created pursuant to the Agreement between EIAJ and SIA on International Cooperation Regarding Semiconductors of August 2, 1996.

The WSC issued the following joint statement that summarizes the council's efforts to forge a consensus on environmental issues, the promotion of free and open markets, and other issues that face the global semiconductor industry. Also attached is the position paper regarding the WSC's PFC Emissions Reduction Goal.

WSC Joint Statement

The European Electronic Component Manufacturers Association (EECA), the Electronic Industries Association of Japan (EIAJ), the Korea Semiconductor Industry Association (KSIA), the Semiconductor Industry Association (SIA) of the United States, and the Taiwan Semiconductor Industry Association (TSIA) today held the third meeting of the World Semiconductor Council (WSC) in Fiuggi/Italy.
The WSC was created pursuant to the Agreement between EIAJ and SIA on International Cooperation Regarding Semiconductors of August 2, 1996.

It is the purpose of the WSC to enhance mutual understanding, to address market access matters, to promote co-operative industry activities, and to expand international cooperation in the semiconductor industry in order to facilitate the healthy growth of the industry from a long-term, global perspective. All WSC activities are based on a respect for market principles. The WSC reaffirmed that markets should be open and competitive, free of all tariff barriers, without discrimination based on capital affiliation. Purchasing decisions should be based on quality, cost, delivery, and service.

Opening statements were made by Pasquale Pistorio (EECA), who chaired this meeting, and by Takamitsu Tsuchimoto (EIAJ), Yoon-Woo Lee (KSIA), Wilf Corrigan (SIA), and Morris Chang (TSIA). The keynote speech under the title "1999 The Year of the Question Marks", was delivered by Doug Dunn (ASML). A report on the EU Economic Situation was given by Jean-Philippe Dauvin (EECA).

Antitrust counsel were present throughout the meeting. During the meeting, the following reports were received and actions confirmed.

(more)

New Member

The Council Members welcomed the Taiwan Semiconductor Industry Association (TSIA) as a new member following the formal commitment of the Taiwan customs territory to expeditiously eliminate semiconductor duties and its Authority's agreement to support the objectives and activities of the WSC and Government Consultative Mechanism.

Agreement Establishing a New World Semiconductor Council

The Charter of the WSC is based on the 1996 bilateral Agreement between EIAJ and SIA.

The WSC approved a multilateral Agreement establishing a new World Semiconductor Council to take effect on August 1, 1999, provided that conditions attached to its coming into effect have been met by that date.

User/Supplier Cooperation

The User/Supplier Cooperation Committee reported the results of four symposia that were held in the Tokyo area since the last WSC in April 1998. Those four symposia included two on telecommunications, one on automotive and one on emerging applications (multimedia).

Members attending the Council recognised that the cooperative activities in the Japanese market are being faithfully conducted and continued by the participating industry associations in accordance with the Agreement between EIAJ and SIA on International Cooperation Regarding Semiconductors, dated August 2, 1996.

It was also reported that UCOM will be dissolved and terminate its activities on August 2, 1999. Before the termination two more events are planned. A symposium will be held on June 24 for emerging applications (advanced video), and a Business Promotion Forum is planned on June 10 for automotive chips.

Reports were well received by the members attending the Council. Appreciation to UCOM was expressed for their excellent support of these activities during the past eleven years. In gratitude, a reception will be held in Tokyo on July 22 to thank the UCOM participants.

Supplier/Supplier Cooperation

Environment, worker safety and health, the year 2000 challenge, further liberalisation of trade and investment, and market development were reaffirmed as issues on which there is shared common interest in the semiconductor industry.

Specifically, the WSC approved several actions:

The 3rd World Semiconductor Council has adopted a Position Paper on PFC Emissions Reduction Goal that was worked out and proposed by the ESH Task Force established under the WSC and consisting of expert representatives from the four semiconductor industry associations, EECA, EIAJ, KSIA and SIA. (Position Paper attached to this Joint Statement.) This agreement exhibits a proactive initiative of world semiconductor industry towards responsible environmental stewardship through international cooperation.

The WSC will also cooperate to ensure all industry suppliers of equipment and gases deliver solutions globally to provide a fair and harmonized base for the reduction of PFC emissions by world semiconductor industry.

At this meeting, the WSC, noting agreement on a global PFC emissions reduction goal as stated in the attached position paper, encouraged other cooperative efforts of the WSC ESH Task Force to share information and explore approaches to issues such as energy and water conservation, chemical management, and worker safety. Members confirmed their support for the 6th International Semiconductor ESH Conference, which will be hosted by SIA on June 14–16, in Williamsburg/Virginia.

Given the importance of the Y2K challenge to all semiconductor manufacturers, the WSC decided to exchange information on utility infrastructure readiness.

Because the Internet is one of the leading electronic infrastructures for the next decade, the WSC asked the Joint Steering Committee to create a mechanism to explore cooperative activities to facilitate E-Commerce and the use of the Internet.

To support international co-operation on technology, the WSC endorsed being a sponsor of the International Forum on Semiconductor Technology, to be held in California in April 2000.

The WSC anticipates that the Technology Roadmap will address post-silicon-based technology in the future.

Free and Open Markets

The WSC reaffirmed its commitment to policies which promote free and open markets around the world, intellectual property protection, full transparency of government policies and regulations, non-discrimination for foreign products in all markets, and an end to investment restrictions tied with technology transfer requirements.

The WSC received a report on the work of a study group to assess the causes of dumping and possible recommendations for fair and effective antidumping measures world-wide. The WSC determined to address this subject again in the Joint Steering Committee after a period of six months.

The WSC also reaffirmed that markets should be tariff-free. In order to spread the benefits of information technology to consumers around the world, further countries should be encouraged to sign on to the Information Technology Agreement.

Adopting a non-regulatory, market-oriented approach to E-Commerce, the WSC reaffirmed its position that the Internet should be a tariff-free environment. The WTO moratorium should remain in place.

The WSC applauds the recent significant progress made towards China's accession to the World Trade Organization (WTO) on commercially viable terms, including its elimination of tariffs on semiconductors and other information technology products under the Information Technology Agreement (ITA).

The WSC decided to communicate further with the China Semiconductor Industry Association regarding its WSC membership.

Analysis of Semiconductor Market and Trade Flow Data

The WSC received and reviewed a report on semiconductor market and trade flow data, including data on market size and market growth.

Reports to Governments

The results of today's meeting will be submitted to the governments of members of the WSC for consideration at the meeting of the Government Consultative Mechanism (to be held this year on 10 June in Brussels) as described in the Joint Statement by the Government of the United States and the Government of Japan Concerning Semiconductors dated August 2, 1996. This will include the following reports and recommendations for their review:

(1) report on the semiconductor market and trade flow data prepared by industry experts;

(2) reports on the user-supplier co-operative activities, and

(3) reports on the supplier-supplier co-operative activities.

The next meeting of the WSC will be hosted by the Korea Semiconductor Industry Association in April 2000.

Information about the members of the World Semiconductor Council can be found at their respective websites:

EECA: http://www.eeca.org
EIAJ: http://www.eiaj.or.jp
KSIA: http://www.ksia.or.kr
SIA: http://www.semichips.org
TSIA: http://www.tsia.org.tw

WORLD SEMICONDUCTOR COUNCIL MEETING

April 23, 1999, Fiuggi/Italy

EECA Delegates

Pasquale Pistorio Delegation Chairman
President and CEO
STMicroelectronics

Ulrich Schumacher
President and CEO
Infineon Technologies A.G.

Arthur van der Poel
Chairman and CEO
Philips Semiconductors International B.V.

Jürgen Knorr
Chairman of EECA Semiconductor Policy Committee
c/o MEDEA

EIAJ Delegates

Takamitsu Tsuchimoto Delegation Chairman
Executive Vice President
CEO of Electronic Devices
Fujitsu Ltd.

Suehiro Nakamura
Corporate Executive Vice President, Sony Corporation
President & CEO Core Technology & Network Company

Masanobu Ohyama
Corporate Senior Executive Vice President
Toshiba Corporation

Shigeki Matsue
Associate Senior Vice President
NEC Corporation

Kunio Hasegawa
Corporate Officer
Executive Vice President, Semiconductor & Integrated Circuits
Hitachi, Ltd.

Koichi Nagasawa
Vice President & Director
Group President, Semiconductor
Mitsubishi Electric Corporation

Yasumasa Mizushima
Corporate Senior Vice President
Logistics & Procurement
Sony Corporation

Mamoru Kitamura
Senior Vice President
Toshiba Corporation

KSIA Delegates

Yoon-Woo Lee — Delegation Chairman
CEO and President
Samsung Electronics

In-Kil Hwang
CEO and Vice Chairman
Anam Semiconductor

Kye-Hwan Oh
Senior Executive Vice President
Hyundai Electronics

SIA Delegates

Wilf Corrigan — Delegation Chairman
CEO & Chairman of the Board
LSI Logic Corporation

John Dickson
President, Microelectronics Group
Lucent Technologies

Steve Appleton
Chairman, CEO and President
Micron Technology

Brian Halla
Chairman of the Board
President and CEO
National Semiconductor Corporation

Pallab Chatterjee
Senior Vice President, Chief Information Officer
Texas Instruments

TSIA Delegates

Morris Chang Delegation Chairman
Chairman & CEO
TSMC

Hong-Jen Wu
President
UMC

***For additional information about the statement, please contact any of the individual associations.*

Position Paper Regarding PFC Emissions Reduction Goal

Emissions reduction for PFC's proposed by the World Semiconductor Council (WSC) Environmental Safety and Health (ESH) Task Force has been approved by members of the WSC (the European Electronic Component Manufacturers Association or EECA, the Electronic Industries Association of Japan or EIAJ, the Korea Semiconductor Industry Association or KSIA and the Semiconductor Industry Association in the U.S. or SIA) at the third WSC meeting in Fiuggi, Italy on April 23, 1999. The WSC is committed to proactively seek to reduce the emissions of PFC's from their semiconductor manufacturing processes.

1. Consensus on the PFC Emissions Reduction Goal

EECA, EIAJ, KSIA, and SIA have reached a consensus to reduce the aggregate absolute emissions of PFC's from the semiconductor fabrication facilities by 10% or greater by the year 2010. The baseline year for EECA, EIAJ, and SIA is 1995, and that for KSIA is 1997. The reduction goal will be applied to each association and be reviewed based on the latest progress as appropriate and necessary.

2. Background of the Emissions Reduction Goal

The semiconductor industry made a conscious choice to proactively pursue an international objective reflecting the global nature of the industry and the issue. This new global commitment is an outgrowth of our earlier voluntary efforts.

The PFC emissions reduction goal built upon the recent consensus reached by the WSC ESH Task Force on the standardized international measurement methods. While the industry is still not in a concrete position, due to technology constraints, to commit to specific emissions reduction methodologies, there have been significant advances in our understanding of potential ways to reduce PFC emissions. The industry will continue its efforts to identify sustainable and cost-effective alternatives that will reduce PFC emissions while not hindering the growth of global semiconductor industries. WSC Members participating in the ESH Task Force will also share pre-competitive information to achieve their progress toward the goal. The WSC will also collaborate to ensure all industry suppliers of equipment and gases deliver solutions globally to provide a fair and harmonized base for the reduction of PFC emissions.

3. Publication

The information on PFC emissions will be made available from each participating association according to their existing agreements.

# # # #

ATTACHMENT B:
2000 MOU Between SIA and EPA

Memorandum of Understanding Between the Semiconductor Industry Association (SIA) the United States Environmental Protection Agency

I. INTRODUCTION

A. This Memorandum of Understanding (MOU) is a voluntary agreement between the Semiconductor Industry Association (SIA) and the United States Environmental Protection Agency (EPA). SIA and EPA are hereinafter referred to as the "Partners." The continuing, collaborative efforts of EPA and SIA to reduce emissions of PFCs (as defined hereinafter) from the U.S. semiconductor industry, including this voluntary agreement, shall be referred to as the "PFC Reduction/Climate Partnership" (Partnership).

B. This MOU (1) builds on the substantial progress achieved by the U.S. semiconductor industry and EPA over the last five years through the "PFC Emission Reduction Partnership for the Semiconductor Industry" and (2) supports the international agreement reached through the World Semiconductor Council (WSC) by SIA and other trade associations representing semiconductor manufacturing companies throughout the world (hereinafter referred to as the "WSC Agreement").

C. The purpose of the Partnership is to reduce PFC emissions from semiconductor manufacturing operations. The Intergovernmental Panel on Climate Change (IPCC) has identified PFCs as potent greenhouse gases with long atmospheric lifetimes.

D. SIA is signing this MOU on behalf of the group of companies listed in Appendix I, which are hereinafter referred to as "participating companies." Other semiconductor manufacturing companies that wish to work collaboratively to reduce PFC emissions may do so either by becoming participating companies or by entering into separate voluntary agreements with EPA.

E. SIA is signing on behalf of the participating companies collectively and not as the agent for any individual company. This MOU applies only to the U.S. semiconductor manufacturing operations of the participating companies.

II. PARTNERSHIP GOAL

The Partnership Goal, which is designed to support the WSC Agreement, is to reduce the annual absolute PFC emissions of the participating companies collectively by ten percent (on an MMTCE basis) below the 1995 baseline PFC emissions of these companies before the end of 2010.

III. BACKGROUND AND GENERAL PRINCIPLES

A. The Partners recognize that (1) there is a very high growth rate in the demand for semiconductor devices; (2) the manufacture of increasingly complex semiconductor devices currently requires increased use of PFCs; and (3) there are no currently known replacements for

PFCs in semiconductor manufacturing, despite the industry's continuing efforts to develop technically feasible alternatives. In light of these three facts, the Partners also recognize that the Partnership Goal will be very challenging and that the semiconductor industry may need to make substantial voluntary investments in order to reach this goal.

B. U.S. semiconductor manufacturers participate in a highly competitive global industry. Restrictions on the availability or use of important materials such as PFCs could significantly affect the industry's ability to compete globally. Moreover, restrictions on the availability of semiconductors could limit the use or delay the introduction of products or devices that are used in energy-saving applications and therefore benefit climate protection.

C. The Partners will use this MOU to support the global efforts of the WSC to reduce PFC emissions worldwide. The Partners recognize that an industry-wide strategy will result in greater environmental protection by this highly globalized industry.

D. The following PFCs are utilized by the industry and are the subject of this MOU: perfluoromethane (CF_4), perfluoroethane (C_2F_6), sulfur hexafluoride (SF_6), nitrogen trifluoride (NF_3), trifluoromethane (CHF_3), and perfluoropropane (C_3F_8) (herein referred to collectively as PFCs). The Partners are mindful that, as semiconductor manufacturing processes evolve, other process chemicals with significant global warming potential may be added to this list.

E. Nothing in this MOU shall constrain the Partners from taking actions relating to PFCs that are authorized or required by law.

IV. SIA RESPONSIBILITIES

A. *Emission Reductions*: SIA and the participating companies will monitor progress toward the Partnership Goal and will support the Partners' efforts to reduce PFC emissions by (1) sharing information about potential PFC emission reduction processes and technologies that are not considered confidential; and (2) adopting technically feasible, cost-effective, and commercially available emission reduction techniques.

B. *Emissions Reporting*: Because the Partners recognize that PFC emissions data from individual companies have potential competitive significance, the Partners will designate a mutually acceptable third party (the Third Party) to collect emissions data annually from each participating company. By compiling such data, the Third Party will prepare an Annual PFC Emissions Report, which it will endeavor to submit to EPA no later than April 15th of each year for the previous year. The Report will include: (1) the aggregate (not company-specific) PFC emissions from all participating companies on an MMTCE basis; and (2) the aggregate (not company-specific) emissions of each PFC covered by this MOU from all participating companies on an MMTCE basis.

C. *Data Quality*: Each participating company will estimate its annual PFC emissions by using one of the Intergovernmental Panel on Climate Change (IPCC) Good Practice Inventory Tier 2 Methods for the Semiconductor Industry (IPCC Tier 2 Methods). For purposes of this paragraph, IPCC Tier 2 Methods shall mean the IPCC Tier 2 Methods in place as of August 1, 2000 or the latest version of such Methods mutually acceptable to the Partners.

Each participating company will prepare and submit to the Third Party a written explanation of the methodology it used to estimate its PFC emissions (hereinafter referred to as a "Methodology Write-Up"). In order to allow the Partners to have continued confidence in the reliability of the Annual PFC Emissions Reports, the Third Party will make available for review by EPA on the Third Party's premises (1) the Methodology Write-Ups and (2) the PFC emissions estimate for each company. In order to address the confidentiality concerns of the participating companies, the Third Party will remove company-identifying information from all such documents before making them available for EPA review.

The Third Party will make the documents available to EPA in such a way that EPA can match the individual emissions reports with the corresponding Methodology Write-Ups. EPA may review the Methodology Write-Ups to determine whether participating companies have estimated their emissions in accordance with the IPCC Good Practice Inventory Tier 2 Methods for the Semiconductor Industry.

D. *Interim Progress*: The Partners agree to publish a progress report by December 15, 2005, detailing the progress that has been made toward achieving the Partnership Goal. In addition, the Partners agree to hold periodic meetings to review progress on finding technically feasible, cost-effective, and commercially available approaches for reaching the Partnership Goal.

E. Each participating company will continue to evaluate and adopt one or more of the following strategies to reduce their PFC emissions to the extent that such strategies are appropriate in terms of protecting worker safety and the environment and are technically feasible, cost-effective, and commercially available: (1) more efficient use of PFCs in the manufacturing process; (2) use of substitute compounds; and (3) recycle and/or abatement options.

F. SIA and the participating companies agree that the activities they undertake in connection with this MOU are not intended to provide services to the Federal government and that they will not submit a claim for compensation based on this MOU to any Federal agency.

V. EPA RESPONSIBILITIES

A. *Support for Emission Reduction Efforts*: EPA will (1) participate in and support conferences to share information on emission reduction technologies; (2) address regulatory barriers that may impede voluntary, worldwide emission reduction strategies; (3) and recognize SIA and the participating companies for their emission reduction commitment, technical leadership, and achievements over time.

B. *Data Quality*: EPA will work with SIA and the IPCC to ensure that the IPCC Good Practice Inventory Tier 2 Methods for the Semiconductor Industry are reliable, accurate, and practical. EPA will also work with SIA to develop, if possible, a data verification method that can be used to self-certify emissions reductions. Upon request by SIA or a participating company, EPA will also work with individual companies to record and verify PFC emissions reductions. In all cases, EPA will work to ensure that emissions are evaluated and reported in such a way as to protect confidential business information. The Partners expect that companies that possess high quality emission reduction data will be in a preferred position to participate in any future program that provides appropriate rewards and recognition for early action.

C. *International Harmonization*: EPA will endeavor to support the efforts of the WSC to reduce global PFC emission reductions in the semiconductor industry worldwide, among other things by working with other governments to encourage the use of voluntary agreements similar to this MOU.

D. EPA acknowledges the benefits to the environment of the voluntary actions to reduce PFC emissions by SIA and the participating companies. EPA also acknowledges the significant contributions that SIA and the participating companies have made to advance the technical understanding of PFC emissions from semiconductor manufacture and towards the development and adoption of emission reduction methods. EPA expects to continue to work cooperatively with SIA and the participating companies, as well as other stakeholders, on any future activities relating to these emissions, with full recognition of the voluntary contributions of SIA and the participating companies.

E. *Designation of Single Liaison*: EPA will designate a single liaison to coordinate with SIA on the implementation of this MOU and other activities of the Partnership.

F. *Availability of Appropriations.* This MOU is not a funds-obligating document. All of EPA's activities are subject to the availability of appropriations.

VI. OTHER ISSUES

A. *Modification*: This MOU can be modified only by means of a document signed by both parties, including modifications to include additional compounds within the scope of the MOU or to add additional participating companies to Appendix I; provided, however, that a participating company may remove its name from Appendix I, and thus cease to be a participating company, by delivering written notice to both Partners.

B. *Effective Date and Termination*: The Partners agree that the terms outlined in this MOU will become effective when both Partners sign it. The Partners agree that either Partner may terminate this MOU at any time, for any reason, with no penalty. This MOU terminates on the date the Annual PFC Emissions Report for 2010 is submitted to EPA unless the MOU is extended in writing by the Partners.

C. *Effect on Existing MOUs*: The existing Memoranda of Understanding between EPA and participating companies that are part of The PFC Emission Reduction Partnership for the Semiconductor Industry are terminated as of the date on which this MOU is signed by both Partners.

D. *Enforceability*: This is a voluntary agreement that expresses the good-faith intentions of the Partners and is not enforceable by any party.

E. *Authority*: The undersigned hereby execute this Memorandum of Understanding on behalf of the Partners listed below. The participating companies listed in Appendix I have duly authorized SIA to sign this MOU on their behalf collectively and not as the agent for any individual company.

For the U.S. Environmental Protection Agency:

Signature: ____________________ Date: 1/19/2001

Name: Paul M. Stolpman
Title: Director, Office of Atmospheric Programs

For the Semiconductor Industry Association

Signature: ____________________ Date: Jan 16, 2001

Name: George Scalise
Title: President

Appendix I

Participating Companies

Advanced Micro Devices

Agere Systems

Agilent Technologies

Conexant Systems

Dominion Semiconductor, L.L.C.

Eastman Kodak Company

Fairchild Semiconductor Corporation

Hyundai Semiconductor America

IBM Microelectronics Division

Intel Corporation

Intersil Corporation

LSI Logic

Micron Technology, Inc.

Motorola

National Semiconductor Corporation

NEC Electronics, Inc.

Philips Semiconductors, Inc.

Sony Semiconductor Company of America

ST Microelectronics

Texas Instruments

ATTACHMENT C:

Final Report on the European Climate Change Programme, Working Group Industry, Work Item Fluorinated Gases (June 18, 2001).

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

Jochen Harnisch (Ecofys) & Ray Gluckman (Enviros)

Contact: j.harnisch@ecofys.de or ray.gluckman@enviros.com

June 18, 2001

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).

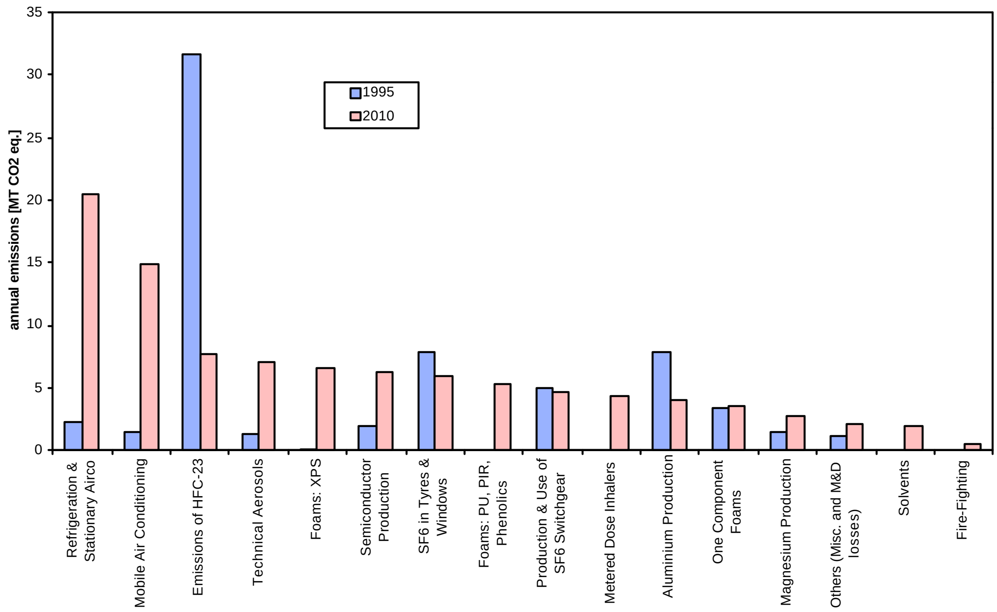

Figure 1 EU-15: Ranking of different sources[7] according to projected reference emissions of HFCs, PFC and SF_6 in 2010 in comparison to emissions in 1995.

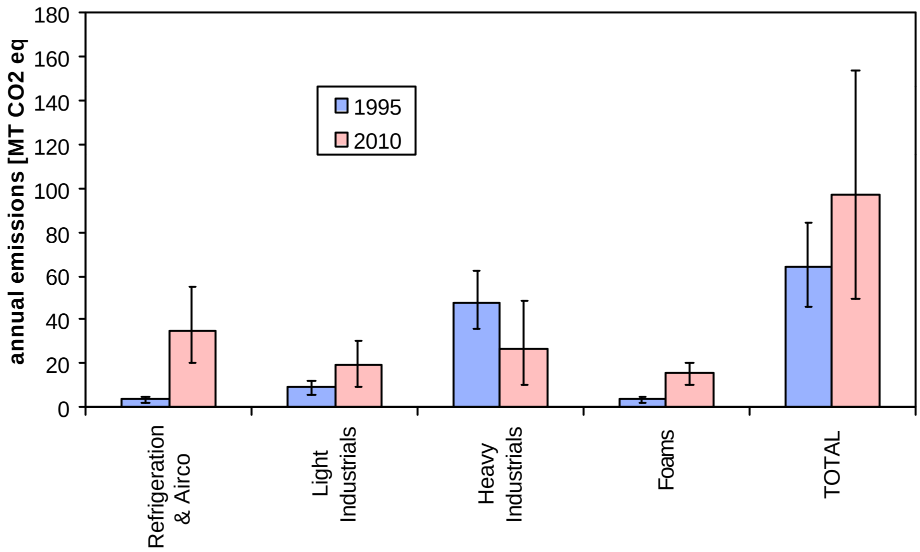

Figure 2 EU-15: Emissions of HFCs, PFC and SF_6 from different groups of sources in 1995 and projected for 2010 including uncertainty bands (see text above for details). Aggregated according to the different sessions of the ECCP process.

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[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.

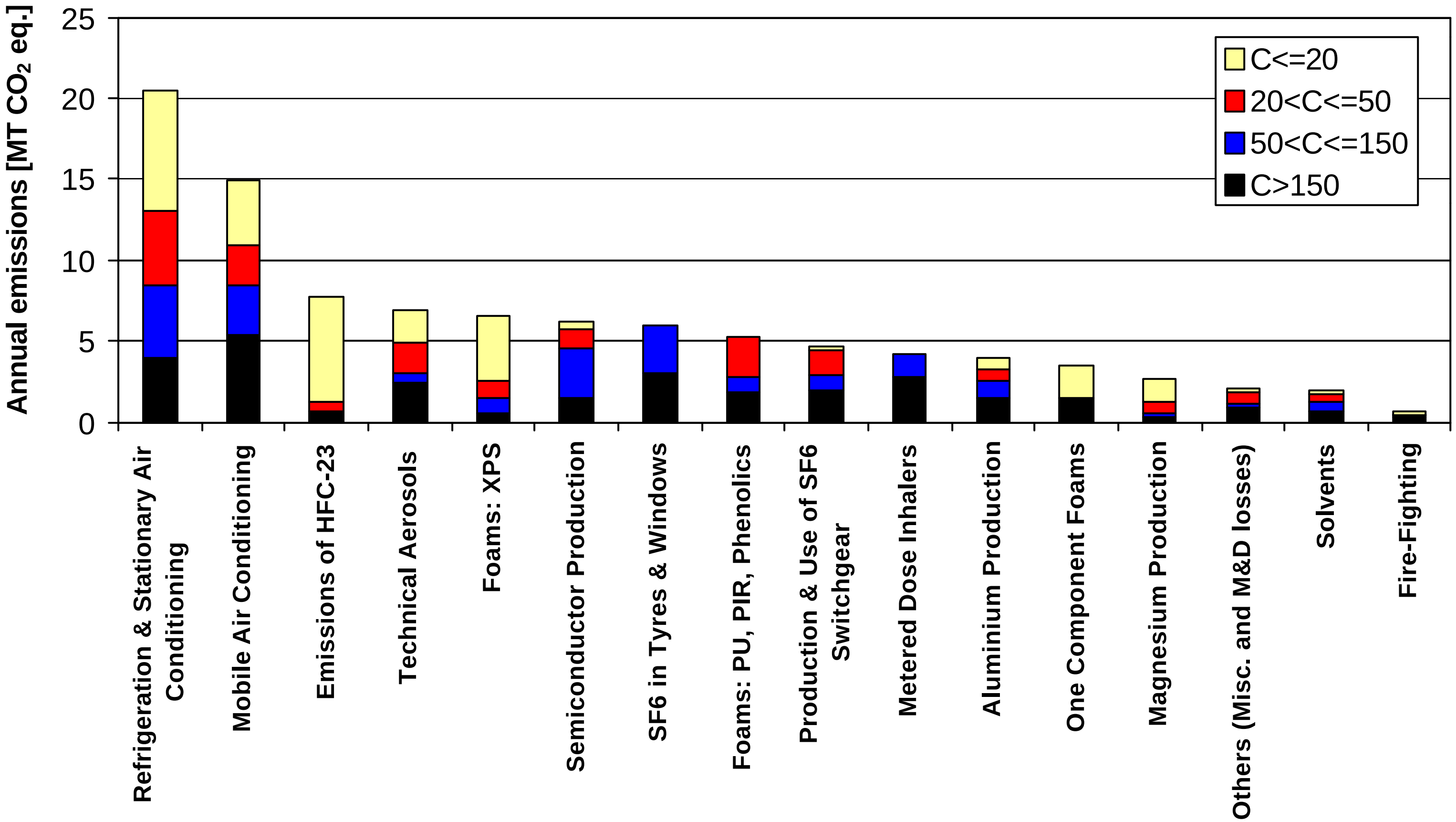

Figure 3 EU-15: Projected emissions of fluorinated gases for 2010 presented for each source as sum of reduction potentials[8] in different cost [C] intervals. Costs are reported as Euros(1999) per ton of CO_2 equivalent. Ranked by the magnitude of projected emissions in 2010.

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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:

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[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

ATTACHMENT D:
Regulation (EC) No 842/2006 of the European Parliament and the Council of 17 May 2006 on certain fluorinated gases

I

(Acts whose publication is obligatory)

REGULATION (EC) No 842/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 May 2006 on certain fluorinated greenhouse gases

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular, Article 175(1) thereof and Article 95 thereof in relation to Articles 7, 8 and 9 of this Regulation,

Having regard to the proposal from the Commission,

Having regard to the opinion of the European Economic and Social Committee ([1]),

Acting in accordance with the procedure laid down in Article 251 of the Treaty ([2]), in the light of the joint text approved by the Conciliation Committee on 14 March 2006,

Whereas:

(1) The Sixth Community Environment Action Programme ([3]) identifies climate change as a priority for action. That Programme recognises that the Community is committed to achieving an 8 % reduction in emissions of greenhouse gases in the period from 2008 to 2012 compared to 1990 levels, and that, in the longer-term, global emissions of greenhouse gases will need to be reduced by approximately 70 % compared to 1990 levels.

(2) The ultimate objective of the United Nations Framework Convention on Climate Change, which was approved by Council Decision 94/69/EC of 15 December 1993 concerning the conclusion of the United Nations Framework Convention on Climate Change ([4]), is to achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level which prevents dangerous anthropogenic interference with the climate system.

(3) Council Decision 2002/358/EC of 25 April 2002 concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder ([5]) commits the Community and its Member States to reduce their aggregate anthropogenic emissions of greenhouse gases listed in Annex A to the Kyoto Protocol by 8 % compared to 1990 levels in the period from 2008 to 2012.

(4) Most fluorinated greenhouse gases controlled under the Kyoto Protocol and this Regulation have a high global warming potential.

(5) Provision should be made for the prevention and minimisation of emissions of fluorinated greenhouse gases, without prejudice to Council Directive 75/442/EEC of 15 July 1975 on waste ([6]), Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control ([7]), Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles ([8]) and Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE) ([9]).

(6) The primary objective of this Regulation is to reduce the emissions of the fluorinated greenhouse gases covered by the Kyoto Protocol and thus to protect the environment.

([1]) OJ C 108, 30.4.2004, p. 62.

([2]) Opinion of the European Parliament of 31 March 2004 (OJ C 103 E, 29.4.2004, p. 600), Council Common Position of 21 June 2005 (OJ C 183 E, 26.7.2005, p. 1) and Position of the European Parliament of 26 October 2005 (not yet published in the Official Journal). Legislative Resolution of the European Parliament of 6 April 2006 and Council Decision of 25 April 2006.

([3]) Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme (OJ L 242, 10.9.2002, p. 1).

([4]) OJ L 33, 7.2.1994, p. 11.

([5]) OJ L 130, 15.5.2002, p. 1.

([6]) OJ L 194, 25.7.1975, p. 39. Directive as last amended by Regulation (EC) No 1882/2003 of the European Parliament and of the Council (OJ L 284, 31.10.2003, p. 1).

([7]) OJ L 257, 10.10.1996, p. 26. Directive as last amended by Regulation (EC) No 166/2006 of the European Parliament and of the Council (OJ L 33, 4.2.2006, p. 1).

([8]) OJ L 269, 21.10.2000, p. 34. Directive as last amended by Council Decision 2005/673/EC (OJ L 254, 30.9.2005, p. 69).

([9]) OJ L 37, 13.2.2003, p. 24. Directive as amended by Directive 2003/108/EC (OJ L 345, 31.12.2003, p. 106).

The legal base should therefore be Article 175(1) of the Treaty.

(7) Nevertheless, it is appropriate to take measures at Community level on the basis of Article 95 of the Treaty to harmonise requirements on the use of fluorinated greenhouse gases and the marketing and labelling of products and equipment containing fluorinated greenhouse gases. Marketing and use restrictions for certain applications of fluorinated greenhouse gases are considered appropriate where viable alternatives are available and improvement of containment and recovery is not feasible. Voluntary initiatives by some industry sectors should also be taken into account, as well as the fact that the development of alternatives is still ongoing.

(8) The application and enforcement of this Regulation should spur technological innovation by encouraging continued development of alternative technologies and transition to already existing technologies that are more environmentally friendly.

(9) Member States should facilitate the cross-border shipment of recovered fluorinated greenhouse gases for destruction or reclamation within the Community in accordance with the Regulation of the European Parliament and of the Council on shipments of waste ([1]).

(10) The placing on the market of the products and equipment containing fluorinated greenhouse gases as listed in Annex II is detrimental to the objectives and commitments of the Community and its Member States with regard to climate change and it is therefore necessary to restrict the placing on the market of these products and equipment as regards the Community. This could also be the case concerning other applications containing fluorinated greenhouse gases and therefore the need for an extension of Annex II should be reviewed, taking account of the environmental benefits, the technical feasibility and cost effectiveness.

(11) Annex II to Decision 2002/358/EC lays down different targets for individual Member States and Member States have adopted different strategies to achieve these targets. Member States should be able to maintain existing national measures adopted in order to meet those targets for a limited period of time in accordance with Article 95 of the Treaty.

(12) In order to contribute to the fulfilment of the commitments of the Community and its Member States under the UN Framework Convention on Climate Change, the Kyoto Protocol and Decision 2002/358/EC, Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air conditioning systems in motor vehicles and amending Council Directive 70/156/EEC ([2]) and this Regulation, which both contribute to prevention and minimisation of emissions of fluorinated greenhouse gases, should be adopted and published in the *Official Journal of the European Union* simultaneously.

(13) Provision should be made for the monitoring, evaluation and review of the provisions contained in this Regulation.

(14) Member States should lay down rules on penalties applicable to infringements of this Regulation and ensure that those rules are implemented. Those penalties must be effective, proportionate and dissuasive.

(15) This Regulation respects the fundamental rights and observes the principles recognised in particular by the Charter of Fundamental Rights of the European Union.

(16) Since the objectives of this Regulation, namely the containment and reporting of certain fluorinated greenhouse gases and the control of use and placing on the market of products and equipment containing certain fluorinated greenhouse gases, in order to protect the environment and to preserve the internal market, cannot be sufficiently achieved by the Member States and can therefore by reason of the scale and effects of this Regulation be better achieved at Community level, the Community may adopt measures, in accordance with the principle of subsidiarity as set out in Article 5 of the Treaty. In accordance with the principle of proportionality, as set out in that Article, this Regulation does not go beyond what is necessary in order to achieve those objectives.

(17) The measures necessary for the implementation of this Regulation should be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission ([3]),

HAVE ADOPTED THIS REGULATION:

Article 1

Scope

The objective of this Regulation is to contain, prevent and thereby reduce emissions of the fluorinated greenhouse gases covered by the Kyoto Protocol. It shall apply to the fluorinated greenhouse gases listed in Annex A to that Protocol. Annex I to this Regulation contains a list of the fluorinated greenhouse gases currently covered by this Regulation, together with their global warming potentials. In the light of revisions provided for by Article 5(3) of the Kyoto Protocol and accepted by the Community and its Member States, Annex I may be reviewed and if appropriate may then be updated.

([1]) Not yet published in the Official Journal.

([2]) See page 12 of this Official Journal.

([3]) OJ L 184, 17.7.1999, p. 23.

This Regulation addresses the containment, use, recovery and destruction of the fluorinated greenhouse gases listed in Annex I; the labelling and disposal of products and equipment containing those gases; the reporting of information on those gases; the control of uses referred to in Article 8 and the placing on the market prohibitions of the products and equipment referred to in Article 9 and Annex II; and the training and certification of personnel and companies involved in activities provided for by this Regulation.

This Regulation shall apply without prejudice to Directives 75/442/EEC, 96/61/EC, 2000/53/EC and 2002/96/EC.

Article 2

Definitions

For the purposes of this Regulation the following definitions shall apply:

1. 'fluorinated greenhouse gases' means hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) as listed in Annex I and preparations containing those substances, but excludes substances controlled under Regulation (EC) No 2037/2000 of the European Parliament and of the Council of 29 June 2000 on substances that deplete the ozone layer ([1]);

2. 'hydrofluorocarbon' means an organic compound consisting of carbon, hydrogen and fluorine, and where no more than six carbon atoms are contained in the molecule;

3. 'perfluorocarbon' means an organic compound consisting of carbon and fluorine only, and where no more than six carbon atoms are contained in the molecule;

4. 'global warming potential' means the climatic warming potential of a fluorinated greenhouse gas relative to that of carbon dioxide. The global warming potential (GWP) is calculated in terms of the 100-year warming potential of one kilogram of a gas relative to one kilogram of CO_2. The GWP figures listed in Annex I are those published in the third assessment report (TAR) adopted by the Intergovernmental Panel on Climate Change (2001 IPCC GWP values) ([2]);

5. 'preparation' means for the purposes of the obligations in this Regulation, excluding destruction, a mixture composed of two or more substances at least one of which is a fluorinated greenhouse gas, except where the total global warming potential of the preparation is less than 150. The total global warming potential ([3]) of the preparation shall be determined in accordance with Part 2 of Annex I;

([1]) OJ L 244, 29.9.2000, p. 1. Regulation as last amended by Commission Regulation (EC) No 29/2006 (OJ L 6, 11.1.2006, p. 27).

([2]) IPCC Third Assessment Climate Change 2001. A Report of the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/pub/reports.htm).

([3]) For the calculation of the GWP of non-fluorinated greenhouse gases in preparations, the values published in the First IPCC Assessment shall apply, see: Climate Change, The IPCC Scientific Assessment, J.T. Houghton, G.J. Jenkins, J.J. Ephraums (ed.), Cambridge University Press, Cambridge (UK) 1990.

6. 'operator' means the natural or legal person exercising actual power over the technical functioning of the equipment and systems covered by this Regulation; a Member State may, in defined, specific situations, designate the owner as being responsible for the operator's obligations;

7. 'placing on the market' means the supplying of or making available to a third party within the Community for the first time, against payment or free of charge, products and equipment containing or whose functioning relies upon fluorinated greenhouse gases, and includes import into the customs territory of the Community;

8. 'use' means the utilisation of fluorinated greenhouse gases in the production, refilling, servicing or maintenance of products and equipment covered by this Regulation;

9. 'heat pump' means a device or installation that extracts heat at low temperature from air, water or earth and supplies heat;

10. 'leakage detection system' means a calibrated mechanical, electrical or electronic device for detecting leakage of fluorinated greenhouse gases which, on detection, alerts the operator;

11. 'hermetically sealed system' means a system in which all refrigerant containing parts are made tight by welding, brazing or a similar permanent connection which may include capped valves and capped service ports that allow proper repair or disposal and which have a tested leakage rate of less than 3 grams per year under a pressure of at least a quarter of the maximum allowable pressure;

12. 'container' means a product which is designed primarily for transporting or storing fluorinated greenhouse gases;

13. 'a non-refillable container' means a container that is designed not to be refilled and is used in the servicing, maintenance or filling of refrigeration, air-conditioning or heat pump equipment, fire protection systems or high--voltage switchgear, or to store or transport fluorinated greenhouse gas based solvents;

14. 'recovery' means the collection and storage of fluorinated greenhouse gases from, for example, machinery, equipment and containers;

15. 'recycling' means the reuse of a recovered fluorinated greenhouse gas following a basic cleaning process;

16. 'reclamation' means the reprocessing of a recovered fluorinated greenhouse gas in order to meet a specified standard of performance;

17. ‘destruction’ means the process by which all or most of a fluorinated greenhouse gas is permanently transformed or decomposed into one or more stable substances which are not fluorinated greenhouse gases;

18. ‘stationary application or equipment’ means an application or equipment which is normally not in transit during operation;

19. ‘novelty aerosol’ means those aerosol generators marketed and intended for sale to the general public for entertainment and decorative purposes as listed in the Annex to Directive 94/48/EC [1].

Article 3

Containment

1. Operators of the following stationary applications: refrigeration, air conditioning and heat pump equipment, including their circuits, as well as fire protection systems, which contain fluorinated greenhouse gases listed in Annex I, shall, using all measures which are technically feasible and do not entail disproportionate cost:

(a) prevent leakage of these gases; and

(b) as soon as possible repair any detected leakage.

2. Operators of the applications referred to in paragraph 1 shall ensure that they are checked for leakage by certified personnel who comply with the requirements of Article 5, according to the following schedule:

(a) applications containing 3 kg or more of fluorinated greenhouse gases shall be checked for leakage at least once every 12 months; this shall not apply to equipment with hermetically sealed systems, which are labelled as such and contain less than 6 kg of fluorinated greenhouse gases;

(b) applications containing 30 kg or more of fluorinated greenhouse gases shall be checked for leakage at least once every six months;

(c) applications containing 300 kg or more of fluorinated greenhouse gases shall be checked for leakage at least once every three months.

The applications shall be checked for leakage within one month after a leak has been repaired to ensure that the repair has been effective.

For the purposes of this paragraph, ‘checked for leakage’ means that the equipment or system is examined for leakage using direct or indirect measuring methods, focusing on those parts of the equipment or system most likely to leak. The direct and indirect measuring methods of checking for leakage shall be specified in the standard checking requirements referred to in paragraph 7.

3. Operators of the applications referred to in paragraph 1, containing 300 kg or more of fluorinated greenhouse gases, shall install leakage detection systems. These leakage detection systems shall be checked at least once every 12 months to ensure their proper functioning. In the case of such fire protection systems installed before 4 July 2007, leakage detection systems shall be fitted by 4 July 2010.

4. Where a properly functioning appropriate leakage detection system is in place, the frequency of the checks required under paragraph 2(b) and (c) shall be halved.

5. In the case of fire protection systems where there is an existing inspection regime in place to meet ISO 14520 standard, these inspections may also fulfil the obligations of this Regulation as long as those inspections are at least as frequent.

6. Operators of the applications referred to in paragraph 1, containing 3 kg or more of fluorinated greenhouse gases, shall maintain records on the quantity and type of fluorinated greenhouse gases installed, any quantities added and the quantity recovered during servicing, maintenance and final disposal. They shall also maintain records of other relevant information including the identification of the company or technician who performed the servicing or maintenance, as well as the dates and results of the checks carried out under paragraphs 2, 3 and 4 and relevant information specifically identifying the separate stationary equipment of applications referred to in paragraph 2(b) and (c). These records shall be made available on request to the competent authority and to the Commission.

7. By 4 July 2007, the Commission shall establish, in accordance with the procedure referred to in Article 12(2), the standard leakage checking requirements for each of the applications referred to in paragraph 1 of this Article.

Article 4

Recovery

1. Operators of the following types of stationary equipment shall be responsible for putting in place arrangements for the proper recovery by certified personnel, who comply with the requirements of Article 5, of fluorinated greenhouse gases to ensure their recycling, reclamation or destruction:

(a) the cooling circuits of refrigeration, air-conditioning and heat pump equipment;

(b) equipment containing fluorinated greenhouse gas-based solvents;

[1] Directive 94/48/EC of the European Parliament and of the Council of 7 December 1994 amending for the 13th time Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations (OJ L 331, 21.12.1994, p. 7).

(c) fire protection systems and fire extinguishers; and

(d) high-voltage switchgear.

2. When a refillable or non-refillable fluorinated greenhouse gas container reaches the end of its life, the person utilising the container for transport or storage purposes shall be responsible for putting in place arrangements for the proper recovery of any residual gases it contains to ensure their recycling, reclamation or destruction.

3. The fluorinated greenhouse gases contained in other products and equipment, including mobile equipment unless it is serving military operations, shall, to the extent that it is technically feasible and does not entail disproportionate cost, be recovered by appropriately qualified personnel, to ensure their recycling, reclamation or destruction.

4. Recovery, for the purpose of recycling, reclamation or destruction of the fluorinated greenhouse gases, pursuant to paragraphs 1 to 3, shall take place before the final disposal of that equipment and, when appropriate, during its servicing and maintenance.

Article 5

Training and certification

1. By 4 July 2007, on the basis of information received from Member States and in consultation with the relevant sectors, minimum requirements and the conditions for mutual recognition shall be established in accordance with the procedure referred to in Article 12(2) in respect of training programmes and certification for both the companies and the relevant personnel involved in installation, maintenance or servicing of the equipment and systems covered by Article 3(1) as well as for the personnel involved in the activities provided for in Articles 3 and 4.

2. By 4 July 2008, Member States shall establish or adapt their own training and certification requirements, on the basis of the minimum requirements referred to in paragraph 1. Member States shall notify the Commission of their training and certification programmes. Member States shall give recognition to the certificates issued in another Member State and shall not restrict the freedom to provide services or the freedom of establishment for reasons relating to the certification issued in another Member State.

3. The operator of the relevant application shall ensure that the relevant personnel have obtained the necessary certification, referred to in paragraph 2, which implies appropriate knowledge of the applicable regulations and standards as well as the necessary competence in emission prevention and recovery of fluorinated greenhouse gases and handling safely the relevant type and size of equipment.

4. By 4 July 2009 Member States shall ensure that the companies involved in carrying out the activities provided for in Articles 3 and 4 shall only take delivery of fluorinated greenhouse gases where their relevant personnel hold the certificates mentioned in paragraph 2 of this Article.

5. By 4 July 2007 the Commission shall determine, in accordance with the procedure referred to in Article 12(2), the format of the notification referred to in paragraph 2 of this Article.

Article 6

Reporting

1. By 31 March 2008 and every year thereafter, each producer, importer and exporter of fluorinated greenhouse gases shall communicate to the Commission by way of a report, sending the same information to the competent authority of the Member State concerned, the following data in respect of the preceding calendar year:

(a) each producer who produces more than one tonne of fluorinated greenhouse gases per annum shall communicate:

— its total production of each fluorinated greenhouse gas in the Community, identifying the main categories of applications (e.g. mobile air-conditioning, refrigeration, air-conditioning, foams, aerosols, electrical equipment, semi-conductor manufacture, solvents and fire protection) in which the substance is expected to be used,

— the quantities of each fluorinated greenhouse gas it has placed on the market in the Community,

— any quantities of each fluorinated greenhouse gas recycled, reclaimed or destroyed;

(b) each importer who imports more than one tonne of fluorinated greenhouse gases per annum, including any producers who also import, shall communicate:

— the quantity of each fluorinated greenhouse gas it has imported or placed on the market in the Community, separately identifying the main categories of applications (e.g. mobile air-conditioning, refrigeration, air-conditioning, foams, aerosols, electrical equipment, semi-conductor manufacture) in which the substance is expected to be used,

— any quantities of each used fluorinated greenhouse gas it has imported for recycling, for reclamation or for destruction;

(c) each exporter who exports more than one tonne of fluorinated greenhouse gases per annum, including any producers who also export, shall communicate:

— the quantities of each fluorinated greenhouse gas it has exported from the Community,

— any quantities of each used fluorinated greenhouse gas it has exported for recycling, for reclamation or for destruction.

2. By 4 July 2007, the Commission shall determine, in accordance with the procedure referred to in Article 12(2), the format of the reports referred to in paragraph 1 of this Article.

3. The Commission shall take appropriate steps to protect the confidentiality of the information submitted to it.

4. Member States shall establish reporting systems for the relevant sectors referred to in this Regulation, with the objective of acquiring, to the extent possible, emission data.

Article 7

Labelling

1. Without prejudice to the provisions of Directive 67/548/EEC ([1]) and of Directive 1999/45/EC ([2]) in respect of the labelling of dangerous substances and preparations, the products and equipment, listed in paragraph 2, containing fluorinated greenhouse gases shall not be placed on the market unless the chemical names of the fluorinated greenhouse gases are identified by way of a label using the accepted industry nomenclature. Such label shall clearly indicate that the product or equipment contains fluorinated greenhouse gases covered by the Kyoto Protocol and their quantity, and this shall be clearly and indelibly stated on the product or equipment, adjacent to the service points for charging or recovering the fluorinated greenhouse gas, or on that part of the product or equipment which contains the fluorinated greenhouse gas. Hermetically sealed systems shall be labelled as such.

Information on the fluorinated greenhouse gases, including their global warming potential, shall be included in the instruction manuals provided for such products and equipment.

2. Paragraph 1 shall apply to the following types of products and equipment:

(a) refrigeration products and equipment which contain perfluorocarbons or preparations containing perfluorocarbons;

(b) refrigeration and air conditioning products and equipment (other than those contained in motor vehicles), heat pumps, fire protection systems and fire extinguishers, if the respective type of product or equipment contains hydrofluorocarbons or preparations containing hydrofluorocarbons;

(c) switchgear which contains sulphur hexafluoride or preparations containing sulphur hexafluoride; and

(d) all fluorinated greenhouse gas containers.

3. The form of the label to be used shall be established in accordance with the procedure referred to in Article 12(2). Labelling requirements additional to those set out in paragraph 1 shall, if appropriate, be adopted in accordance with the same procedure. Before submitting a proposal to the Committee referred to in Article 12(1), the Commission shall review the desirability of including additional environmental information, including the global warming potential, on labels, taking due account of existing labelling schemes already applicable to the products and equipment referred to in paragraph 2.

Article 8

Control of use

1. The use of sulphur hexafluoride or preparations thereof in magnesium die-casting, except where the quantity of sulphur hexafluoride used is below 850 kg per year, shall be prohibited from 1 January 2008.

2. The use of sulphur hexafluoride or preparations thereof for the filling of vehicle tyres shall be prohibited from 4 July 2007.

Article 9

Placing on the market

1. The placing on the market of products and equipment containing, or whose functioning relies upon, fluorinated greenhouse gases, as listed in Annex II shall be prohibited as specified in that Annex.

2. Paragraph 1 shall not apply to products and equipment shown to be manufactured before the date of entry into force of the relevant placing on the market prohibition.

3. (a) Where a Member State has, by 31 December 2005, adopted national measures which are stricter than those laid down in this Article and which fall within the scope of this Regulation, concerning the placing on the market of products and equipment containing, or whose functioning relies upon, fluorinated greenhouse gases, that Member State may, subject to point (b), maintain those national measures until 31 December 2012.

(b) The Member State in question shall notify the national measures to the Commission, accompanied by justification in support of those measures, by 4 July 2007. Such

([1]) Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances (OJ 196, 16.8.1967, p. 1). Directive as last amended by Commission Directive 2004/73/EC (OJ L 152, 30.4.2004, p. 1).

([2]) Directive 1999/45/EC of the European Parliament and of the Council of 31 May 1999 concerning the approximation of the laws, regulations and administrative provisions of the Member States relating to the classification, packaging and labelling of dangerous preparations (OJ L 200, 30.7.1999, p. 1). Directive as last amended by Commission Directive 2006/8/EC (OJ L 19, 24.1.2006, p. 12).

measures must be compatible with the Treaty. The Commission shall provide to the Committee referred to in Article 12(1) relevant information on such measures.

Article 10

Review

1. On the basis of progress in potential containment or replacement of fluorinated greenhouse gases in air conditioning systems, other than those fitted to motor vehicles referred to in Council Directive 70/156/EEC of 6 February 1970 on the approximation of laws relating to the type-approval of motor vehicles and their trailers [1], and in refrigeration systems contained in modes of transport, the Commission shall review this Regulation and publish a report by 31 December 2007 at the latest. It shall, if appropriate, accompany this report with legislative proposals by 31 December 2008, with a view to applying the provisions of Article 3 to air-conditioning systems, other than those fitted to motor vehicles referred to in Directive 70/156/EEC, and refrigeration systems contained in modes of transport.

2. By 4 July 2011, the Commission shall publish a report based on the experience of the application of this Regulation. In particular, the report shall:

(a) assess the impact of relevant provisions on emissions and projected emissions of fluorinated greenhouse gases and examine the cost-effectiveness of these provisions;

(b) in the light of future assessment reports of the IPCC, assess whether additional fluorinated greenhouse gases should be added to Annex I;

(c) evaluate the training and certification programmes established by Member States under Article 5(2);

(d) assess the need for Community standards relating to the control of emissions of fluorinated greenhouse gases from products and equipment, in particular as regards foam, including technical requirements with respect to the design of products and equipment;

(e) evaluate the effectiveness of containment measures carried out by operators under Article 3 and assess whether maximum leakage rates for installations can be established;

(f) assess and, if appropriate, may propose a modification of the reporting requirements in Article 6(1), in particular the one tonne quantitative limit, and assess the need for the competent authorities to report periodically to the Commission estimated emissions based on representative samples to improve the practical application of those reporting requirements;

(g) assess the need for the development and dissemination of notes describing best available techniques and best environmental practices concerning the prevention and minimisation of emissions of fluorinated greenhouse gases;

(h) include an overall summary of the development, both within the Community and at an international level, of the state of technology, in particular as regards foams, experience gained, environmental requirements and any impacts on the functioning of the internal market;

(i) assess whether the substitution of sulphur hexafluoride in sand casting, permanent mould casting and high-pressure die-casting is technically feasible and cost-effective and, if appropriate, propose a revision of Article 8(1) by 1 January 2009; it shall also review the exemption contained in Article 8(1) in the light of further assessment of the available alternatives by 1 January 2010;

(j) assess whether the inclusion of further products and equipment containing fluorinated greenhouse gases in Annex II is technically feasible and cost-effective, taking account of energy-efficiency, and, if appropriate, make proposals to amend Annex II in order to include such further products and equipment;

(k) assess whether Community provisions concerning the global warming potential of fluorinated greenhouse gases should be amended; any changes should take account of technological and scientific developments and the need to respect industrial product planning timescales;

(l) assess the need for further action by the Community and its Member States in the light of existing and new international commitments regarding the reduction of greenhouse gas emissions.

3. Where necessary, the Commission shall present appropriate proposals for revision of the relevant provisions of this Regulation.

Article 11

Without prejudice to relevant Community law, in particular Community rules on State aid and Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on Information Society services [2], Member States may promote the placing on the market of products and equipment which use alternatives to gases with a high global warming potential and which are efficient, innovative and further reduce the climate impact.

[1] OJ L 42, 23.2.1970, p. 1. Directive as last amended by Directive 2005/64/EC of the European Parliament and of the Council (OJ L 310, 25.11.2005, p. 10).

[2] OJ L 204, 21.7.1998, p. 37. Directive as last amended by the 2003 Act of Accession.

Article 12

Committee

1. The Commission shall be assisted by the Committee instituted by Article 18 of Regulation (EC) No 2037/2000.

2. Where reference is made to this paragraph, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at three months.

3. The Committee shall adopt its Rules of Procedure.

Article 13

Penalties

1. Member States shall lay down rules on penalties applicable to infringements of the provisions of this Regulation and shall take all measures necessary to ensure that such rules are implemented. The penalties provided for shall be effective, proportionate and dissuasive.

2. Member States shall notify the rules on penalties to the Commission by 4 July 2008 and shall also notify it without delay of any subsequent amendment affecting those rules.

Article 14

Without prejudice to Article 9(3), Member States may maintain or introduce more stringent protective measures in accordance with the procedures laid down in Article 95 of the Treaty, in relation to Articles 7, 8 and 9 of this Regulation, or Article 176 of the Treaty in relation to other Articles of this Regulation.

Article 15

Entry into force

This Regulation shall enter into force on the 20th day following its publication in the *Official Journal of the European Union*.

It shall apply with effect from 4 July 2007, with the exception of Article 9 and Annex II, which shall apply from 4 July 2006.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Strasbourg, 17 May 2006.

For the European Parliament
The President
J. BORRELL FONTELLES

For the Council
The President
H. WINKLER

ANNEX I

PART 1

Fluorinated greenhouse gases referred to in Article 2(1)

Fluorinated greenhouse gas	Chemical Formula	Global warming potential (GWP)
Sulphur hexafluoride	SF_6	22 200
Hydrofluorocarbons (HFCs):		
HFC-23	CHF_3	12 000
HFC-32	CH_2F_2	550
HFC-41	CH_3F	97
HFC-43-10mee	$C_5H_2F_{10}$	1 500
HFC-125	C_2HF_5	3 400
HFC-134	$C_2H_2F_4$	1 100
HFC-134a	CH_2FCF_3	1 300
HFC-152a	$C_2H_4F_2$	120
HFC-143	$C_2H_3F_3$	330
HFC-143a	$C_2H_3F_3$	4 300
HFC-227ea	C_3HF_7	3 500
HFC-236cb	$CH_2FCF_2CF_3$	1 300
HFC-236ea	CHF_2CHFCF_3	1 200
HFC-236fa	$C_3H_2F_6$	9 400
HFC-245ca	$C_3H_3F_5$	640
HFC-245fa	$CHF_2CH_2CF_3$	950
HFC-365mfc	$CF_3CH_2CF_2CH_3$	890
Perfluorocarbons (PFCs):		
Perfluoromethane	CF_4	5 700
Perfluoroethane	C_2F_6	11 900
Perfluoropropane	C_3F_8	8 600
Perfluorobutane	C_4F_{10}	8 600
Perfluoropentane	C_5F_{12}	8 900
Perfluorohexane	C_6F_{14}	9 000
Perfluorocyclobutane	$c\text{-}C_4F_8$	10 000

PART 2

Method of calculating the total global warming potential (GWP) for a preparation

The total GWP for a preparation is a weighted average, derived from the sum of the weight fractions of the individual substances multiplied by their GWPs.

Σ (Substance X % x GWP) + (Substance Y % x GWP) + … (Substance N % x GWP)

where % is the contribution by weight with a weight tolerance of +/- 1 %.

For example: applying the formula to a theoretical blend of gases consisting of 23 % HFC-32; 25 % HFC-125 and 52 % HFC-134a;

Σ (23 % x 550) + (25 % x 3 400) + (52 % x 1 300)

→ Total GWP = 1 652,5

ANNEX II

Placing on the market prohibitions in accordance with Article 9

Fluorinated greenhouse gases	Products and equipment	Date of prohibition
Fluorinated greenhouse gases	Non-refillable containers	4 July 2007
Hydrofluorocarbons and perfluorocarbons	Non-confined direct-evaporation systems containing refrigerants	4 July 2007
Perfluorocarbons	Fire protection systems and fire extinguishers	4 July 2007
Fluorinated greenhouse gases	Windows for domestic use	4 July 2007
Fluorinated greenhouse gases	Other windows	4 July 2008
Fluorinated greenhouse gases	Footwear	4 July 2006
Fluorinated greenhouse gases	Tyres	4 July 2007
Fluorinated greenhouse gases	One component foams, except when required to meet national safety standards	4 July 2008
Hydrofluorocarbons	Novelty aerosols	4 July 2009

ATTACHMENT E:
Summary of World Fab Watch Data for California FABs

Summary of World Fab Watch Data for California FABs
Arranged in Decreasing Order of Maximum Wafer Production

	California Company	Description of Facility	Type	Maximum Wafers/Mo 8" Equiv.	Clean Room (Sq Ft)	Date Last Updated
1	NEC Electronics Corporation MOU	SIA, MOU	Fab	20,813	111,112	01/30/04
2	Jazz Semiconductor	Non-SIA, Non-MOU, foundry	Fab	17,000	100,000	06/12/06
3	International Rectifier	Older tech, discretes/power	Fab	15,625	12,800	07/05/05
4	Intel Corporation MOU	SIA, MOU	Fab, R&D	15,000	204,000	03/25/05
5	Vishay Intertechnology	Non-SIA, Non-MOU	Fab	13,781	25,000	
6	Micrel Semiconductor Inc	Non-SIA, Non-MOU	Fab	13,500	28,000	12/29/05
7	International Rectifier	Older tech, discretes/power	Fab	11,250	7,500	07/05/05
8	International Rectifier	Older tech, discretes/power	R&D, Pilot	11,250	10,000	07/05/05
9	Maxim Integrated Products, Inc.	Non-SIA, Non-MOU	Fab	10,000	21,000	02/11/04
10	Cypress Semiconductor Corporation	Small, R&D, foundry, Non MOU, Non SIA	R&D	9,000	16,000	09/22/05
11	Spectro Labs	Small, opto	Fab	7,500	10,000	02/03/05
12	Standard MEMS	Small, MEMS	Fab	6,750	25,000	10/26/00
13	Lucas Novasensor	Older tech, discretes/MEMS	Fab	6,000	0	09/13/99
14	NEC Electronics Corporation MOU	SIA, MOU	Fab	6,000		03/06/06
15	International Rectifier	Older tech, discretes/power	Fab, Pilot	5,859	6,000	07/05/05
16	Spansion LLC	R&D, Pilot, SIA, MOU	R&D, Pilot	5,805	42,500	02/23/06
17	IMT (Innovative Micro Technology)	Non-SIA, Non-MOU	Fab, R&D	5,625	30,000	02/06/06
18	TRW	Non-SIA, Non-MOU	Fab	5,000	0	09/20/99
19	Lawrence Livermore Labs	R&D, Pilot	R&D, Pilot	5,000	12,000	
20	Linear Technology Corporation	Small	Fab	4,500	0	03/27/01
21	Silicon Microstructures Inc. (SMI)	Small, bipolar, MEMS	Fab	4,500	6,000	06/24/04
22	Polarfab	Non-SIA, Non-MOU, foundry	Fab	4,000	63,000	08/19/04
23	Supertex Inc	Small	Fab, Pilot	3,094	9,000	05/02/00
24	Microsemi Corp.	Small, discrete/opto	Fab, R&D	3,000	9,000	03/26/01
25	Semicoa Semiconductors	Small, Bipolar, power	Fab	3,000	10,000	
26	TRW	non-SIA, non-MOU	Fab	2,500		08/27/01

	California Company	Description of Facility	Type	Maximum Wafers/Mo 8” Equiv.	Clean Room (Sq Ft)	Date Last Updated
27	Universal Semiconductor Inc (USI)	Non-SIA, Non-MOU,foundry	Fab	2,500	30,000	01/26/04
28	M/A-Com	Small, discrete, power	Fab	2,500	0	
30	Vitesse Semiconductor Corporation	Small	Fab	2,000	6,000	06/08/01
31	Skyworks Solutions Inc.	Small, discrete, power	Fab	2,000	6,140	06/16/06
29	Vishay Intertechnology	Non-SIA, Non-MOU	Fab	2,000	13,000	
34	Analog Devices Inc	Closed	Fab	1,969	3,000	03/17/05
32	WJ Communications, Inc.	Small	Fab	1,875	10,000	05/30/01
33	GCS (Global Communication Semiconductors)	Small, foundry, optoelectronics	Fab	1,631	7,000	06/12/06
35	TRW	Non-SIA, Non-MOU	Fab	1,600	15,000	
36	TRW	Non-SIA, Non-MOU	R&D, Pilot	1,250	0	
37	Applied Materials	Not a Fab	Pilot	1,125	39,000	02/03/05
38	Emcore Corporation	Small, discrete, foundry	Fab	1,013		04/04/03
39	Defense Microelectronics Activity (DMEA)	Small	Fab	1,000		01/04/06
40	Solid State Devices, Inc.	Pilot	Pilot	1,000	10,000	
41	Calogic Corporation	Small CR, Small wafers	Pilot	900	5,000	05/24/01
43	Novalux	Small, discrete/optoelectronics	Fab	875		02/03/05
42	FlexICs	Small, pilot	Pilot	844		07/05/01
44	Perkin Elmer Optoelectronics	Small, pilot	Pilot	800	4,600	02/21/01
45	Elume, Inc.	Very small, foundry	Fab	563	1,500	12/14/06
46	Bipolarics, Inc.	Pilot	Pilot	538	0	07/06/01
47	THAT Corporation	Small	Fab	500	0	09/20/00
48	Applied Materials	Not a Fab	Pilot	500	0	02/03/05
49	Seaway Semiconductor Inc.	Small, foundry, optoelectronics	Fab	500	0	
50	TRW	Non-SIA, Non-MOU	Pilot	400	13,000	
51	SenSym ICT	Small, Bipolar, discretes	Fab	375	10,000	01/09/02
52	Microsemi Corp.	Small, discrete/power	Fab	323	4,000	11/21/05
53	Universal Semiconductor Technology Inc (USTI)	Small, GaAs	Fab	200	20,000	01/01/02
54	Lockheed Martin	Small, R&D, Optoelectronics	R&D	200	3,000	
55	Spectro Labs	R&D	R&D	141	3,000	05/11/01

	California Company	Description of Facility	Type	Maximum Wafers/Mo 8" Equiv.	Clean Room (Sq Ft)	Date Last Updated
57	McDonnell Douglas	Development	Pilot	141	4,000	02/03/05
56	OEPIC Inc.	Small, discrete/opto	Fab	125		02/03/05
59	Dimatix, Inc	Small	Fab, R&D	125	5,000	06/14/05
58	University of California at Berkeley	R&D	R&D	84	10,000	02/27/06
61	Microwave Monolithics	R&D, Pilot	R&D, Pilot	70	1,500	02/03/05
60	Endevco Corporation	Very small, MEMS	Fab, R&D	63	2,500	03/23/06
62	Blu-Si	Very small	Fab	56	2,000	08/16/04
63	McDonnell Douglas	Pilot	Pilot	56	6,000	
64	Avago Technologies	R&D	R&D, Pilot	31	25,000	01/17/06
66	HRL Laboratories	R&D	R&D	28	9,000	07/12/01
65	Nanostructures, Inc.	Small, MEMS	Fab, R&D	28	1,000	09/01/04
67	Agilent Technologies Inc.	Development	R&D, Pilot	28	3,000	09/19/05
68	Stanford University	R&D	R&D	25	6,000	02/03/05
69	HRL Laboratories	R&D	R&D	23	4,000	07/12/01
70	Teledyne Electronic Technologies	Pilot	Pilot	11	6,000	
71	McDonnell Douglas	R&D	R&D	4	0	
72	HRL Laboratories	R&D	R&D	1	2,500	07/12/01
73	Cree, Inc	R&D	R&D	N/A		08/14/06
74	Microfabrica	R&D, Pilot	R&D, Pilot	N/A		09/27/06
75	WJ Communications, Inc.	Small	Fab	N/A		12/07/06

[MOU] = MOU Participant.

"MEMS" = Micro Electrical Mechanical Systems.

"Foundry" = a FAB at which many different devices are made for one or more customers.

"Discrete" = discrete semiconductor circuit, which is a circuit contained in its own package, and not built on a common semiconductor substrate with other components, as is the case with integrated circuits.

"Optoelectronics" = electrical devices that interact with light or other electromagnetic radiation.

ATTACHMENT F:
Summary of Online Employment Statistic Resources

State of California Semiconductor Industry Employment Statistics (NAICS 2334413)

2002: http://www.bls.gov/cew/cewbultn02.htm [Bottom of page. Table 10, select "Manufacturing"]
http://www.bls.gov/cew/ew02sect3133.pdf (p. 337)

2003: http://www.bls.gov/cew/cewbultn03.htm [Bottom of page. Table 10, select "Manufacturing"]
http://www.bls.gov/cew/ew03sect3133.pdf (p. 343)

2004: http://www.bls.gov/cew/cewbultn04.htm [Bottom of page. Table 10, select "Manufacturing"]
http://www.bls.gov/cew/ew04sect3133.pdf (p. 353)

2005: http://www.bls.gov/cew/cewbultn05.htm [Bottom of page. Table 10, select "Manufacturing"]
http://www.bls.gov/cew/ew05table10.pdf (p. 10-256)

State of California Employment of "Semiconductor Processors" [SOC 51-9141]

2002: http://stats.bls.gov/oes/2002/oes_ca.htm#b51-0000 [see SOC 51-9141]

2003: http://stats.bls.gov/oes/2003/may/oes_ca.htm#b51-0000 [see SOC 51-9141]

2004: http://stats.bls.gov/oes/2004/may/oes_ca.htm#b51-0000 [see SOC 51-9141]

2005: http://stats.bls.gov/oes/2005/may/oes_ca.htm#b51-0000 [see SOC 51-9141]

MISCELLANEOUS EMPLOYMENT URLs
Other source of occupational employment data by state and SOC code
http://stats.bls.gov/oes/oes_dl.htm

BLS National Employment Matrix: 2004 – 2014 (Occupation by industry)
http://stats.bls.gov/emp/empoils.htm