Analysis on the Recovery of Fluorinated Greenhouse Gases in EU-27 in the Period 2004-2007 and Determination of Options for Further Progress

Prepared by:
ICF International

Prepared for:
The European Commission

October 2008

—FINAL REPORT—

Contents

Executive Summary

Fluorinated greenhouse gases (F-gases) controlled under the Kyoto Protocol—i.e., HFCs, PFCs, and SF_6—have high global warming potentials (GWPs) and are used in a variety of equipment types and industrial applications (see Table ES-1:). By 1995, F-gas emissions represented only 2% of all GHG emissions from the EC; assuming no additional mitigation measures were put in place, emissions of F-gases were expected to grow to as much as 4% of all GHG emissions by 2010. This increase would occur in part because F-gases are the primary alternatives for many ozone depleting substances (ODS), which are being phased-out in the European Community, per requirements under Regulation (EC) No 2037/2000, and the provisions of the Montreal Protocol.

Table ES-1: GWPs and Industrial Applications of Fluorinated Greenhouse Gases Regulated by (EC) No 842/2006

F-Gas Type	Sulphur Hexafluoride (SF_6)	Hydrofluorocarbons (HFCs)[a]	Perfluorocarbons (PFCs)[b]
GWP (100-yr)	22,200	97- 12,000	5,700 -11,900
Major Applications	• Electrical Power • Magnesium Production • Semiconductor Manufacturing	• Refrigeration • Air Conditioning & Heat pumps • Fire Protection • Solvents • Aerosols • Foams	• Semiconductor Manufacturing • Aluminium Production

[a] Common HFCs (and their *100 yr-GWPs based on IPCC TAR*) include HFC-23 (*12,000*), HFC-32 (*550*), HFC-125 (*3,400*), HFC-134a (*1,300*), HFC-143a (*4,300*), HFC-152a (*120*) and HFC-227ea (*3,500*).

[b] Common PFCs (and their *100 yr-GWPs based on IPCC TAR*) include perfluoromethane (*5,700*) and perfluoroethane (*11,900*).

On 17 May 2006, Regulation (EC) No 842/2006 was adopted to reduce the emissions of F-gases and assist the EU in making a significant contribution toward the European Community's Kyoto Protocol target. The regulation contains a number of provisions to monitor the consumption and reduce the emissions of F-Gases, including labelling, reporting, and leak checking requirements. Article 4 of the Regulation requires operators of a specified list of stationary applications to put in place arrangements for the proper recovery of F-gases at equipment servicing, maintenance, and disposal events, for the purpose of recycling, reclamation or destruction. These applications include:

- Cooling circuits of refrigeration, air conditioning and heat pump equipment;
- Equipment containing fluorinated greenhouse gas-based solvents;
- Fire protection systems and fire extinguishers;
- High voltage switchgear; and
- Other products and equipment, including mobile equipment.

This report aims to estimate levels of fluorinated greenhouse gas (F-gas) recovery, recycling, reclamation, and destruction (RRRD) during the period of 2004-2007, and identify barriers to these activities and possible solutions to overcome these barriers to facilitate a continued increase in F-gases recovered for recycling, reclamation, and destruction in the EU-27.

To do so, extensive survey efforts were undertaken across F-gas sector stakeholders in the EU-27. Specifically, reclamation facilities were surveyed regarding the technologies they use to reclaim F-gases, the quantities of F-gas they've reclaimed since 2004, and the capacity of their facilities to reclaim F-gases. Similarly, destruction facilities were surveyed regarding the technologies they use to destroy F-gases, the quantities of F-gases they have destroyed, and the capacity of their facilities to destroy F-gases. F-gas producers/importers/exporters that have reclaimed or destroyed F-gases at their facilities were also surveyed. In addition, F-gas users (i.e., equipment operators and service providers) were surveyed to estimate quantities of F-gases recovered and recycled.

Despite the dissemination of approximately 350 questionnaires and extensive follow up to a variety of stakeholder groups, including trade associations that were asked to further disseminate the questionnaires to their member companies, very few responses were received. Based on the limited data collected through the survey effort, estimates of F-gas RRRD, by year, by gas, and by sector were "scaled up" for the entire EU-27. Because of the poor response, the EU-wide RRRD F-gas estimates developed for and presented in this study are based on very limited quantitative data reported by industry stakeholders and, hence, are uncertain. The following methodologies for scaling up, by sector, were used:

Refrigeration/Air Conditioning/Heat Pumps (RAC)

Survey data on on-site reclamation/destruction (from commercial reclamation and destruction facilities, producers/importers/exporters, and multinational RAC servicing companies) were deemed to be the most reliable, comprehensive, and non-duplicative datasets for estimating total HFC reclamation and destruction in the EU.[1] However, because not all such facilities that reclaim/destroy F-gases responded to the questionnaires prepared for this study, two scenarios were developed in order to account for their activities:

- **Upper Bound Scenario:** all commercial reclamation/destruction facilities that did not respond to the survey reclaim/destroy HFCs at 50% of the rate as the average levels (by year and by gas) of those that did respond to the survey. It is assumed that F-gas producers/importers/exporters that responded to the survey account for 95% of all reclamation/destruction performed by producers/importers/exporters in the EU-27. It was further assumed that there are a total of five large multinational RAC servicing companies that perform reclamation on-site (at their facilities) in the EU; therefore, the one multinational RAC servicing company that responded to the survey is assumed to account for 20% of the F-gases reclaimed by this stakeholder group.
- **Lower Bound Scenario:** non-respondents did not reclaim/destroy HFCs.

Based on estimated levels of HFC refrigerant reclaimed and destroyed for 2004-2007 under the upper and lower bound scenarios, total quantities of HFC refrigerant recycled were subsequently estimated by assuming that recycled quantities represent approximately 70% of the total quantities recovered, (i.e., recovered F-gas = 70% recycled + 30% reclaimed/ destroyed). This assumption was developed based on aggregated amounts of RRRD of HCFCs reported by EU-15 Member States to the EU Commission under Article 16 of EC Regulation 2037/2000 (Ecofys, 2006). Given that no parallel data exist for HFCs whilst survey responses (outlined in section 5.1) were inconclusive, these data on the fate of recovered HCFC refrigerants were deemed to provide the best proxy for understanding trends in the fate of recovered HFC refrigerants.[2] Levels of HFC refrigerants recovered were then estimated by summing the quantities of total HFC refrigerant recycled, reclaimed, and destroyed.

High Voltage Switchgear

Survey data on on-site reclamation and destruction (from SF_6 producers/importers/exporters and commercial destruction facilities, respectively) were deemed to be the most reliable, comprehensive, and non-duplicative datasets for estimating total SF_6 reclamation and destruction in the EU.[3] More

[1] End-user data on F-gas quantities sent for reclamation and destruction were not deemed as reliable, since such quantities could be double-counted against that provided by facilities that actually performed the reclamation/destruction on-site.

[2] The fate of recovered CFC refrigerant was not deemed to be an appropriate proxy, given that CFCs cannot legally be reused in the EC.

[3] End-user data on SF_6 quantities sent for reclamation and destruction were not deemed as reliable, since such quantities could be double-counted against that provided by facilities that actually performed the reclamation/destruction on-site.

specifically, to estimate EU-wide levels of SF_6 reclamation and destruction, the following methodology and assumptions were used:

- ***Reclamation***: the quantities of SF_6 reclaimed across the EU are based on those quantities of SF_6 reclaimed on-site (at company facilities, not sent off-site for the purpose of reclamation), as reported by producers/importers/exporters per the requirements of Article 6 of Regulation (EC) No 842/2006. Reported quantities were not scaled up to account for non-respondents, because it is believed that all SF_6 reclamation is performed by the few producers, all of which are believed to have complied with the reporting requirements of Article 6 of Regulation (EC) No 842/2006. For those producers that submitted reports to the EC (for year 2007) but did not respond to the survey prepared for this study, it was assumed that their 2007 SF_6 reclamation levels were the same in years 2004-2006.
- ***Destruction***: the quantities of SF_6 destroyed across the EU are based on those quantities of SF_6 destroyed on-site (at company facilities, not sent off-site for the purpose of destrictopm), as reported by commercial destruction facilities through this survey. While it possible that other companies that did not respond to the survey prepared for this study also destroy SF_6, since this gas is very difficult to destroy,[4] it is conservatively assumed that survey respondents account for 100% of SF_6 destruction.

To estimate total quantities of SF_6 recycled during 2004-2007, information provided by end-users in the electricity transmission/distribution sector on the fate of recovered SF_6 was used. Specifically, based on surveys submitted by stakeholders, the following ratios were estimated for the fate of recovered SF_6:

- Recycled: ~ 85%
- Reclaimed/destroyed: ~ 14%
- Stored indefinitely: ~ 1%

Therefore, once quantities of SF_6 reclaimed and destroyed were estimated, the sum of those quantities was scaled (i.e., multiplied by 85/14) to estimate the quantity of SF_6 recycled in each year. Next, annual levels of SF_6 recovered were estimated by summing the quantities of total SF_6 recycled, reclaimed, destroyed, and stored.

Solvents

The solvents sector is the smallest of the F-gas sectors in the EU-27. In 2007, this sector represented only 0.2% of EU-27 F-gas sales. Given that no quantitative data were received from company contacts during the survey effort, no scale-up effort could be conducted for this sector. However, from 2004-2007, RRRD levels from the solvents sector in the EU-27 are believed to be negligible. Therefore, for the purpose of this analysis, levels of F-gas recovery, recycling, reclamation, and destruction are assumed to be zero.

Fire Protection

Three survey responses were received on RRRD levels of HFC-227ea and HFC-125 in the fire protection sector: one from a producer/importer of insulation-fire protection products, one from a commercial reclamation facility, and one from a company that supplies/maintains fire protection systems. The latter company is believed to be one of roughly 10 major HFC fire protection companies in the EU-27 (Hughes Associates, 2008). To determine EU-wide RRRD estimates, the respondent company that supplies/maintains fire protection systems was assumed to be representative of the 10

[4] Due to the very high thermal stability of SF_6, it is essential to use a destruction process that combines high temperature ($\geq$1,200 degrees C) with a long residence time as the basic prerequisite for a high destruction and removal efficiency. As such, only three technologies may be suitable for SF_6 destruction: rotary kiln incineration, inductively coupled radio frequency plasma, and microwave plasma. Rotary kiln incinerators are believed to be the only technology used for destroying SF_6 in the EU (CIGRE, 2003; Solvay, 2008).

major players in the EU-27 fire protection market. Therefore, levels of F-gas RRRD reported by this company were scaled up for the nine other companies. Additional quantities of HFC-227ea reported as having been reclaimed by the producer/importer[5] and the commercial reclamation facility were added to this total.[6]

Results

Based on the analysis conducted for this study, the most likely estimated ranges of F-gas recovery, recycling, reclamation, and destruction are presented in Table ES-2 and Table ES-3, expressed in tonnes and million metric tonnes of carbon dioxide ($MMTCO_2$) equivalent, respectively.

Table ES-2. Estimated Total Metric Tonnes (t) of F-Gas RRRD in the EU-27 (2004-2007)

Upper Bound					Lower Bound				
F-gas Type/Fate	2004	2005	2006	2007	F-gas Type/Fate	2004	2005	2006	2007
HFCs					HFCs				
Recycled	19,284.8	16,449.5	16,723.6	20,757.2	Recycled	4,665.7	4,116.2	4,209.1	5,111.2
Reclaimed	1,169.8	1,193.8	1,297.3	1,585.8	Reclaimed	608.8	637.2	705.5	830.0
Destroyed	7,211.3	5,987.8	6,042.1	7,521.6	Destroyed	1,506.9	1,258.8	1,270.6	1,572.0
Recovered	27,665.9	23,631.1	24,063.0	29,864.6	Recovered	6,781.4	6,012.1	6,185.1	7,513.2
PFCs					PFCs				
Recycled	Unknown	Unknown	Unknown	Unknown	Recycled	Unknown	Unknown	Unknown	Unknown
Reclaimed	1.6	1.2	3.6	0.4	Reclaimed	1.6	1.2	3.6	0.4
Destroyed	0.2	0.1	0.4	0.0	Destroyed	0.2	0.1	0.4	0.0
Recovered	Unknown	Unknown	Unknown	Unknown	Recovered	Unknown	Unknown	Unknown	Unknown
SF_6					SF_6				
Recycled	538.8	596.1	658.1	721.7	Recycled	538.8	596.1	658.1	721.7
Reclaimed	85.2	71.2	79.2	90.2	Reclaimed	85.2	71.2	79.2	90.2
Destroyed	0.1	23.1	24.9	24.0	Destroyed	0.1	23.1	24.9	24.0
Recovered	631.6	698.7	771.4	845.9	Recovered	631.6	698.7	771.4	845.9
Total F-Gases					Total F-Gases				
Recycled	19,823.7	17,045.6	17,381.7	21,478.9	Recycled	5,204.5	4,712.3	4,867.2	5,832.9
Reclaimed	1,256.6	1,266.3	1,380.1	1,676.4	Reclaimed	695.7	709.6	788.3	920.5
Destroyed	7,211.6	6,011.0	6,067.4	7,545.6	Destroyed	1,507.1	1,282.0	1,295.9	1,596.0
Recovered	28,297.5	24,329.8	24,834.4	30,710.5	Recovered	7,413.0	6,710.9	6,956.5	8,359.1

Notes: Recycling, reclamation and destruction values may not add to recovery totals because some facilities store F-gases indefinitely on-site. Summary totals include PFCs as reported by commercial reclamation and destruction facilities; however, such quantities are negligible, and therefore have not been scaled up because of data limitations.

[5] This producer/importer submitted a report to the EC for year 2007 but did not respond to the survey prepared for this study; it was assumed that their 2007 HFC-227ea reclamation levels were the same in years 2004-2006.

[6] Quantities reclaimed by the producer/importer and commercial reclamation facility were not scaled up to account for non-respondents because the previous scale-up methodology (applied to account for RRRD levels of the major industry players in the fire protection market) is intended to represent the majority of the industry.

Table ES-3. Estimated Total MMTCO$_2$eq F-Gas RRRD in the EU-27 (2004-2007)

Upper Bound					Lower Bound				
F-gas Type/Fate	2004	2005	2006	2007	F-gas Type/Fate	2004	2005	2006	2007
HFCs					HFCs				
Recycled	43.3	36.9	37.2	38.7	Recycled	9.9	8.7	8.9	9.4
Reclaimed	2.2	2.1	2.4	3.0	Reclaimed	1.2	1.2	1.4	1.7
Destroyed	16.7	14.1	14.1	14.3	Destroyed	3.5	3.0	3.0	3.0
Recovered	62.2	53.2	53.7	56.0	Recovered	14.6	12.9	13.3	14.1
PFCs					PFCs				
Recycled	Unknown	Unknown	Unknown	Unknown	Recycled	Unknown	Unknown	Unknown	Unknown
Reclaimed	<1	<1	<1	<1	Reclaimed	<1	<1	<1	<1
Destroyed	<1	<1	<1	<1	Destroyed	<1	<1	<1	<1
Recovered	Unknown	Unknown	Unknown	Unknown	Recovered	Unknown	Unknown	Unknown	Unknown
SF_6					SF_6				
Recycled	12.0	13.2	14.6	16.0	Recycled	12.0	13.2	14.6	16.0
Reclaimed	1.9	1.6	1.8	2.0	Reclaimed	1.9	1.6	1.8	2.0
Destroyed	0.0	0.5	0.6	0.5	Destroyed	0.0	0.5	0.6	0.5
Recovered	14.0	15.5	17.1	18.8	Recovered	14.0	15.5	17.1	18.8
Total F-Gases					Total F-Gases				
Recycled	55.2	50.2	51.8	54.7	Recycled	21.9	22.0	23.5	25.4
Reclaimed	4.1	3.7	4.2	5.0	Reclaimed	3.1	2.8	3.2	3.7
Destroyed	16.8	14.7	14.7	14.9	Destroyed	3.5	3.5	3.5	3.5
Recovered	76.2	68.7	70.9	74.8	Recovered	28.6	28.4	30.4	32.9

Notes: Recycling, reclamation and destruction values may not add to recovery totals because some facilities store F-gases indefinitely on-site. Summary totals include PFCs as reported by commercial reclamation and destruction facilities; however, such quantities are negligible, and therefore have not been scaled up because of data limitations.

Barriers

Many questionnaire respondents indicated that there were significant barriers to recovery, recycling, reclamation, and/or destruction of F-gases in the EU-27. Perceived and real barriers include those relating to technical, infrastructure, economic, regulatory, and informational concerns. In particular:

- **Infrastructure Barriers:** There is a lack of capacity in some Member States relating to F-gas purity testing, reclamation, and/or destruction. Access to reclamation and destruction facilities poses a challenge particularly for those Member States without any such facilities. Based on information gathered for this report, there are no known commercial reclamation facilities in at least eight (8) Member States, and no destruction facilities in nine (9) Member States.

- **Technical Barriers:** Recycled refrigerants are not typically preferred in the market place because of their lower quality and performance characteristics attributable to the inability to meet original equipment manufacturer (OEM) specifications. In addition, recovered refrigerant blends are difficult to recycle because end users have purity requirements for the refrigerants used in their equipment, which require the use of virgin or reclaimed fluids. Moreover, many reclamation facilities will not accept refrigerant blends containing HFCs because blends are difficult to separate and it may not be possible to reformulate blends to manufacturers' specifications given the proprietary nature of the formulation and governing patent laws. Reconstituting with the proper lubricant oils is also complex.

- **Economic Barriers:** The cost associated with the purchase and operation of equipment for the recovery and recycling of F-gas is a significant barrier—especially for smaller companies. Moreover, for recovered F-gases that are too contaminated for recycling, end-users must pay for reclamation or destruction. Not only are companies typically charged a fee to bring contaminated fluids to reclamation or destruction facilities, they must also pay for transportation. And, with limited access to reclamation and destruction facilities, transborder waste shipment is often required, which triggers administrative requirements that can be costly and time-consuming (see regulatory barriers described below). The burden associated with reclamation/destruction is particularly heavy for small quantities of F-gases.

- **Regulatory Barriers:** Per Regulation (EC) 1013/2006 on shipments of waste, the shipment of F-gas refrigerant sent for disposal or reclamation across different MS within the EU-27 requires prior written notification and consent, which is perceived as a barrier by industry stakeholders because of the paperwork required. Additionally, there may be a lack of standardized regulations across the EU-27, which complicates the transfer of F-gases within the EU.

- **Informational Barriers:** There is a general lack of industry and customer awareness and dissemination of knowledge regarding the need to recover F-gases, the methods by which to recover F-gases, and what should be done with F-gases once they are recovered. For example, in the high-voltage switchgear sector, there is industry uncertainty as to whether reclaimed SF_6 must be treated as a waste, according to national legislation. Poor knowledge of the regulations and a lack of technical knowledge about proper techniques/practices results in low recovery rates, and hence, increased emissions. There are also informational barriers associated with the location of nearest reclamation/destruction facilities. This uncertainty effectively limits the extent of F-gas reclamation and destruction activities. While this study has helped identify the names and locations of F-gas reclamation and destruction facilities across the EU-27 (see *Annex C: List of F-Gas Reclamation* Facilities), more work is needed to develop a comprehensive listing.

Recommendations

Recommendations to overcome the real and perceived barriers associated with F-gas RRRD activities and to improve the certainty of historical and future F-gas RRRD estimates are presented below.

Remove Cost Burden

RRRD related cost impacts to the end-users should be minimised. In short, creating economic incentives—or at least removing disincentives—is important for increasing levels of reclamation and destruction across the EU. Therefore, the EC should consider the following schemes:

- Mandate F-gas producer responsibility for the take-back of unwanted F-gases for the purpose of reclamation or destruction, allowing users to return recovered F-gases to producers (through the supply chain) at no-cost. Carbon credits may also represent a potential funding source to be explored by F-gas producers—should F-gas destruction projects be approved by carbon trading platforms. Finally, destruction of F-gases could be used as an offset for production allowances, should there be a cap placed on HFC production in the future.

- Offer a rebate on the return of recovered F-gases to create an incentive for F-gas recovery. A number of countries have implemented mandatory reclamation/destruction requirements on F-gases (e.g., Norway, France, Australia) and have experienced incremental increases in the amount of gases returned for reclamation/destruction.[7] Such refund schemes are often funded by levies placed on newly produced/imported F-gases.[8]

[7] For example, in France, where reclaimed refrigerant totals have been gathered, there has been a significant increase in the efficiency of the recovery program. In 1992, without any regulation, only 200 MT of recovered

Further study would be needed to evaluate existing schemes and funding options in place to determine the most appropriate design and infrastructure for any such scheme across the EU-27.

Increase Awareness

Member State governments and companies/technicians must be universally aware of the locations of reclamation and destruction facilities within their State and beyond. This report provides an excellent starting point for developing this information, but Member States should play a role in expanding upon it and in providing assistance in education in the following capacities:

- Work with national trade associations representing the F-gas sectors to educate their members about where reclamation/destruction facilities can be found, and what procedures are needed to safely and legally ship the F-gases.
- Provide a clearinghouse of information, such as a website, with a listing of the reclamation and destruction facilities, EU-wide and national legislations that directly and indirectly impact RRRD activities, points of contact, and guidance materials.
- Pursue outreach efforts through the supply chain to ensure information is reaching all stakeholders down to the F-gas servicing sector, where many small operations exist.

Clarify/Expedite Regulatory Requirements within the EU-27

Both real and perceived legal barriers must be overcome to facilitate recovery and shipment of recovered F-gases for the purposes of reclamation and destruction. As many Member States do not have their own reclamation or destruction facilities, it is imperative that end-users in these countries are able to ship their recovered F-gases for reclamation and destruction easily and without great expense. Moreover, while the Commission conducts regular meetings with Member States and stakeholders on waste shipments, drafts guidelines to assist in the interpretation of these regulations, and lists competent Member State authorities who can provide guidance to stakeholders as needed,[9] some legal misinterpretation and confusion remains. Accordingly, the EC should take the following steps to ensure that EC regulations allow for clear, non-burdensome transport of F-gases for reclamation and destruction:

- Conduct outreach/education to further clarify the requirements triggered under Regulation (EC) 1013/2006 when used F-gases are shipped within the Community for the purpose of reclamation or destruction. In particular, in order to reduce the perceived barriers, the EC, the European Chemicals Agency (ECHA) and other relevant bodies should develop joint guidance on how to interpret Regulation (EC) 1013/2006, as they pertain to the recovery, reclamation, and destruction of F-gases, and make such guidance accessible to industry by posting on the EUROPA website and disseminating widely through key industry associations.
- Reconsider and amend its classifications of waste under Regulation (EC) 1013/2006 to allow for the inter-MS shipment of F-gases that can be safely transported (i.e., all F-gases except for spent solvents) for reclamation or destruction to occur without triggering notification/consent requirements under waste regulations. In the coming months, the Commission will begin considering proposals from Member States to include additional "green"-listed wastes in Annex IIIB of Regulation (EC) 1013/2006; the shipments of such wastes would not have to undergo the notification procedure. Therefore, this represents an important opportunity for amending the

---

refrigerant (CFCs and HCFCs) were reclaimed. In 1993, after making recovery mandatory and carrying out a deposit-refund scheme, the quantity grew to 300 MT, and the number of refrigeration companies concerned doubled from 200 to 400 (out of 2,500). Government incentives were necessary to reach full development of recovery schemes (RTOC, 2006).

[8] For example, in Australia, import levies apply to imports of F-gases (and ODS) in bulk and to those contained in pre-charged equipment. The current import and manufacture levy rates for F-gases are approximately US$140 per metric ton (ICF, 2008b).

[9] See http://ec.europa.eu/environment/waste/shipments/lists.htm.

waste classification of recovered F-gases and overcoming current barriers related to compliance with notification procedures.

Ensure Adequate Reclamation/Destruction Capacity

Additional capacity in certain Member States and/or streamlined procedures for trans-border shipments (discussed above) may be required. Individual Member States will need to assess national capacity against demand for reclamation/destruction,[10] to ensure that stakeholders in their countries have feasible means of reclamation/destruction by taking the following actions:

- Conduct stakeholder consultations to determine reclamation/destruction capacity in each MS and assess the national need for additional reclamation/destruction infrastructure.[11]
- Assess whether it will be more economically and environmentally feasible to build new facilities, upgrade existing ones, or ship recovered F-gases to neighbouring countries with existing facilities. This analysis may be appropriate for those Member States that do not have sufficient in-country capacity, as well as those without any capacity. In addition, Member States should identify (e.g., through targeted analysis and consulting with national trade associations and other industry representatives) the most suitable infrastructure to meet national demand for reclamation/destruction services—be it through the establishment of collection points for bulk F-gases, enhanced coordination between neighbouring countries, or other related activities.
- Consider providing initial incentives, such as grants or low-interest loans, to help reclamation facilities develop initially, should one or more new in-State reclamation facility be deemed necessary.

Refine Historical Estimates and Mandate Company Reporting

A more effective method to collect data on levels of F-gas RRRD must be identified and implemented in order to improve historical estimates presented in this study and more accurately track changes over time. While operators of refrigeration/AC (RAC) and fire protection equipment are now obliged under Article 3(6) of Regulation (EC) No 842/2006 to maintain records of inter alia recovered quantities, there are no reporting procedures in place to ensure that the fates of recovered quantities are accounted for. Further, a more simplistic indicator to assess changes in levels of F-gas recovery must be adopted because of the difficulty in tracking and obtaining data on F-gas recovery and recycling. As such, the Commission should use reclamation and destruction data as indicators of the effectiveness of F-gas recovery and related regulations by pursuing the following action:

- Require annual reports on F-gas reclamation and destruction, by gas, from all facilities that perform F-gas reclamation and destruction *on*-site.

[10] If the EC adopts a producer responsibility scheme, such an assessment by Member States would not be needed, as producers would be responsible for securing adequate reclamation/destruction capacity.

[11] Note that existing high-performance facilities may be upgraded to handle F-gases in certain instances.

1 Introduction

On February 16, 2005, the Kyoto Protocol to the United Nations Framework Convention on Climate Change entered into force and became legally binding on approximately 130 signatory parties. Today, there are more than 170 signatory parties. The Protocol requires all signatory industrialised countries to reduce their emissions of six major greenhouse gases—CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6—to below 1990 levels by 2012. As a signatory party, the European Community must cut its total greenhouse gas (GHG) emissions by 8% by 2012. Post-2012 commitments under the Kyoto Protocol are currently under consideration.

Fluorinated greenhouse gases (F-gases) controlled under the Kyoto Protocol—i.e., HFCs, PFCs, and SF_6—have high global warming potentials (GWPs) and are used in a variety of equipment types and industrial applications (see Table 1-1). As of 1995, F-gas emissions represented only 2% of all GHG emissions from the EC; assuming no additional mitigation measures were put in place, emissions of F-gases were expected to grow by as much as 4% of all GHG emissions by 2010. This increase would occur in part because F-gases are the primary alternatives for many ozone depleting substances (ODS), which are being phased-out under Regulation (EC) No 2037/2000, per the Montreal Protocol.

Table 1-1. GWPs and Industrial Applications of Fluorinated Greenhouse Gases Regulated by (EC) No 842/2006

F-Gas Type	Sulphur Hexafluoride (SF_6)	Hydrofluorocarbons (HFCs)[a]	Perfluorocarbons (PFCs)[b]
GWP (100-yr)	22,200	97- 12,000	5,700 -11,900
Major Applications	• Electrical Power • Magnesium Production • Semiconductor Manufacturing	• Refrigeration • Air Conditioning and Heat Pumps • Fire Protection • Solvents • Aerosols • Foams	• Semiconductor Manufacturing • Aluminium Production

[a] Common HFCs (and their *100 yr-GWPs based on IPCC TAR*) include HFC-23 (*12,000*), HFC-32 (*550*), HFC-125 (*3,400*), HFC-134a (*1,300*), HFC-143a (*4,300*), HFC-152a (*120*) and HFC-227ea (*3,500*).

[b] Common PFCs (and their *100 yr-GWPs based on IPCC TAR*) include perfluoromethane (*5,700*) and perfluoroethane (*11,900*).

On 17 May 2006, Regulation (EC) No 842/2006 was adopted in order to reduce the emissions of F-gases and assist the EU in making a significant contribution toward the European Community's Kyoto Protocol target. The regulation contains a number of provisions to monitor the consumption and reduce the emissions of F-Gases, including labelling, reporting, and leak checking requirements. Article 4 of the Regulation requires operators of a specified list of stationary applications to put in place arrangements for the proper recovery of F-gases at equipment servicing maintenance, and disposal events, for the purpose of recycling, reclamation or destruction. These applications include:

- Cooling circuits of refrigeration, air conditioning and heat pump equipment;
- Equipment containing fluorinated greenhouse gas-based solvents;
- Fire protection systems and fire extinguishers;
- High voltage switchgear; and
- Other products and equipment, including mobile equipment.

Although not all F-gases can be easily recovered and/or made available for recycling/destruction, the amounts of "accessible" F-gases in stationary applications can be significant. From an environmental perspective, it is critical that F-gases contained in end-of-life equipment in the EU-27 be fully recovered for recycling/reclamation or destruction to avoid venting of the potent GHGs to the atmosphere.

Article 6 of Regulation (EC) No 842/2006 requires that producers, importers and exporters of F-gases report, inter alia, the amounts of F-gases produced, imported, or exported in EU-27, the intended use of the gases, and quantities of F-gases reclaimed and destroyed to the European Commission annually, beginning in 2008 (for activities occurring during 2007) if those amounts are greater than one metric tonne of F-gases per annum. According to 2007 data reported by producers, importers and exporters pursuant to Article 6 of Regulation (EC) No 842/2006, more than 93,000 tonnes of F-gases were sold in 2007 in the EU. Table 1-2 details each sector's percent share of these sales. Companies reported that during 2007, they reclaimed over 355 metric tonnes (t) of F-gases and, destroyed over 50 t.[12]

Key Terms (per Regulation (EC) No 842/2006)

Recovery: the collection and storage of fluorinated greenhouse gases from, for example, machinery, equipment and containers.

Recycling: the reuse of a recovered fluorinated greenhouse gas following a basic cleaning process.

Reclamation: the reprocessing of a recovered fluorinated greenhouse gas in order to meet a specified standard of performance.

Destruction: 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.

Table 1-2. Percent Share of EU-27 F-gas Sales (in metric tonnes) in 2007, by Sector

Sector	Percent Share
Sectors covered under Article 4, Regulation (EC) No 842/2006 and Analysed in this Report	
Refrigeration and Air Conditioning (RAC)	69.4%
Switchgear	1.7%
Fire Protection	0.7%
Solvents	0.2%
Other Sectors covered under Regulation (EC) No 842/2006	
Foams	15.7%
Aerosols	10.2%
Magnesium die casting, semiconductor manufacture, feedstock, and other unknown sectors	2.1%

Historical levels of F-gas recovery, recycling, reclamation, and destruction (RRRD) and industry's general business practices provide a benchmark for measuring current and future levels and practices. Furthermore, to maximize levels of F-gas RRRD in the EU, it is critical to identify any barriers (e.g., information gaps, market disincentives, infrastructure deficiencies) so that effective policy prescriptions may be developed.

To this end, this report aims to (1) estimate levels of RRRD during the period of 2004-2007, and (2) identify barriers to these activities and possible solutions to overcome these barriers to facilitate a continued increase in F-gases recovered for recycling, reclamation, and destruction in the EU-27.

The remainder of the report is organised as follows:

- Section 2 describes the methodology undertaken for the study, including the survey approach and analysis of responses;
- Section 3 presents the data reported by stakeholders on F-gas reclamation;
- Section 4 presents the data reported by stakeholders on F-gas destruction;
- Section 5 summarises the questionnaire responses from stakeholders in the refrigeration and air conditioning, high-voltage switchgear, fire protection, and solvents F-gas sectors;

[12] The destruction of HFC-23 for carbon credits is not included in this tally, as this study seeks data on the fate of recovered F-gases collected and stored from machinery, equipment and containers; therefore, HFC-23 produced as a by-product of production of HCFC-22 is not considered in this study.

- Section 6 presents estimates of total F-gas RRRD in the EU-27, based on analysis of all survey data;
- Section 7 concludes with a summary of the findings of the RRRD analysis, which include a presentation of the cross-sectoral and sector-specific barriers to proper RRRD of F-gases, as identified by stakeholders; and provides recommendations for improving F-gas RRRD in the EU-27;
- Annex A provides the questionnaires sent to industry and Member State representatives;
- Annex B presents a list of industry associations contacted for this study;
- Annex C provides a list of reclamation facilities in the EU-27; and
- Annex D provides a list of destruction facilities in the EU-27.

2 Methodology

To estimate levels of F-gas recovery, recycling, reclamation, and destruction by gas across the EU-27 for years 2004-2007, extensive survey efforts were undertaken across F-gas sector stakeholders in the EU-27. Specifically, reclamation facilities were surveyed regarding the technologies they use to reclaim F-gases, the quantities of F-gas they've reclaimed since 2004, and the capacity of their facilities to reclaim F-gases. Similarly, destruction facilities were surveyed regarding the technologies they use to destroy F-gases, the quantities of F-gases they have destroyed, and the capacity of their facilities to destroy F-gases. F-gas producers/importers/exporters that have reclaimed or destroyed F-gases at their facilities were also surveyed. In addition, F-gas users (i.e., equipment operators and service providers) were surveyed to estimate quantities of F-gases recovered and recycled. Such extensive survey efforts were needed because much of this information is not tracked by stakeholders, and none is actually reported to Member State representatives; therefore, approaching stakeholders directly and through major trade associations was the only way this information could be obtained.

However, the collection of data on the quantities of F-gases recovered and recycled during years 2004-2007 posed several challenges that were recognised at the outset of the project. In particular, while Article 3 of Regulation (EC) No 842/2006 requires that operators of certain F-gas equipment[13] maintain records on the quantity of F-gases recovered during servicing, maintenance, and final disposal of equipment, and that these records be made available on request to the Commission, identifying and collecting information from such a large and diffuse group of stakeholders represented a serious logistical barrier. Moreover, quantities of F-gases recovered and recharged into equipment is difficult to measure and track, and was not required to be recorded by equipment operators as early as 2004. Therefore, associations representing equipment operators and service providers were surveyed about the approximate *proportion* of recovered F-gases that are recycled versus reclaimed or destroyed in each sector. Other qualitative information was also solicited from industry stakeholders.

Finally, to identify actual or perceived barriers to the recovery, reclamation, and/or destruction of F-gases in the EU, ICF solicited input from Member States, reclamation facilities, destruction companies, importers, exporters, and selected associations representing equipment operators/service providers. Information was also obtained based on other available studies.

This remainder of this section describes the survey approach and methodology in more detail.

2.1 Survey Approach

Questionnaires were designed to collect quantitative estimates of the amount of F-gas, by type that were recovered, recycled, reclaimed, and destroyed from 2004 to 2007 from the following sources:

- Stationary refrigeration, air conditioning (AC), and heat pump equipment;
- Stationary equipment containing F-gas-based solvents;
- Stationary fire protection systems and fire extinguishers;
- High voltage switchgear (used in electric power systems);
- Refillable and non-refillable fluorinated F-gas containers; and
- Other products and equipment, including mobile equipment.

These sources cover the refrigeration and air conditioning (RAC), solvent cleaning, electrical power systems, and fire protection industrial sectors ("F-gas sectors") that use and emit HFCs, PFCs, and

[13] This regulation pertains to operators of refrigeration, air conditioning and heat pump equipment, as well as fire protection systems.

SF_6. Therefore, questionnaires were tailored to the following stakeholder groups in the EU-27, which are likely to recover, recycle, reclaim, and destroy F-gases, as described in the text box below:

(1) Commercial F-gas reclamation facilities
(2) Commercial F-gas destruction facilities
(3) F-gas producers/importers/ and exporters
(4) Selected industry associations and companies in F-gas sectors representing equipment operators and service providers in the following sectors:
    - Stationary RAC
    - Mobile RAC
    - Solvent cleaning
    - Electrical power systems
    - Fire protection

Overview of Stakeholders Involved in the F-Gas Recovery "Cycle": Focus on the Refrigeration/AC Sector

Many groups of stakeholders are involved in F-gas recovery, recycling, reclamation, and destruction in the EU-27, as can be illustrated by the handling of F-gases in the most important sector—refrigeration/AC, which accounts for nearly 70% of all F-gases sold on the EU market.

First, F-gas refrigerants are recovered from equipment at time of service and disposal. Recovery must performed by certified technicians, who may be equipment operators, independent servicing contractors/companies, equipment manufacturers, demanufacturing facilities, or waste handlers. For example, recovery of F-gases from obsolete household appliances is typically performed after transportation to a waste facility upon disposal, whereas evacuation of commercial and industrial equipment can generally be performed on site using mobile recovery equipment. F-gases may also be collected from stockpiles held at industrial facilities or other warehouses. Once recovered, F-gases may be stored, recycled, reclaimed, or destroyed.

Recycling—or the reuse of a recovered F-gas following a basic cleaning process, such as filtering and drying—is the most economical option, as it involves recharge back into equipment (resulting in cost savings from avoided purchase of new refrigerant). Recycling is typically performed on-site by equipment owners or contracted service technicians. However, recycling can only be performed in cases where the recovered refrigerant is not excessively contaminated. In cases when recovered refrigerant is too contaminated for simple recycling, reclamation may be performed to restore the F-gas to a specified standard of performance.

Reclamation—or the re-processing and upgrading of recovered F-gases through mechanisms such as filtering, drying, distillation and chemical treatment—is performed offsite by commercial reclaimers or by F-gas producers that reclaim gases onsite as part of routine business procedures. Reclamation costs vary depending on the market value and level of contamination of the recovered F-gas, as well as the distance between the physical location of the material and the reclamation facility. When reclamation cannot be performed cost-effectively (e.g., due to lack of access to reclamation facilities), or when technological or legal barriers are at play (e.g., in the case of refrigerant blends, which cannot be reconstituted without a patent), the recovered refrigerant must be destroyed.

Destruction is the process by which all or most of an F-gas is permanently transformed or decomposed into one or more stable substances which are not fluorinated greenhouse gases. Destruction may be performed by commercial facilities that operate high-temperature incinerators or other approved destruction technologies, or by F-gas producers that destroy gases on-site as part of routine business procedures. Destruction is associated with a cost (~€1- 11/kg) (ICF 2008b).

Before being transported for reclamation or destruction, F-gases are consolidated and often stored temporarily, to avoid shipping many smaller containers of F-gases, which leads to complications and additional expense. This process of consolidation prior to shipment may occur several times at multiple levels of the supply chain (ICF 2008b). For example, F-gases service companies may consolidate their recovered stocks and send them to a distributor that further consolidates received stocks into an even larger shipment. In addition, F-gases may be transported to numerous locations before ultimate destruction is performed; for example, F-gases may be transported from service companies to distributors for consolidation, and then shipped again to the destruction facility.

Member States were also surveyed for national data on the amount of F-gas substances recovered, recycled, reclaimed, and destroyed between 2004 and 2007, to the extent such data were available. Additionally, MS were asked to provide names and contact information for reclamation and destruction facilities within their country, as well as to identify industry associations for each of the F-gas sectors.

All stakeholder groups were asked about actual or perceived barriers to the recovery, reclamation, and/or destruction of F-gases in the EU. All questionnaire templates are presented in Annex A

In total, questionnaires were disseminated to approximately 350 contacts within the five stakeholder groups.[14] Questionnaires were disseminated via electronic mail in February, March, and April 2008. A second set of questionnaires were sent in May, June, and July 2008, as additional contact information became available from Member State representatives and official EC data reports submitted by companies pursuant to Article 6 of Regulation (EC) No 84/2006. To encourage responses, follow-up emails were sent to non-responsive representatives as the questionnaire deadlines approached. Deadlines for completing the questionnaires were extended several times to accommodate requests of respondent companies that needed more time and to further encourage participation.

ICF focused its efforts on obtaining questionnaire responses from reclaimers and destruction companies, since those target groups were deemed most likely to have reliable, comprehensive data on historical F-gas quantities reclaimed and destroyed, which could serve as the basis for estimating quantities recovered and recycled. Thus, to encourage industry questionnaire responses, Member State representatives were asked to urge reclamation and destruction companies within their country to respond to the questionnaires.

Moreover, to better enable the F-gas user community to respond to the questionnaires, revised questionnaires were developed and disseminated soliciting *qualitative* information from stakeholders in each F-gas sector—recognising that quantitative data on historical levels of F-gas RRRD may not be widely available. By collecting qualitative information from F-gas users, information could be used to fill in any data gaps by characterising historical levels of F-gas recovery/recycling in cases where quantitative data was not possible to obtain. As part of the effort to obtain qualitative information from the F-gas user community, telephone calls were also made to key industry associations in each sector, and a stakeholder meeting was held in Brussels, Belgium between ICF International, the EC, the European Partnership for Energy and the Environment (EPEE), the Air Conditioning and Refrigeration European Association (AREA), Solvay, DuPont, and Daikin Industries, Ltd. in June 2008.

[14] The actual number of questionnaires disseminated is greater than the number of contacts identified here because some of these contacts include trade associations that subsequently distributed the questionnaires to their member companies.

2.2 Questionnaire Response Rate

Table 2-1 summarises the survey response by target group.

Table 2-1. Questionnaire Dissemination and Response, by Target Group

Target Group	Questionnaires Disseminated		Responses Received	
	Trade Associations	Company/ Member States	Trade Associations	Company/ Member States
Member States	NA	27	NA	20
Reclaimers	NA	46	NA	10
Destruction Companies	NA	54	NA	7
F-gas Producers, Importers, and Exporters				
Producers	NA	2	NA	2
Importers	NA	27	NA	7
Exporters	NA	16	NA	1
Producer/Importer/ Exporter	NA	6	NA	2
Producer/Exporter	NA	3	NA	3
Importer/Exporter	NA	18	NA	4
F-Gas Stakeholders by Sector				
Refrigeration, Air conditioning and Heat Pumps	17	1	3	9
High Voltage Switchgear	5	0	4	NA
Fire Protection	32	51	3	7
Solvents	19	2	1	0

NA= Not applicable.

Note: Trade associations also disseminated surveys to an unknown number of companies causing some instances where the number of "responses received" is higher than "questionnaires disseminated."

Sections 3 through 5 present the data reported in these questionnaire responses and provide summary totals on reclamation and destruction as well as summaries by F-gas sector.

2.3 Data Analysis

Based on the data collected through the survey effort, estimates of F-gas RRRD, by year, by gas, and by sector were "scaled up" for the entire EU-27. Distinct methodologies for scaling up these estimates were developed for each F-gas sector, based on consideration of unique sector characteristics, available data, and data limitations. Specifically, the following methodology was used:

2.3.1 Refrigeration/Air Conditioning/Heat Pumps

Survey data on on-site reclamation/destruction (from commercial reclamation and destruction facilities, producers/importers/exporters, and multinational RAC servicing companies) were deemed to be the most reliable, comprehensive, and non-duplicative datasets for estimating total HFC reclamation and destruction in the EU. However, because not all such facilities that reclaim/destroy F-gases responded to the questionnaires prepared for this study, upper and lower bound scenarios were developed in order to account for their activities:

- **Upper Bound Scenario:** all commercial reclamation/destruction facilities that did not respond to the survey reclaim/destroy HFCs at 50% of the rate as the average levels (by year and by gas) of those that did respond to the survey. It is assumed that F-gas producers/importers/exporters that responded to the survey account for 95% of all reclamation/destruction performed by producers/importers/exporters in the EU-27. It was further assumed that there are a total of five large multinational RAC servicing companies that perform on-site reclamation (i.e., at their facilities) in the EU; therefore, the one

multinational RAC servicing company that responded to the survey is assumed to account for 20% of the F-gases reclaimed by this stakeholder group.

- **Lower Bound Scenario:** non-respondents did not reclaim/destroy HFCs.

Based on estimated levels of HFC refrigerant reclaimed and destroyed for 2004-2007 under the upper and lower bound scenarios, total quantities of HFC refrigerant recycled were subsequently estimated by assuming that recycled quantities represent approximately 70% of the total quantities recovered. (i.e., recovered F-gas = 70% recycled + 30% reclaimed/destroyed). This assumption was developed based on aggregated amounts of RRRD of HCFCs reported by EU-15 Member States to the EU Commission under Article 16 of EC Regulation 2037/2000 (Ecofys, 2006)[15] which was deemed as the best available proxy. Levels of HFC refrigerants recovered were then estimated by summing the quantities of total HFC refrigerant recycled, reclaimed, and destroyed.

2.3.2 High Voltage Switchgear

Survey data on on-site reclamation and destruction (from SF_6 producers/importers/exporters and commercial destruction facilities, respectively) were deemed to be the most reliable, comprehensive, and non-duplicative datasets for estimating total SF_6 reclamation and destruction in the EU.[16] More specifically, to estimate EU-wide levels of SF_6 reclamation and destruction, the following methodology and assumptions were used:

- ***Reclamation***: the quantities of SF_6 reclaimed across the EU are based on those quantities of SF_6 reclaimed on-site (i.e., at company facilities, not sent off-site for the purpose of reclamation), as reported by producers/importers/exporters per the requirements of Article 6 of Regulation (EC) No 842/2006. Reported quantities were not scaled up to account for non-respondents, because it is believed that all SF_6 reclamation is performed by the few producers, all of which are believed to have complied with the reporting requirements of Article 6 of Regulation (EC) No 842/2006. For those producers that submitted reports to the EC (for year 2007) but did not respond to the survey prepared for this study, it was assumed that their 2007 SF_6 reclamation levels were the same in years 2004-2006.
- ***Destruction***: the quantities of SF_6 destroyed across the EU are based on those quantities of SF_6 destroyed on-site (i.e., at company facilities, not sent off-site for the purpose of destruction), as reported by commercial destruction facilities through this survey. While it possible that other companies that did not respond to the survey prepared for this study also destroy SF_6, since this gas is very difficult to destroy,[17] it is conservatively assumed that survey respondents account for 100% of SF_6 destruction.

To estimate total quantities of SF_6 recycled during 2004-2007, information provided by end-users in the electricity transmission/distribution sector on the fate of recovered SF_6 was used. Specifically, based on surveys submitted by stakeholders, the following ratios were estimated for the fate of recovered SF_6:

[15] Given that no parallel data exist for HFCs, these data on the fate of recovered HCFC refrigerants were deemed to provide the best proxy for understanding trends in the fate of recovered HFC refrigerants. The fate of recovered CFC refrigerant was not deemed to be an appropriate proxy, given that CFCs cannot legally be reused in the EC.

[16] End-user data on SF_6 quantities sent for reclamation and destruction were not deemed as reliable, since such quantities could be double-counted against that provided by facilities that actually performed the reclamation/destruction on-site.

[17] Due to the very high thermal stability of SF_6, it is essential to use a destruction process that combines high temperature ($\geq$1,200 degrees C) with a long residence time as the basic prerequisite for a high destruction and removal efficiency. As such, only three technologies may be suitable for SF_6 destruction: rotary kiln incineration, inductively coupled radio frequency plasma, and microwave plasma. Rotary kiln incinerators are believed to be the only technology used for destroying SF_6 in the EU (CIGRE, 2003; Solvay, 2008).

— Recycled: ~ 85%
— Reclaimed/destroyed: ~ 14%
— Stored indefinitely: ~ 1%

Therefore, once quantities of SF_6 reclaimed and destroyed were estimated, the sum of those quantities was scaled (i.e., multiplied by 85/14) to estimate the quantity of SF_6 recycled in each year. Next, annual levels of SF_6 recovered were estimated by summing the quantities of total SF_6 recycled, reclaimed, destroyed, and stored.

2.3.3 Solvents

The solvents sector is the smallest of the F-gas sectors in the EU-27. In 2007, this sector represented only 0.2% of EU-27 F-gas sales. Given that no quantitative data were received from company contacts during the survey effort, no scale-up effort could be conducted for this sector. However, from 2004-2007, RRRD levels from the solvents sector in the EU-27 are believed to be negligible. Therefore, for the purpose of this analysis, levels of F-gas recovery, recycling, reclamation, and destruction are assumed to be zero.

2.3.4 Fire Protection

Three survey responses were received on RRRD levels of HFC-227ea and HFC-125 in the fire protection sector: one from a producer/importer of insulation-fire protection products, one from a commercial reclamation facility, and one from a company that supplies/maintains fire protection systems. The latter company is believed to be one of roughly 10 major HFC fire protection companies in the EU-27 (Hughes Associates, 2008). To determine EU-wide RRRD estimates, the respondent company that supplies/maintains fire protection systems was assumed to be representative of the 10 major players in the EU-27 fire protection market. Therefore, levels of F-gas RRRD reported by this company were scaled up for the nine other companies. Additional quantities of HFC-227ea reported as having been reclaimed by the producer/importer[18] and the commercial reclamation facility were added to this total.[19]

These methodologies, along with the resulting estimates, are described in further detail in Section 6.

In addition, qualitative information on barriers to F-gas reclamation and destruction was compiled across all F-gas stakeholders and are presented along with the findings and recommendations of this analysis in Section 7.

[18] This producer/importer submitted a report to the EC for year 2007 but did not respond to the survey prepared for this study; it was assumed that their 2007 HFC-227ea reclamation levels were the same in years 2004-2006.
[19] Quantities reclaimed by the producer/importer and commercial reclamation facility were not scaled up to account for non-respondents because the previous scale-up methodology (applied to account for RRRD levels of the major industry players in the fire protection market) is intended to represent the majority of the industry.

3 F-Gases Reclamation in the EU-27

This section summarises available data on reclamation of F-gases based on questionnaire responses received from commercial reclamation facilities, Member States, and F-gas producers, importers, and exporters.

3.1 Reclamation Totals Reported by Commercial Facilities

A total of 46 commercial reclamation facilities[20] were identified through Member State representatives and based on a recent ICF study prepared for the EC (ICF, 2008a).[21] As shown in Table 3-1, of the 46 facilities sent questionnaires, 22% submitted responses.

Table 3-1. Number of Known Commercial F-Gas Reclamation Facilities and Questionnaire Responses

Country	Reclamation Facilities	Number of Responses Received	Country	Reclamation Facilities	Number of Responses Received
Austria	3	0	Latvia	NR	NA
Belgium	3	1	Lithuania	1	NA
Bulgaria	2	1	Luxembourg	1	0
Cyprus	0	NA	Malta	NR	NA
Czech Republic	3	1	Netherlands	3	1
Denmark	NR	NA	Poland	1	1
Estonia	1	1	Portugal	Unknown	NA
Finland	0	NA	Romania	Unknown	NA
France	3	0	Slovakia	2	0
Germany	2	0	Slovenia	1	1
Greece	0	NA	Spain	3	0
Hungary	1	0	Sweden	Unknown	NA
Ireland	0	NA	UK	3	2
Italy	14	0	Total	46	10

NR = No response received from MS questionnaire; it is unknown how many (if any) reclamation facilities are in operation.
NA = Not applicable.
Unknown = Member State representative was not able to provide information on in-country reclamation facilities, and no other information is readily available on the existence of in-country facilities.

As shown, Cyprus, Finland, Greece, Ireland, Portugal, Romania and Sweden have no known commercial reclamation facilities in their territory. Italy reported the greatest number of reclamation facilities (14). No information is available on reclamation facilities in Denmark, Latvia, and Malta, as no feedback was received and no other information was available on reclamation capacity in these Member States. Information on known reclamation facilities in Belgium, Germany, the Netherlands, and Slovenia was taken from ICF (2008a).

[20] For the purposes of this report, "commercial reclamation facilities" are defined as those facilities that accept F-gases from the public for the purposes of reclamation. F-gas producers, importers, and/or exporters that perform on-site reclamation of F-gases that are recovered from their own activities and/or from their customers, are considered separately in Section 3.3.

[21] Several facilities identified by Member States are not included in this total because they were found to no longer be in operation or to not perform reclamation services.

According to questionnaire responses from commercial reclamation facilities, a variety of F-gases were reclaimed in the EU-27 between 2004 and 2007. As shown in Table 3-2, HFCs accounted for the vast majority (99.8%) of F-gases reclaimed by commercial facilities in 2007, with PFCs accounting for roughly 0.2%. No SF_6 reclamation was reported by commercial facilities. Of the HFCs reclaimed, HFC-134a accounted for the greatest share (48%), with HFC-407a/b and HFC-407c also reclaimed in significant quantities. It is important to note that many reclamation facilities did not have historical data available on quantities of F-gases destroyed. The majority of the reclamation facilities (80%) that responded to the questionnaire provided quantitative data. Two facilities responded that they have reclamation capabilities but have not begun to reclaim F-gases, although they plan to do so in the future. Quantitative data on historical reclamation levels were provided by facilities in the United Kingdom, Bulgaria, Poland, Belgium, the Netherlands, and the Czech Republic. Based on this limited data, the greatest amount of F-gas reclamation was performed in the UK.

Table 3-2. F-Gases Reclaimed (t) by Gas, as Reported by Commercial Reclamation Facilities (2004-2007)

F-Gas Type	2004	2005	2006	2007
HFCs and HFC Blends				
HFC-134a	12.1	32.2	32.9	78.3
HFC-227eea	0.0	0.0	1.0	1.0
R-401a	1.0	0.0	0.2	0.0
R-402a	1.1	0.0	0.5	0.0
R-404a	3.0	7.3	12.4	19.3
R-407a/b	0.0	0.0	1.0	2.0
R-407c	0.0	26.4	41.4	60.9
R-408a	0.0	0.0	6.8	0.0
R-413a	0.0	0.0	0.0	0.0
R-507a	0.0	0.0	0.7	0.5
Subtotal—HFCs	*17.2*	*66.0*	*96.9*	*162.1*
PFCs				
C_2F_6	0.0	0.0	0.0	0.0
C_4F_{10}	0.0	0.0	0.3	0.3
Subtotal—PFCs	*0.0*	*0.0*	*0.3*	*0.3*
F-Gas Total				
HFCs, PFCs	17.2	66.0	97.2	162.4

3.2 Reclamation Totals Reported by Member States

In response to the survey request, Italy provided national data on HFC reclamation for years 2005 through 2007, as presented in Table 3-3. Although no questionnaires were received by commercial reclamation facilities in Italy, the data presented in Table 3-3 is assumed to represent national reclamation totals for Italy (i.e., for all 14 facilities).

Table 3-3. HFCs Reclaimed in Italy (t), as Reported by Member State (2005-2007)

Specific F-Gas Type	2005	2006	2007
HFCs and HFC Blends			
HFC-134a	0.4	5.5	5.1
R-404a	0.0	0.3	0.9
R-407c	4.4	13.2	9.4
R-410a	0.1	5.4	1.8
R-507a	0.0	2.7	0.0
R-402	0.2	0.1	0.0
R-408	0.0	0.0	0.0
TOTAL HFCs	5.1	27.2	17.2

3.3 Reclamation Totals Reported by F-Gas Producers, Importers and Exporters

On-site reclamation data collected from F-gas producers, importers, and exporters are presented in Table 3-4. This summary data is based on 19 company questionnaire responses submitted for this study; of the 19 respondents, five (26%) respondents quantified the historical amount of F-gases reclaimed on-site, while no others reported performing reclamation on-site. In addition to summarising the survey data collected for this report, Table 3-4 includes data for year 2007 obtained from 2007 data reported by producers, importers and exporters pursuant to Article 6 of Regulation (EC) No 842/2006; thus, data for 2007 is more robust than prior years (as it includes data from a greater number of companies).

Table 3-4. F-Gases Reclaimed (t) as Reported by F-Gas Producers, Importers, and Exporters (2004-2007)

F-Gas Type	2004	2005	2006	2007
HFCs and HFC Blends				
HFC-134a	25.2	24.5	29.6	262.8
R-404a	5.8	3.6	3.9	11.2
R-407c	9.7	5.5	9.4	27.1
Other (HFC-32, 125, 143a, 152a, 227ea)	1.0	1.0	1.0	26.7
Total HFCs	*41.8*	*34.6*	*44.0*	*327.9*
PFCs				
C_6F_{14}	*1.6*	*1.2*	*3.3*	*0.1*
SF_6				
SF_6	*35.0*	*21.0*	*29.0*	*90.2*

Note: sums may not add due to independent rounding.

3.4 Reclamation Reported by Multinational Servicing Companies

One multi-national refrigeration and air conditioning (RAC) equipment servicing company reported data for quantities reclaimed. For confidentiality reasons, these quantities cannot be disclosed as such in this report but have been accounted in the analysis.

3.5 Total Reported F-Gas Reclamation

Based on the survey information presented in Sections 3.1 through 3.3, the total quantities of F-gases reclaimed by facilities on-site, by gas, during 2004-2007 are presented Table 3-5.

Table 3-5. Total Reported On-Site F-Gas Reclamation (t) (2004-2007)

F-Gas Type	2004	2005	2006	2007
HFCs and HFC Blends				
HFC-134a	37.3	57.0	67.9	386.2
R-401a	1.0	0.0	0.2	0.0
R-402a	1.1	0.2	0.6	0.0
R-404a	8.8	10.9	16.6	31.4
R-407a/b	0.0	0.0	1.0	2.0
R-407c	9.7	36.4	63.9	177.4
R-408a	0.0	0.0	6.8	0.0
R-410a	0.0	0.1	5.4	1.8
R-413	0.0	0.0	0.0	0.0
R-507a	0.0	0.0	3.4	0.5
Other (HFC-32, 125, 143a, 152a, 227ea)	1.0	1.0	2.0	27.7
Total HFCs	*59.0*	*105.7*	*167.9*	*627.1*
PFCs				
C_2F_6	0.0	0.0	0.0	0.0
C_4F_{10}	0.0	0.0	0.3	0.3
C_6F_{14}	1.6	1.2	3.3	0.1
Total PFCs	*1.6*	*1.2*	*3.6*	*0.4*
SF_6				
SF_6	*35.0*	*21.0*	*29.0*	*90.2*
TOTAL F-GASES RECLAIMED				
HFCs, PFCs, SF_6	95.6	127.9	200.5	717.7

3.6 Reclamation Technologies, Costs, Capacity, and Feasibility

A number of commercial reclamation facilities provided information on reclamation technologies used, cost, capacity, feasibility, and sources of F-gases. The key findings are summarised below:

- **Reclamation Technologies in Use.** The reclamation technologies in use employ filtration, distillation, adsorption, and other separation technologies.

- **Cost.** The price charged to customers for F-gas reclamation in the EU-27 ranged from €0- €10 per kg, with the average price being roughly €4/kg during 2004-2007. The majority of the reclamation facilities did not expect costs to change in the future—unless new legislation is introduced that could drive up costs.

- **Reclamation Capacity.** Nine reclamation companies provided information on their annual reclamation capacity; combined, their capacity is approximately 1,600 t per year. The capacity of individual reclamation facilities ranged from 8 t per year (facility in Bulgaria) to 500 t per year (facility in the UK). The average reclamation capacity, based on questionnaire data, is nearly 190 t per year.

- **Reclamation Feasibility.** On average, facilities were unable to reclaim about one-third of gases collected, most commonly citing impurities (i.e., gases mixed with HCFCs, CFCs, or other HFCs) and high oil content as the reason for not reclaiming used F-gases.

  Gases that were not reclaimable were primarily sent off-site for destruction, mostly to the UK, Germany, or Belgium. One reclamation facility in Bulgaria reported that all non-reclaimable F-gases were stored, while another facility in Poland reported that mixtures that were not

reclaimable that contain only HFCs and HCFCs were stored and most likely sent for separation and reclamation in the United States.

- **Intra-EU trade in F-gases for purposes of reclamation.** The majority of questionnaire respondents indicated that used F-gases received for reclamation were from within their Member State; only a few facilities reported receiving F-gases from other countries. The most exceptional case was for one Belgian facility which receives between 60% and 70% of used F-gases for reclamation from the UK.

- **Source sectors of F-gases reclaimed.** Based on limited information received from commercial reclamation facilities, ICF estimates that the majority of HFCs (80%-100%) recovered for reclamation originated from the stationary refrigeration/air-conditioning, and heat pump equipment sector during the 2004-2007 period. A smaller percentage of HFCs (roughly 5%-20%) came from the mobile RAC sector. Approximately 5% of HFCs received for reclamation is believed to originate from F-gas containers at end of life (refillable and non-refillable containers).

4 F-Gas Destruction in the EU-27

This section summarises available data on the destruction of F-gases based on questionnaire responses received from commercial destruction facilities, Member States, and F-gas producers, importers, and exporters.

4.1 Destruction Totals Reported by Commercial Facilities

A total of 55 commercial destruction facilities[22] were identified through Member State representatives surveyed for this study, as well as through contact information developed for a previous EC study conducted by ICF (2006).[23] Of the 55 facilities surveyed, only 7 facilities (13%) submitted responses, as shown in Table 4-1.

Table 4-1. Number of Known Commercial F-Gas Destruction Facilities and Questionnaire Responses

Country	Destruction Facilities	Number of Responses Received	Country	Destruction Facilities	Number of Responses Received
Austria	1	0	Latvia	NR	NA
Belgium	1	0	Lithuania	1	NA
Bulgaria	Unknown	NA	Luxembourg	0	NA
Cyprus	0	NA	Malta	NR	NA
Czech Republic	2	1	Netherlands	5	0
Denmark	3	0	Poland	0	NA
Estonia	1	0	Portugal	0	NA
Finland	1	1	Romania	1	NA
France	3	1	Slovakia	1	0
Germany	3	0	Slovenia	NR	NA
Greece	0	NA	Spain	0	NA
Hungary	5	0	Sweden	3	2
Ireland	0	NA	UK	13	2
Italy	12	0	Total	55	7

NR= No information was provided; it is unknown if/how many destruction facilities are in operation.
NA= Not applicable.
Unknown= No information was provided on in-country destruction facilities, and no other information is readily available on the existence of in-country facilities.

Not all Member States have commercial destruction facilities. For example, Cyprus, Greece, Ireland, Luxembourg, Poland, Portugal, and Spain have no destruction facilities in-country. The United Kingdom (UK) reported the greatest number of destruction facilities (13). Information on known destruction facilities in Belgium, Denmark, Germany, the Netherlands, and Slovenia is based on ICF (2006). No information is available on reclamation facilities in Latvia, Malta, and Slovenia.

According to questionnaire responses from commercial destruction facilities, Table 4-2 presents the quantities of F-gases destroyed in the EU-27, by gas. As shown, there has been a steady increase in the level of F-gas destruction from 2004 to 2007. Ninety-eight percent of all F-gases destroyed in 2007 were HFCs, with the remaining 2% being SF_6; no PFC destruction was reported during the

[22] For the purposes of this report, "commercial destruction facilities" are defined as those facilities that accept F-gases from the public for the purposes of destruction. F-gas producers, importers, and/or exporters that perform on-site destruction of F-gases that are recovered from their own activities and/or from their customers, are considered separately in Section 4.2.
[23] Several facilities identified by Member States are not included in this total because they were found to no longer be in operation or to not perform destruction services.

2004-2007 period. A full 50% of HFCs destroyed in 2007 were HFC blends, while HFC-134a accounted for 42%. Quantitative data on HFC destruction was provided by facilities in France, the UK, the Czech Republic, and Finland; data on SF_6 destruction was provided by facilities in France, Sweden, and the UK. Based on this limited data, the greatest amount of HFC destruction in recent years was performed in the UK, while France has destroyed the greatest amounts of SF_6.

Table 4-2. F-Gases Destroyed (t) as Reported by Commercial Destruction Facilities (2004-2007)

F-Gas Type	2004	2005	2006	2007
HFCs and HFC Blends				
HFC-134a	-	182.3	243.0	632.5
HFC-404a	-	260.5	273.3	107.9
HFC-407c	-	6.9	0.7	0.5
HFC blends[a]	1,005.0	756.0	699.7	776.5
Subtotal—HFCs	*1,005.0*	*1,205.7*	*1,216.8*	*1,517.5*
SF_6				
SF_6	*0.1*	*23.1*	*24.9*	*24.0*
TOTAL F-GASES DESTROYED[b]				
HFCs, SF_6	1,005.1	1,228.8	1,241.7	1,541.5

[a] Information received from respondents did not identify blends that were destroyed; according to some respondents, it is sometimes difficult to determine the gases being destroyed. A further discussion can be found in Section 5.5.

[b] No destruction of PFCs was reported by commercial destruction facilities for years 2004-2007.

4.2 Destruction Totals Reported by F-Gas Producers, Importers and Exporters

In addition to information submitted by commercial destruction facilities, information on historical destruction quantities was also provided by F-gas producers, importers, and exporters. Specifically, Table 4-3 summarises the quantities of F-gases destroyed on-site, as reported by four respondent producers/importers/exporters, as well as company reports for year 2007 submitted to the EC pursuant to Article 6 of Regulation (EC) No 842/2006; thus, data for 2007 is more robust than prior years (as it includes data from a greater number of companies).

Table 4-3. F-Gases Destroyed On-Site (t) as Reported by Producers, Importers, and Exporters (2004-2007)

F-Gas Type	2004	2005	2006	2007
HFCs				
HFC-125	1.3	0.0	3.2	19.7
HFC-134a	1.7	0.0	0.0	32.1
HFC-152a	0.0	0.0	0.0	0.2
Subtotal—HFCs	*3.0*	*0.0*	*3.2*	*52.0*
PFCs				
C_6F_{14}	0.2	0.1	0.4	0.0

4.3 Total F-Gas Destruction Reported

Based on the information presented in Sections 4.1 and 4.2, the total estimated quantities of F-gases destroyed, by gas, during 2004-2007 are presented Table 4-4.

Table 4-4. Total Reported On-Site F-Gases Destruction (t) (2004-2007)

F-Gas Type	2004	2005	2006	2007
HFCs and HFC Blends				
HFC-125	1.3	0.0	3.2	19.7
HFC-134a	1.7	182.3	243.0	664.6
HFC-152a	0.0	0.0	0.0	0.2

F-Gas Type	2004	2005	2006	2007
HFC-404a	0.0	260.5	273.3	107.9
HFC-407c	0.0	6.9	0.7	0.5
HFC blends[a]	1,005.0	756.0	699.7	776.5
Subtotal—HFCs	*1,880.9*	*1,813.2*	*1,852.7*	*2,587.0*
PFCs				
C_6F_{14}	0.2	0.1	0.4	0.0
SF_6				
SF_6	0.1	23.1	24.9	24.0
TOTAL F-GASES DESTROYED				
HFCs, PFCs, SF_6	1,881.2	1,836.4	1,878.0	2,611.0

[a] Information received from respondents did not identify blends that were destroyed; according to some respondents, it is sometimes difficult to determine the types of gases being destroyed. See Section 5.5 for more information.

4.4 Destruction Technologies, Costs, Capacity, and Feasibility

Questionnaire respondents also provided information on destruction technologies used, cost, capacity, feasibility, and sources of F-gases sent for destruction. The key findings are summarised below:

- **Destruction Technologies in Use.** Based on information collected for this report, Table 4-5 presents the number of F-gas destruction facilities in operation across the EU-27, as well known technologies and capacities. Several destruction companies provided information on the technologies employed at their facilities; these include high-temperature incineration (5), reactor cracking (1), and thermal decomposition using the plasma arc technology (1). Table 4-5 also presents additional information available on EU destruction technologies used to destroy ODS, based on ICF (2008b), which are likely also used to destroy F-gases.
- **Cost.** The average price charged to customers for F-gas destruction ranged from €1-11 per kilogramme, with the average price being roughly €3.90/kg across the 2004-2007 period.[24] While the majority of the destruction facilities did not expect costs to change in the future, two facilities suspected the costs would increase due to increasing energy costs and salaries, as well as a lack of availability of incinerators licensed to incinerate fluorocarbons (preventing market prices from being negotiated down). Similarly, one facility noted that incineration prices have increased 40% over the last two years, and predicted this trend would continue.
- **Destruction Capacity and Feasibility.** Five destruction companies provided information on their annual destruction capacity; combined, their capacity is approximately 5,000 tonnes per year. The reported annual capacity of individual facilities ranged from 100 t (facility in Sweden) to approximately 1,000 t (facility in the UK), with an average of 400 t per year. Two facilities (in France and Sweden) reported destruction capacity of 300 kg per hour.[25]
- **Intra-EU trade in F-gases for purposes of destruction.** Very few facilities reported that they received any F-gases for destruction from outside their Member State. Of those that did (i.e., companies in France, Sweden, and the UK), the percentage received from outside of their Member States ranged from 1% to 48%; such F-gases sent for destruction were sent from Ireland, Spain, Belgium, Greece, Italy, Austria, and the Netherlands.

[24] According to industry experts, the cost charged for destruction by destruction companies in the Netherlands is €20-25/kg (ICF, 2008c).
[25] Assuming 6,000 hours of operation per year, this roughly translates to 1,800 t per year.

Table 4-5. Available Information on F-Gas and ODS Destruction Technologies Used in the EU-27

EU Country	F-Gas Destruction			ODS Destruction[a]		
	Number of Known Destruction Facilities in Operation	Technologies Utilized	Destruction Capacity (MT/yr, unless otherwise specified)	Number of Known Destruction Facilities in Operation	Technologies Utilized	Destruction Capacity (MT/yr, unless otherwise specified)
Austria	1			NA		
Belgium	1			2	Rotary Kiln	NA
Bulgaria						
Czech Republic	2			1	Rotary Kiln	40 MT/year
Denmark	3			4	NA	NA
Estonia	1			1	NA	NA
Finland	1			1	Rotary Kiln	545 MT/year
France	3	▪ Incineration	▪ 300 kg/hr	2	NA	NA
Germany	3	▪ Reactor cracking		6	▪ Hazardous Waste Incinerator ▪ Reactor Cracking	1,600 MT/year[b] (reactor cracking)
Hungary	5			5	▪ Rotary Kiln ▪ Liquid Injection Incineration	▪ 13 MT/year (liquid injection incineration) ▪ 75 MT/year[c] (rotary kiln)
Italy	12			12	NA	NA
Netherlands	5			6	NA	NA
Poland				1	NA	NA
Slovakia	1			1	NA	NA
Spain				1	NA	NA
Sweden	3	▪ High temperature incineration ▪ Plasma arc	▪ 150 ▪ 350 kg/hr	4	Air Plasma, among others	100 MT/year (air plasma)
United Kingdom	14	▪ High temperature incineration	▪ 1,000	2	High-Temperature Incineration	NA

[a] Source: ICF (2008b).
[a] Capacity is not specific to ODS; value shown refers to capacity for all hazardous wastes and/or other types of wastes.
[b] Number represents approximate ODS destruction capacity based on known overall plant capacity and typical ODS feed rates for rotary kilns.

- **Source sectors of F-gases destroyed.** Based on limited information from commercial destruction facilities, ICF estimates that the majority of HFCs for destruction (60%-100%) originated from the stationary refrigeration, air conditioning, and heat pump equipment sector. A smaller percentage of HFCs (15-20%) came from the mobile refrigeration and air conditioning equipment sectors. Several facilities reported a small amount of HFCs (2%-5%) originating from F-gas containers at end of life (i.e., refillable and non-refillable containers). Of the SF_6 collected for destruction, one company collected 100% from high voltage switchgear, while another collected 100% from "other products and equipment" (which were not specified).

5 RRRD by F-Gas Sector

F-gases controlled under Regulation (EC) No 842/2006 are used in the refrigeration/AC and heat pumps (RAC), high voltage switchgear, fire protection, and solvents sectors. Questionnaires soliciting information on F-gas recovery, recycling, reclamation, and destruction (RRRD) were developed and sent to stakeholders in each of these sectors, disseminated via key industry associations (as listed in Annex B). Overall, however, the questionnaires response rates were low. Some of the reasons for the low responses are likely to include:

- It may have been difficult to obtain some or all of the information requested; because record keeping/reporting on F-gas recovered, recycled, or sent for reclamation/destruction was not required by F-gas users prior to the entry into application of the F-Gas Regulation, records may not exist.
- The questionnaire request may have been perceived as burdensome and no legal basis existed to compel respondents to participate.
- Available data on historical levels of F-gas recovery, reclamation, and destruction may show a decline over time, which respondents may not want to share with the Commission. Likewise, respondents may not want to share data for other reasons, such as confidentiality concerns.
- There may be language barrier. For example, one multi-national association representative indicated that some of the smaller refrigeration and air-conditioning equipment servicing companies might have a difficult time understanding the English survey.

To overcome these barriers, a number of efforts were made. Specifically, to reduce burden response and account for the fact that historical records may not exist, simplified, qualitative questionnaires were developed and disseminated to industry as alternatives to the original survey. In addition, numerous attempts were made to open a dialogue with key industry players (e.g., industry associations and large companies in the refrigeration/AC sector) in order to solicit information through telephone calls and/or in-person meetings. Unfortunately, resources were not available to allow for the translation of the six industry surveys, although respondents were given the option to reply to the surveys in the language of their choice.

Because of the limited number of quantitative responses, data presented in this section cannot be considered conclusive. Moreover, for the RAC sector, which has several thousand individual stakeholders conducting F-gas recovery activities, it is not possible to obtain comprehensive survey data on historical levels of F-gas RRRD across the EU-27; there was no mandate for such data to be tracked or reported. However, even in the RAC and other sectors for which quantitative survey data is scarce, much can be learned from qualitative information provided by questionnaire respondents, as summarised below.

Sources of Recovered HFCs

According to the majority of questionnaire responses from commercial facilities that perform on-site reclamation and destruction, the majority of HFCs (60%-100%) historically recovered for reclamation/destruction originated from the *stationary* RAC and heat pump equipment sector,[26] while most of the remainder originated from the *mobile* RAC sector. Some HFCs received for reclamation and destruction also originates from refillable and non-refillable F-gas containers at end of life.[27] Only one facility (in the Czech Republic) reported reclaiming HFCs from the fire protection sector. Other

[26] Respondents noted that recovered HFCs originated largely in the industrial process refrigeration, chillers, and household refrigeration equipment.

[27] While the overall amount of HFCs recovered from containers is believed to be small (i.e., <5%), for some commercial reclamation facilities, this sources is the most significant for HFC recovery/return.

sources of recovered HFCs treated by producers, importers, and exporters included aerosol waste (100% of one producer/exporter's recovered HFCs), and foaming agent in used PU-foam cans (100% of one producer/exporter's recovered HFCs).

Sources of Recovered PFCs and SF_6

Survey data also confirmed what is known about other F-gas uses: that recovered PFCs originate from the fire protection sector[28] and the semiconductor industry (i.e., for use as a heat transfer fluid)[29], and the majority of SF_6 recovered originates from high voltage switchgear.

The remainder of this section presents the information provided through questionnaire responses submitted by F-gas users within the refrigeration/AC, high voltage switchgear, fire protection, and solvents sectors.

5.1 Refrigeration and Air Conditioning/ Heat pumps

HFCs are widely used as refrigerants in heat pumps and stationary and mobile refrigeration and air conditioning applications. The refrigeration and air conditioning (RAC) sector is comprised of thousands of manufacturers, service companies, equipment decommissioning facilities, and users. Based on data reported by F-gas producers, importers, and exporters under Article 6 of Regulation (EC) 842/2006, the majority of F-gases placed on the EC market (73%) were used in the RAC sector.

Questionnaire Response Rate in the RAC Sector

- Questionnaires Sent: 17 sent to trade associations, some associations disseminated to their members
- Responses Received: 12 company responses; only 5 provided quantitative data

The user community in the RAC sector comprises a large number of individual actors. According to Ecofys (2006), there are well over 1 million individuals that may be involved with the RRRD of F-gas refrigerants, as shown in Table 5-1. For this reason, it is difficult to obtain reliable or comprehensive survey data on F-gas RRRD levels from end users in this sector.

Table 5-1. Types and Numbers of Stakeholders in the RAC Sector

RAC Stakeholder Type	Estimated Number of Individual Actors in EU-25
Fluid Manufacturers/Importers	10
Fluid Importers/Traders	20
Distributors	25+
Wholesaler	250+
Original Equipment Manufacturers	50+
Equipment Importers	25
Contractors	100,000+
Operators	1,000,000+
Waste collectors	1,000
Waste handlers	250+
Dismantling firms	1,000
Operators of destruction facilities	100

Source: Ecofys (2006).

To attempt to develop a more robust understanding of F-gas RRRD levels, as well as the barriers facing F-gas RRRD facilities in this sector, questionnaires were sent to 17 industry associations (see Annex B for a listing), and disseminated by those associations to their company members. Only twelve entities submitted questionnaire responses; these entities represented large

[28] The placing on the market of fire protection systems and fire extinguishers containing PFCs has been prohibited in the EC as of 4 July 2007.

[29] The semiconductor industry was not contacted in the survey effort.

commercial/industrial users of RAC equipment, large equipment service providers, refrigerator recycling facilities, RAC equipment manufacturers, and one association—the UK Motor Cabin Air Conditioning Committee. Of these 12 respondents, only five provided quantitative information, as listed below:

- Two large commercial/industrial users of refrigeration/AC equipment, one of which also services equipment (France);
- One WEEE-certified appliance recycling facility (UK);
- One equipment manufacturer (Belgium); and
- One multinational equipment service provider.

According to the questionnaire responses received by these stakeholders, equipment installers are commonly trained on how to recover refrigerant and where to take it for disposal. Likewise, the vast majority of installers have the necessary equipment to perform refrigerant recovery. According to one multinational service provider, refrigerant recovery is widely practiced in the EU—with an estimated participation rate of more than 95%. Likewise, one manufacturer of refrigerated appliances in the UK stated that recovery has been universally practiced since well before 2004.

But as noted by one multinational RAC equipment manufacturer, refrigerant recovery levels vary across Member States; according to the respondent, in some Member States, equipment installers recover over 90% of refrigerant, while in others, recovery levels may be closer to only 40%-70%. According to one large equipment user (in France), estimated levels of recovery from 2004-2007 were significantly lower than this—estimated at less than 10%.

There is also a wide variation in recovery levels across end-use types. Lower levels of refrigerant recovery were also reported by an appliance recycling company (in the UK), which stated that they struggle to recover 50% of CFC from domestic refrigerators and freezers, and that HFC recovery rates are significantly lower.[30] According to a recent study by Barrault and Clodic (2008), there are no economic drivers that create an incentive to improve the recovery of F-gas refrigerant from small equipment (e.g., domestic refrigerators, small AC units, MVACs), since the costs of recovery equipment (about €3,000 for an MVAC recovery device) and labour (roughly 15 minutes required) outweigh the economic gains that can be reaped by recovering a few kilogrammes of refrigerant worth approximately €1.50/kg. In addition, because small equipment is often transported to a recycling plant prior to refrigerant recovery, refrigerant losses during transport/handling are common. As a result, it is estimated that 2% or less of refrigerant is recovered from small equipment at end of life, whereas 70%-80% of refrigerant is recovered from large equipment (Barrault and Clodic, 2008). For this reason, large equipment manufacturers and service providers are likely to exhibit high levels of recovery, as are those dealing with very large equipment types (e.g., industrial refrigeration systems, chillers). This is especially true in countries that have a long history of rigorous technician training/certification programs.

Once refrigerant is recovered, it must be stored, recycled, reclaimed, or destroyed. Stationary equipment respondents indicated that after recovery, F-gas refrigerant is typically not stored for more than a few weeks on-site before being recycled, reclaimed, or destroyed. According to ECOFYS (2006), a significant share of refrigerant was recovered and immediately recycled by contractors. According to the UK Motor Cabin Air Conditioning Committee (MCACC), recycling is certainly the primary fate of recovered refrigerant in the mobile sector; it was reported that the vast majority of the F-gases (i.e., HFC-134a) recovered from vehicles is reused either in the same vehicle or in ones subsequently serviced. If HFCs are recycled, refrigerant does not go to waste and cost savings are realized through avoided costs of virgin refrigerant. For this reason there is very little F-gas sent for

[30] This recycling company noted that estimates of F-gas recovery are difficult to obtain because the rate of recovery remains unknown, and has historically not been monitored (in the UK).

reclamation or destruction from the mobile sector; the exception is F-gases extracted from end-of-life vehicles (MCACC, 2008). According to MCACC, recovery of HFC-134a from the vehicle dismantling/salvage sector is currently low, but will likely increase in the future with improved technology and reduced leak rates from equipment.

The same is likely to be true in the stationary RAC service sector. According to one large equipment user (in France) and an equipment manufacturer (in Belgium), 100% of recovered F-gases are recycled. According to one large equipment user, 75%-100% of refrigerant recovered at servicing is pure enough to be recycled. Conversely, at equipment end of life, recovered refrigerant is not typically pure enough for recycling, so must be reclaimed or destroyed. In cases where refrigerant is not pure enough for recycling, the fate of recovered refrigerant—reclamation or destruction—will depend on a myriad of local factors, including proximity to reclamation/destruction facilities, costs of reclamation/destruction, feasibility of reclamation, and the strength of regulatory programs in place. Overall, refrigerant will be recycled where technically and economically feasible, based on purity level, volume recoverable, and identified internal need/availability of customers for resale. Reclamation will also depend on purity and volume, as well as the market value of the refrigerant. When recycling or reclamation are not feasible, destruction is the only legal option, though currently, sufficient economic incentives are not in place to facilitate such activities.

A French, large equipment user, Belgian manufacturer, and multinational service company provided data on the total quantity of F-gas recovered for the period 2004-2007. According to these companies, the vast majority of recovered F-gases (nearly 80%) were reclaimed, while the remainder was recycled (11%) and destroyed (10%). It is not surprising that the majority of F-gases recovered by large service companies is reclaimed and not recycled, given that reclamation of recovered refrigerant prior to recharge into different equipment is good technician practice and necessary for ensuring optimal equipment performance. Conversely, service technicians that deal with MVACs or large equipment owners that maintain their own equipment are more likely to recycle recovered refrigerant than to reclaim it offsite. Those dealing with equipment at end of life are most likely to send it for reclamation or destruction, whichever can be performed most cost-effectively.

5.2 High Voltage Switchgear

Sulphur hexafluoride (SF_6) is used to insulate high voltage switchgear equipment in the electric power systems industry. Based on questionnaire responses received from nine companies and six national trade associations (see text box, right) the total reported amounts of SF_6 RRRD from 2004 to 2007 are summarised in Table 5-2. As shown, most SF_6 recovered from 2004 to 2007 was recycled, with smaller percentages being reclaimed, and only minimal amounts being destroyed. Reported quantities are from companies in Belgium, Denmark, France, Germany, Italy, the Netherlands, Finland, Spain, the UK, and Ireland—although they may represent a subset of national totals.

High Voltage Switchgear F-gas Sector Survey Overview

- Questionnaires Sent: 5 trade associations, of which four (CAPIEL, ZVEI, EURELECTRIC and CIGRE) distributed questionnaires to their member companies/ associations.
- Associations Contacted: CAPIEL, ZVEI, EURELECTRIC, CIGRE and the Energy Networks Association.
- Responses Received: 9 companies and 6 national trade associations

Table 5-2. RRRD of SF_6 (t) as Reported by Companies and Trade Associations in the Switchgear Sector (2004-2007)

F-Gas Fate	2004	2005	2006	2007
Recycled	13.1	41.4	38.9	55.2
Reclaimed	1.5	5.9	6.6	8.2
Destroyed	0.2	0.5	0.6	0.9
Recovered[a]	15.1	48.2	46.7	64.7

[a] Recycled, Reclaimed and Destroyed totals may not sum to Recovered due to the fact that some facilities temporarily store recovered gas on-site.

Nine respondents indicated that some recovered SF_6 is stored before being sent for recycling, reclamation, or destruction. Respondents also reported that the SF_6 can be stored up to a year. One company reported that they store the SF_6 because they must accumulate at least 500 kg before they can economically send it for reclamation or destruction (which is performed in a neighbouring Member State).

Nine respondents characterized the state of SF_6 recovery in their national industry from 2004-2007, and since the implementation of Regulation (EC) No 842/2006. All but one respondent indicated that rates were greater than 95% historically, and all nine indicated rates are greater than 95% currently. Members of the German national association BDEW/VIK/ZVEI are members of a voluntary commitment[31] in which members "commit themselves to minimise extensively the SF_6 emissions during production, commissioning and operation of electrical equipment, as well as during recovery, recycling (including reuse) and disposal of the SF_6." This commitment began in 1997 and was updated in 2005. Members of the French association, Gimelec, are also members of a voluntary commitment in France which began in 2004 and was updated in 2005. Such voluntary schemes are known to exist in Germany and Spain, and possibly other Member States as well. Because of these commitments, recycling has been a key practice for years in these Member States, even before the implementation of Regulation (EC) No 842/2006. Similarly, an Italian association indicated that SF_6 recovery for recycling was already a key practice of theirs before the EC regulation was enacted.

Additional qualitative information on SF_6 sent for reclamation and destruction by the end-user community is summarised below:

- **SF_6 Reclamation:** Reclamation is necessary when the purity level of SF_6 is not high enough for recycling and reuse. While not as widespread as recycling, SF_6 is also reclaimed by electric utilities. For two respondent companies, reclamation is not a normal practice, but certain circumstances have led them to reclaim more recently. In particular, one of the companies explained that they are reclaiming more SF_6 to reduce stocks and thereby comply with their company's policy to reduce the amount of SF_6 stored at substations. Whereas recycling of SF_6 is typically conducted on-site, respondents typically send their recovered SF_6 *off-site* to another company for reclamation. Of the eight respondents that indicate they send their SF_6 off-site for reclamation, four send their SF_6 to facilities within their MS (Germany, Finland, France, and the UK), and the other four respondents (located in Belgium, Denmark, Italy and the UK) send their SF_6 to France and Germany.[32] Based on high voltage switchgear questionnaire responses, most reclamation of SF_6 appears to be occurring in Germany and France. Because of the need for many companies to send their unwanted SF_6 to Germany and France for reclamation, there is a need to streamline and expedite F-gas transport for the purpose of reclamation (see Section 7 for further discussion on this subject).

- **SF_6 Destruction:** Most companies in the electricity transmission/distribution sector that were surveyed do not typically destroy recovered SF_6. Only six of the 15 respondents reported having destroyed SF_6 from 2004-2007, and only two of these respondents reported destroying more than 3% of their recovered SF_6. This is because SF_6 must only be destroyed if it is heavily arced (e.g., if contained in equipment where failure arcing occurred)—which is rare. SF_6 is typically recovered from switchgear compartments after normal switching operations, at which point it is considered normally arced gas. Decomposition products may be present in normally arced gas, which in most cases, can be adequately cleaned on-site (using a recycling

[31] "Voluntary Commitment of SF_6 Producers, Manufacturers and Users of Electrical Equipment > 1kV for Transmission and Distribution of Electric Power in the Federal Republic of Germany on SF_6 as an Insulating and Arc Extinguishing Medium."

[32] Response received from the Swiss association indicated that Switzerland also sends its recovered SF_6 to Germany for reclamation.

cart), returned back to a useable state, and directly refilled into the breaker. SF_6 gas is considered acceptable for reuse when the maximum tolerable impurity level of 50 ppmv is reached.

Of the five respondents that indicated they sent SF_6 off-site for destruction from 2004-2007, two (in Ireland and Italy) sent the SF_6 to another MS (Germany) for destruction. The other three (in Germany, France and the UK) sent their SF_6 for destruction within their own states. Questionnaire results again indicate that most SF_6 destruction activity is occurring in Germany and France. Because of the need for many companies to send their unwanted SF_6 to Germany and France for destruction, there is a need to streamline and expedite F-gas transport for the purpose of destruction (see Section 7 for further discussion).

Fire Protection F-gas Sector Survey Overview

- Questionnaires Sent: 32 trade associations; 1 association (ASSURE) subsequently sent to their 27 members. Questionnaires also sent directly to 51 companies.
- Responses Received: 7 responses from companies; 1 response included quantitative data. 2 companies (system manufacturers) only purchase HFCs from chemical companies and install them in fire extinguishing systems and do not recover, reuse or destroy F-gases.

5.3 Fire Protection

In the EU-27, the F-gas fire protection sector is very small (ASSURE, 2008). Based on data reported by companies under Article 6 of Regulation (EC) 842/2006, only 0.7% (685 tonnes) of F-gases placed on the EC market in 2007 went to the fire protection sector. Moreover, due to the nature of F-gas usage in this sector, there has not been much F-gas recovery in recent years. In particular, HFC fire suppression systems only entered the market around 1993, and systems typically have a lifetime of about 15-20 years; since F-gases are typically only recovered from systems at time of system decommissioning/end of life (given that recovery is not possible after discharged), very few have been decommissioned to date (ASSURE, 2008).

During the life of the system, the gases stay within the leak proof cylinders in which they are housed and then can easily be transported back to the factory for recycling, reclamation or destruction when the system is decommissioned. Moreover, because the most common F-gases used and recovered in the fire suppression sector—primarily HFC-227ea and HFC-125—are pure substances and not a mixture, it is relatively easy to recover and recycle/reclaim. Given the high price of HFCs, companies have a greater incentive to recycle/reclaim, rather than destroy, when they do recover gases.

Only three companies in the fire suppression sector submitted quantitative survey data on levels of HFC RRRD during 2004-2007. These included: one producer/importer of insulation-fire protection products, one commercial reclamation facility, and one company that supplies/maintains fire protection systems. The producer/importer and commercial reclamation facility both reported on reclamation levels of HFC-227ea. The fire protection system supplier reported on historical levels of recovery, recycling, and reclamation of HFC-125 and HFC-227ea.

Specifically, the fire protection system supplier reported steadily increasing quantities of HFC recovery during 2004-2007, reaching roughly 25 t in 2007. This company is a major player in the F-gas fire protection market. It is believed that there are a total of approximately 10 major HFC fire protection companies in the EU-27 (Hughes Associates, 2008). The company performed all F-gas reclamation on site (i.e., on the premises), which they estimated to be 50 metric tonnes of HFC-125 and 15 tonnes of HFC-227ea over the 2004-2007 period. The respondent reported no destruction of HFCs for this time period.

The fire protection system supplier that provided quantitative data also indicated that about 85% of recovered HFCs were reclaimed, while the remaining 15% were recycled during 2004-2007. The company typically stores F-gases for about three months before recycling or reclamation. According to the respondent, 5% of recovered HFCs come from equipment disposal and the remaining 95 percent come from bulk containers returned from customers. This company estimates that for their

national industry as a whole, there was about a 75% recovery rate during years 2004-2007; and that since the enactment of Regulation (EC) No 842/2006, the recovery rate has increased to more than 95%.

Solvents F-gas Sector Survey Overview

- Questionnaires Sent: 2 companies and 19 trade associations; 1 association (Cefic) distributed to their members.
- Responses Received: No quantitative data received from company contacts. Qualitative data provided by the European Chemical Industry Council (Cefic), and one company that is a member of Cefic.

5.4 Solvents

In the EU-27, the F-gas solvents sector is very small (ICF, 2006). HFCs commonly used in solvent cleaning include HFC-4310mee, HFC-365mfc, and HFC-245fa (as an aerosol solvent cleaner). PFCs used in solvent cleaning, though rarely in the EU-27, include C_5F_{12}, C_6F_{14}, C_7F_{16}, and C_8F_{18}. Based on data reported by companies under Article 6 of Regulation (EC) 842/2006, only 0.2% (about 209 tonnes) of F-gases placed on the EC market in 2007 were intended for use in the solvents sector. According to Hamisch, (2003), F-gas solvent was virtually non-existent in 2000 but expected to increase by 2010 (to quantities less than 20,000 metric tonnes)[33] and continue to grow to 2020. While the 2007 company reported data reveal that the F-gas solvents market has not reached this size yet, use may increase in the coming years.

Solvent recovery systems remove clean solvent from solvent waste in order to return some of the solvent to productive use. Larger users typically have an in-house collection and recycling system whereas smaller users generally collect used solvent and transport it to an off-site recycler (UNEP 2002). As much as 95% of waste solvent is recoverable, and reclamation is an effective means for solvent conservation (NPI 1999). However, the use of the resulting recycled solvents and the use of recovery and recycling systems vary within the solvent sector. For example, although there are economic reasons for preferring recycled solvent, which typically cost between 75%- 95% less than pure solvents, only certain solvent cleaning operations can use recycled solvents. In particular, recycled solvents are feasible for use in electronics and metal cleaning, but not for high-performance applications that require a high level of cleanliness (i.e., precision cleaning) (U.S. EPA 2004).

For this study, industry information was obtained from the European Chemical Industry Council (Cefic) and one company that uses HFCs in small quantities for solvent use, as described in the overview box (right).

According to Cefic, the fate of F-gas solvents after recovery depends on practices within the particular Member State, as well as the purity of the recovered F-gas itself. Typically, it is easier and more cost effective to recover F-gases from large units, provided the F-gases are not mixtures. Indeed, recovering from small units can be difficult, as there tends to be high levels of contamination with oil. But whether from a small or large unit, if the F-gas recovered is a mixture, it must be destroyed. According to Cefic, the only time one could reuse an F-gas mixture is when the user knows it has not been too contaminated and that it has been recovered in small cylinders and is immediately reinstalled into the system (Cefic, 2008).

According to the one company respondent, HFC-134a was used at their facilities in a specialty application in 2007 and all recovered HFC-134a was reused on-site. Once the HFC is no longer reusable (due to contamination), the company noted that it will be destroyed.

No industry contacts provided information on overall recovery levels in the sector pre/post-Regulation (EC) No 842/2006; however information on barriers to F-gas recycling, reclamation and destruction in the EU-27, summarized in Section 7, was provided by Cefic.

[33] Exact projections are not ascertainable from the graphics providing this information in Harnisch (2003).

5.5 Treatment of F-Gas Containers and Practices to Reduce Emissions

Twelve (63%) of the producers, importers, and exporters that submitted questionnaires stated that during 2004-2007, they collected F-gases or F-gas cylinders from their customers. Once collected, the F-gases contained in cylinders were typically recycled, reclaimed on-site, or destroyed on- or off-site. Cylinders were emptied and reused or sent back to suppliers.

Other respondents noted practices to reduce emissions included using only refillable cylinders during the period 2004-2007. No respondents of the RAC questionnaire stated that they used disposable cylinders, which are banned as of 4 July 2007. Three such respondents indicated that once the containers were empty, all were returned either to the distributor or producer.[34]

Six of nineteen respondents to the producer/importer/exporter questionnaire indicated that they have implemented changes to improve F-gas recovery rates since the enactment of Regulation (EC) No 842/2006. One importer noted that it had contacted recycling companies to obtain information on where and how used F-gases can safely be sent to educate its customers on the subject. Another importer began reclaiming F-gases on-site (i.e., on premises). Other changes by importers and exporters include introduction of recovery machines, gas flow meters, delivery equipment, training for delivery drivers and technical staff, and use, servicing, and refilling of recovery and reusable cylinders. One importer and one producer/importer/exporter are conducting additional research to determine sources of emissions and possible further actions for reducing them. One importer/exporter is educating its clients about F-gas regulatory requirements.

Additionally, one RAC equipment manufacturing company in Belgium indicated that it recovers 100% of gases during their quality control procedures, and minimises emissions in production by using high-quality equipment and valves, as well as data recording, leak detection/testing, and maintaining a highly trained workforce.

Based on survey responses, it can be concluded that a high number of reusable F-gas-containers were sent to manufacturers for recovery, although it was not possible to determine what percentage of the overall pool this represents. Additionally, use of reusable cylinders seems to encourage and enhance proper handling of F-gases

[34] The use of refillable cylinders eliminates the concern of recovering refrigerant heels (small quantities of refrigerant remaining in cylinders).

6 Analysis of Total F-Gas RRRD Levels from 2004 to 2007

With millions of F-gas users and stakeholders in the refrigeration/AC, switchgear, fire protection, and solvents sectors, the limited survey responses from these target sectors was deemed inadequate to serve as the sole basis for determining (2004-2007) levels of F-gas RRRD by sector. Methodologies for "scaling up survey" data were developed for each of the F-gas sectors, as described below.

6.1 Refrigeration, Air Conditioning and Heat Pumps

The refrigeration/AC is the largest use sector of F-gases in the EU-27, and hence the most important for this study. Generally, recovered HFC is recycled, reclaimed, or destroyed; while recovered refrigerant can be temporarily stored, it is generally only stored for a few weeks. Therefore, for simplification purposes, this analysis assumes that HFC recovery levels are equal to the amounts recycled, reclaimed, and destroyed. However, the percent of each of these fates is uncertain, as data received from industry questionnaires did not provide conclusive trends. In addition, there is uncertainty regarding the reclamation and destruction activities performed by the non-responsive facilities. As such, two scenarios for reclamation and destruction rates of these non-responsive facilities were developed. For each scenario, two sets of assumed recovery fates were developed. Therefore, this methodology generates four sets of results.

Reclamation and Destruction

Reported quantities of reclamation and destruction served as the starting point for developing RRRD levels associated with each scenario. Several thousand individual entities recover refrigerant annually across the EU-27 for recycling, reclamation, and destruction. Of the different fates of recovered HFCs, reclamation and destruction are two distinct activities that are limited to a certain set of facilities that have appropriate reclamation/destruction infrastructure—namely (a) commercial reclamation and destruction facilities, (b) producers/importers/exporters, and (c) multinational RAC servicing companies. Data on on-site reclamation/destruction from these types of companies were deemed to be the most reliable, comprehensive, and non-duplicative datasets for estimating total HFC reclamation and destruction in the EU. However, because not all such facilities that reclaim/destroy F-gases responded to the questionnaires prepared for this study, two scenarios were developed in order to account for their activities:

— **Upper Bound Scenario**: all commercial reclamation/destruction facilities that did not respond to the survey reclaim/destroy HFCs at 50% of the rate as the average levels (by year and by gas) of those that did respond to the survey. It is assumed that F-gas producers/importers/exporters that responded to the survey account for 95% of all reclamation/destruction performed by producers/importers/exporters in the EU-27.[35] It was further assumed that there are a total of five large multinational RAC servicing companies that perform on-site reclamation in the EU; therefore, the one multinational RAC servicing company that responded to the survey is assumed to account for 20% of the F-gases reclaimed by this stakeholder group.

— **Lower Bound Scenario**: none of the non-respondents reclaim/destroy HFCs.

[35] Because a small number of producers/importers/exporters account for 95% of all F-gases sold on the EC market, it assumed that these few entities (that reported to the EC and/or to this survey) also account for 95% F-gas destruction/reclamation.

These scenarios provide a range of possible potential reclamation and destruction levels. The lower bound scenario is deemed appropriate given that it is believed that the survey response is biased towards those companies that performed on-site reclamation/destruction (i.e., those companies that did not reclaim or destroy on-site may have been less inclined to submit a survey response). Given that several commercial reclamation/destruction facilities identified by Member State representatives were found to not reclaim or destroy F-gases—either because the companies went out of business or because they performed similar activities but do not deal with F-gases—it is possible that non-respondents also fit into this category.

For the upper bound scenario, average levels of HFC reclamation/destruction by year and by gas were determined for (a) commercial reclamation and destruction facilities and (b) producers/importers/exporters.[36] Total reported reclamation and destruction quantities were divided by the number of reporting facilities.[37] Those facilities that only reclaimed or destroyed PFCs or SF_6 were not considered in these calculations.

These averages were then used in a scale-up approach to account for non-respondents in the upper bound scenario. Quantities of HFCs reclaimed and destroyed increased using the following factors:

- Average quantity of HFCs reclaimed was scaled up by 50% for 44 commercial reclamation facilities;
- Average quantity of HFCs reclaimed was scaled up by 5% for 59 producers/importers/ exporters;
- Average quantity of HFCs reclaimed was scaled up 80% for multinational servicing companies;
- Average quantity of HFCs destroyed was scaled up by 50% for 53 commercial destruction facilities; and
- Average quantity of HFCs destroyed was scaled up by 5% for 61 producers/importers/ exporters.[38]

Table 6-1 and Table 6-2 present the estimates of total HFC reclamation and destruction during 2004-2007 in the EC, by gas for both the upper and lower bound scenarios.

Table 6-1. Estimated Total HFC Refrigerants Reclaimed (t) in the EU-27 (2004-2007)

HFC Type	Upper Bound Scenario				Lower Bound Scenario			
	2004	2005	2006	2007	2004	2005	2006	2007
HFC-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HFC-32	2.0	2.0	2.0	2.0	1.9	1.9	1.9	1.9
HFC-125	2.0	2.0	2.0	2.0	6.0	6.0	6.0	6.0
HFC-134a	480.2	544.2	549.0	691.3	316.8	336.0	341.0	381.2
HFC-143a	4.0	4.0	4.0	4.0	3.8	3.8	3.8	3.8
HFC-152a	1.1	1.0	1.1	1.1	1.0	1.0	1.0	1.0
R-401a	3.3	1.9	0.6	0.6	1.0	0.6	0.2	0.2
R-402a	3.5	2.5	1.5	1.5	1.1	0.8	0.5	0.5
R-404a	37.7	33.1	45.5	74.5	16.2	13.3	17.3	30.5

[36] Because only one multinational RAC servicing company reported HFC reclamation quantities, no average needed to be calculated for this group.

[37] Eight commercial reclamation facilities and six commercial destruction facilities reported HFC reclamation and destruction quantities, respectively. Eight producers/importers/exporters reported HFC reclamation quantities and three producers/importers/exporters reported destruction quantities.

[38] Sixty-one producers/importers/exporters reported on-site destruction of HFCs, while only 59 reported on-site reclamation of HFCs.

HFC Type	Upper Bound Scenario				Lower Bound Scenario			
	2004	2005	2006	2007	2004	2005	2006	2007
R-407a/b	3.3	3.3	3.3	6.5	1.0	1.0	1.0	2.0
R-407c	433.7	429.3	474.3	546.4	127.9	123.7	140.2	168.0
R-408a	22.2	22.2	22.2	22.2	6.8	6.8	6.8	6.8
R-413	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0
R-507a	2.4	2.4	2.4	1.7	0.7	0.7	0.7	0.5
Total HFCs	*999.8*	*1,052.3*	*1,112.3*	*1,358.3*	*484.3*	*495.7*	*520.5*	*602.5*

Table 6-2. Estimated Total HFC Refrigerants Destroyed in the EU-27 (t) (2004-2007)

HFC Type	Upper Bound Scenario				Lower Bound Scenario			
	2004	2005	2006	2007	2004	2005	2006	2007
HFC-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HFC-125	18.0	19.0	20.0	20.7	17.1	18.1	19.0	19.7
HFC-134a	931.7	931.7	1,230.3	3,145.4	216.0	216.0	276.8	666.3
HFC-152a	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
HFC-404a	1,286.2	1,286.2	1,347.8	534.6	261.6	261.6	274.1	108.7
HFC-407c	33.9	33.9	3.5	2.6	6.9	6.9	0.7	0.5
HFC blends	4,941.3	3,716.8	3,440.2	3,817.9	1,005.0	756.0	699.7	776.5
Total HFCs	*7,211.3*	*5,987.8*	*6,042.1*	*7,521.6*	*1,506.9*	*1,258.8*	*1,270.6*	*1,572.0*

Recycling and Recovery

Based on estimated levels of HFC refrigerant reclaimed and destroyed for 2004-2007 under Scenarios A and B, total quantities of HFC refrigerant recycled were subsequently approximated by assuming that recycled quantities represent approximately 70% of the total quantities recovered, (i.e., recovered F-gas = 70% recycled + 30% reclaimed/ destroyed). This assumption was developed based on aggregated amounts of RRRD of HCFCs reported by EU-15 Member States to the EU Commission under Article 16 of EC Regulation 2037/2000 (Ecofys, 2006). Given that no parallel data exist for HFCs, these data on the fate of recovered HCFC refrigerants were deemed to provide the best proxy for understanding trends in the fate of recovered HFC refrigerants.[39] Levels of HFC refrigerants recovered were then estimated by summing the quantities of total HFC refrigerant recycled, reclaimed, and destroyed.

As suggested by the above assumption, the vast majority of recovered refrigerant is believed to be recycled—not reclaimed/destroyed—given the economic and logistic factors currently at play in the EC. Specifically, by recycling refrigerant, end-users can realise cost savings by avoiding the need to purchase new refrigerant; moreover, stakeholders can avoid the costs associated with reclamation/destruction, as well as the barriers (real or perceived) associated with transporting used HFCs for reclamation/destruction (see Section 7 for more detail). While the ratio of recycling to reclamation/destruction is likely to vary within and across Member States—e.g., based on national laws, infrastructure in place, etc.—the 70/30 ratio is believed to be appropriate as an overall average. Table 6-3 presents the resulting upper and lower bound scenario estimates for HFC recycling in the EC, by gas for the time period 2004 through 2007.

[39] The fate of recovered CFC refrigerant was not deemed to be an appropriate proxy, given that CFCs cannot legally be reused in the EC.

Table 6-3. Estimated Total HFC Refrigerants Recycled (t) in the EU-27 (2004-2007): Upper and Lower Bound Scenarios

HFC Type	Upper Bound Scenario				Lower Bound Scenario			
	2004	2005	2006	2007	2004	2005	2006	2007
HFC-23	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
HFC-32	4.7	4.7	4.7	4.7	4.4	4.4	4.4	4.4
HFC-125	56.8	59.1	61.5	63.1	53.9	56.2	58.4	60.0
HFC-134a	3,294.4	3,443.7	4,151.7	8,952.3	1,243.4	1,288.1	1,441.4	2,444.1
HFC-143a	9.3	9.3	9.3	9.3	8.9	8.9	8.9	8.9
HFC-152a	3.0	2.9	3.0	3.0	2.9	2.7	2.9	2.9
R-401a	7.6	4.5	1.4	1.4	2.3	1.4	0.4	0.4
R-402a	8.2	5.9	3.6	3.6	2.5	1.8	1.1	1.1
R-404a	3,089.0	3,078.3	3,251.1	1,421.3	648.2	641.4	680.0	324.9
R-407a/b	7.6	7.6	7.6	15.2	2.3	2.3	2.3	4.7
R-407c	1,091.0	1,080.7	1,114.9	1,281.2	314.5	304.7	328.8	393.3
R-408a	51.8	51.8	51.8	51.8	15.9	15.9	15.9	15.9
R-413	0.4	0.4	0.4	0.4	0.1	0.1	0.1	0.1
R-507a	5.5	5.5	5.5	3.9	1.7	1.7	1.7	1.2
HFC blends	11,529.8	8,672.6	8,027.1	8,908.4	2,345.0	1,763.9	1,632.6	1,811.9
Total HFCs	*19,265.3*	*16,427.0*	*16,693.6*	*20,719.7*	*4,646.2*	*4,093.7*	*4,179.1*	*5,073.7*

Having estimated quantities recycled, reclaimed, and destroyed, Table 6-4 presents the estimates of HFC refrigerants recovered (i.e., the summed total of quantities recycled, reclaimed, and destroyed) in the EC during 2004-2007 for the two scenario outcomes.

Table 6-4. Summary of Estimates of HFC Refrigerants Recovered (t) (2004-2007): Upper and Lower Bound Estimates

HFC Type	Upper Bound Scenario				Lower Bound Scenario			
	2004	2005	2006	2007	2004	2005	2006	2007
HFC-23	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
HFC-32	6.7	6.7	6.7	6.7	6.3	6.3	6.3	6.3
HFC-125	81.1	84.5	87.8	90.2	77.1	80.2	83.4	85.7
HFC-134a	4,706.3	4,919.5	5,931.0	12,789.0	1,776.2	1,840.2	2,059.2	3,491.6
HFC-143a	13.3	13.3	13.3	13.3	12.7	12.7	12.7	12.7
HFC-152a	4.3	4.1	4.3	4.3	4.1	3.9	4.1	4.1
R-401a	10.9	6.5	2.0	2.0	3.3	2.0	0.6	0.6
R-402a	11.7	8.4	5.1	5.1	3.6	2.6	1.6	1.6
R-404a	4,412.9	4,397.6	4,644.4	2,030.4	926.0	916.3	971.5	464.1
R-407a/b	10.8	10.8	10.8	21.7	3.3	3.3	3.3	6.7
R-407c	1,558.6	1,543.8	1,592.7	1,830.3	449.3	435.3	469.7	561.8
R-408a	73.9	73.9	73.9	73.9	22.8	22.8	22.8	22.8
R-413	0.5	0.5	0.5	0.5	0.2	0.2	0.2	0.2
R-507a	7.9	7.9	7.9	5.6	2.4	2.4	2.4	1.7
HFC blends	16,471.2	12,389.4	11,467.3	12,726.2	3,350.1	2,519.9	2,332.3	2,588.4
Total HFCs	27,521.9	23,467.1	23,848.0	29,599.6	6,637.4	5,848.1	5,970.1	7,248.2

6.2 High Voltage Switchgear

Survey data on on-site reclamation and destruction (from SF_6 producers/importers/exporters and commercial destruction facilities, respectively) were deemed to be the most reliable, comprehensive, and non-duplicative datasets for estimating total SF_6 reclamation and destruction in the EU.[40] More specifically, to estimate EU-wide levels of SF_6 reclamation and destruction, the following methodology and assumptions were used:

- ***Reclamation***: the quantities of SF_6 reclaimed across the EU are based on those quantities of SF_6 reclaimed on-site (i.e., on premises), as reported by producers/importers/exporters per the requirements of Article 6 of Regulation (EC) No 842/2006. Reported quantities were not scaled up to account for non-respondents, because it is believed that all SF_6 reclamation is performed by the few producers, all of which are believed to have complied with the reporting requirements of Article 6 of Regulation (EC) No 842/2006. For those producers that submitted reports to the EC (for year 2007) but did not respond to the survey prepared for this study, it was assumed that their 2007 SF_6 reclamation levels were the same in years 2004-2006.
- ***Destruction***: the quantities of SF_6 destroyed across the EU are based on those quantities of SF_6 destroyed on-site (i.e., on premises), as reported by commercial destruction facilities through this survey. While it possible that other companies that did not respond to the survey prepared for this study also destroy SF_6, it is conservatively assumed that survey respondents account for 100% of SF_6 destruction, since this gas is very difficult to destroy.[41]

To estimate total quantities of SF_6 recycled during 2004-2007, information provided by end-users in the electricity transmission/distribution sector on the fate of recovered SF_6 was used. Specifically, based on surveys submitted by stakeholders, the ratios shown in Table 6-6 were estimated for the fate of recovered SF_6.

Table 6-5. Average SF_6 RRD Rates (Percent) Based on Survey Respondents[a]

Percent Recycled	Percent Reclaimed and Destroyed	Percent Stored Indefinitely
85	14	1

Therefore, once quantities of SF_6 reclaimed and destroyed were estimated, the sum of those quantities was scaled (i.e., multiplied by 85/14) to estimate the quantity of SF_6 recycled in each year. Next, annual levels of SF_6 recovered were estimated by summing the quantities of total SF_6 recycled, reclaimed, destroyed, and stored.

The resulting estimates of total SF_6 recovered, recycled, reclaimed, and destroyed in the EU-27 from 2004-2007 are presented in Table 6-6.

Table 6-6. Estimated Total SF_6 RRRD (t) in the EU-27 (2004-2007)

F-Gas Fate	2004	2005	2006	2007
Recycled	538.8	596.1	658.1	721.7
Reclaimed	85.2	71.2	79.2	90.2
Destroyed	0.1	23.1	24.9	24.0
Recovered[a]	631.6	698.7	771.4	845.9

[a] Because some SF_6 is stored on-site, recovered quantities are greater than the sum of quantities recycled, reclaimed, and destroyed.

[40] End-user data on SF_6 quantities sent for reclamation and destruction were not deemed as reliable, since such quantities could be double-counted against that provided by facilities that actually performed the reclamation/destruction on-site.

[41] Because SF_6 is inert and nonflammable, it is very difficult to destroy this fluorinated compound. Indeed, destruction efficiency must be greater than 99% at a temperature of 1200 degrees C (CIGRE, 2003).

6.3 Solvents

The solvents sector is the smallest of the F-gas sectors in the EU-27. In 2007, this sector represented only 0.2% of EU-27 F-gas sales. Given that no quantitative data were received from company contacts during the survey effort, no scale-up effort could be conducted for this sector. However, from 2004-2007, RRRD levels from the solvents sector in the EU-27 are believed to be negligible. Therefore, for the purpose of this analysis, levels of F-gas recovery, recycling, reclamation, and destruction are assumed to be zero.

6.4 Fire Protection

Three survey responses were received on RRRD levels of HFC-227ea and HFC-125 in the fire protection sector: one from a producer/importer of insulation-fire protection products, one from a commercial reclamation facility, and one from a company that supplies/maintains fire protection systems. The latter company is believed to be one of roughly 10 major HFC fire protection companies in the EU-27 (Hughes Associates, 2008). To determine EU-wide RRRD estimates, the respondent company that supplies/maintains fire protection systems was assumed to be representative of the 10 major players in the EU-27 fire protection market. Therefore, levels of F-gas RRRD reported by this company were scaled up for the 9 other companies. Additional quantities of HFC-227ea reported as having been reclaimed by the producer/importer[42] and the commercial reclamation facility were added to this total.[43] The results are presented below.

Table 6-7. Estimated Total HFC RRRD (t) in the EU-27 Fire Protection Sector (2004-2007)

F-Gas Fate	2004	2005	2006	2007
Recycled	19.5	22.5	30.0	37.5
Reclaimed	124.5	141.5	185.0	227.5
Destroyed	-	-	-	-
Recovered	144.0	164.0	215.0	265.0

6.5 Summary: Total F-Gas Estimates of RRRD

Based on the analysis conducted for this study, estimated levels of F-gas reclamation and destruction are presented in Table 6-8 and Table 6-9, expressed in tonnes and million metric tonnes of carbon dioxide ($MMTCO_2$) equivalent, respectively. GWP values are based on the IPCC's Third Assessment Report (IPCC 2003). In addition, no GWP values have been assigned to ODS that are constituents of F-gas blends.

Table 6-8. Estimated Total Tonnes (t) of F-Gas RRRD in the EU-27 (2004-2007)

Upper Bound					Lower Bound				
F-gas Type/Fate	2004	2005	2006	2007	F-gas Type/Fate	2004	2005	2006	2007
HFCs					HFCs				
Recycled	19,284.8	16,449.5	16,723.6	20,757.2	Recycled	4,665.7	4,116.2	4,209.1	5,111.2
Reclaimed	1,169.8	1,193.8	1,297.3	1,585.8	Reclaimed	608.8	637.2	705.5	830.0
Destroyed	7,211.3	5,987.8	6,042.1	7,521.6	Destroyed	1,506.9	1,258.8	1,270.6	1,572.0
Recovered	27,665.9	23,631.1	24,063.0	29,864.6	Recovered	6,781.4	6,012.1	6,185.1	7,513.2
PFCs					PFCs				
Recycled	Unknown	Unknown	Unknown	Unknown	Recycled	Unknown	Unknown	Unknown	Unknown
Reclaimed	1.6	1.2	3.6	0.4	Reclaimed	1.6	1.2	3.6	0.4

[42] This producer/importer submitted a report to the EC for year 2007 but did not respond to the survey prepared for this study; it was assumed that their 2007 HFC-227ea reclamation levels were the same in years 2004-2006.

[43] Quantities reclaimed by the producer/importer and commercial reclamation facility were not scaled up to account for non-respondents because the previous scale-up methodology (applied to account for RRRD levels of the major industry players in the fire protection market) is intended to represent the majority of the industry.

Upper Bound					Lower Bound				
F-gas Type/Fate	2004	2005	2006	2007	F-gas Type/Fate	2004	2005	2006	2007
Destroyed	0.2	0.1	0.4	0.0	Destroyed	0.2	0.1	0.4	0.0
Recovered	Unknown	Unknown	Unknown	Unknown	Recovered	Unknown	Unknown	Unknown	Unknown
SF_6					SF_6				
Recycled	538.8	596.1	658.1	721.7	Recycled	538.8	596.1	658.1	721.7
Reclaimed	85.2	71.2	79.2	90.2	Reclaimed	85.2	71.2	79.2	90.2
Destroyed	0.1	23.1	24.9	24.0	Destroyed	0.1	23.1	24.9	24.0
Recovered	631.6	698.7	771.4	845.9	Recovered	631.6	698.7	771.4	845.9
Total F-Gases					Total F-Gases				
Recycled	19,823.7	17,045.6	17,381.7	21,478.9	Recycled	5,204.5	4,712.3	4,867.2	5,832.9
Reclaimed	1,256.6	1,266.3	1,380.1	1,676.4	Reclaimed	695.7	709.6	788.3	920.5
Destroyed	7,211.6	6,011.0	6,067.4	7,545.6	Destroyed	1,507.1	1,282.0	1,295.9	1,596.0
Recovered	28,297.5	24,329.8	24,834.4	30,710.5	Recovered	7,413.0	6,710.9	6,956.5	8,359.1

Notes: Recycling, reclamation and destruction values may not add to recovery totals because some facilities store F-gases indefinitely on-site. Summary totals include PFCs as reported by commercial reclamation and destruction facilities; however, such quantities are negligible, and therefore have not been scaled up because of data limitations.

Table 6-9. Estimated Total MMTCO_2eq F-Gas RRRD in the EU-27 (2004-2007

Upper Bound					Lower Bound				
F-gas Type/Fate	2004	2005	2006	2007	F-gas Type/Fate	2004	2005	2006	2007
HFCs					HFCs				
Recycled	43.3	36.9	37.2	38.7	Recycled	9.9	8.7	8.9	9.4
Reclaimed	2.2	2.1	2.4	3.0	Reclaimed	1.2	1.2	1.4	1.7
Destroyed	16.7	14.1	14.1	14.3	Destroyed	3.5	3.0	3.0	3.0
Recovered	62.2	53.2	53.7	56.0	Recovered	14.6	12.9	13.3	14.1
PFCs					PFCs				
Recycled	Unknown	Unknown	Unknown	Unknown	Recycled	Unknown	Unknown	Unknown	Unknown
Reclaimed	<1	<1	<1	<1	Reclaimed	<1	<1	<1	<1
Destroyed	<1	<1	<1	<1	Destroyed	<1	<1	<1	<1
Recovered	Unknown	Unknown	Unknown	Unknown	Recovered	Unknown	Unknown	Unknown	Unknown
SF_6					SF_6				
Recycled	12.0	13.2	14.6	16.0	Recycled	12.0	13.2	14.6	16.0
Reclaimed	1.9	1.6	1.8	2.0	Reclaimed	1.9	1.6	1.8	2.0
Destroyed	0.0	0.5	0.6	0.5	Destroyed	0.0	0.5	0.6	0.5
Recovered	14.0	15.5	17.1	18.8	Recovered	14.0	15.5	17.1	18.8
Total F-Gases					Total F-Gases				
Recycled	55.2	50.2	51.8	54.7	Recycled	21.9	22.0	23.5	25.4
Reclaimed	4.1	3.7	4.2	5.0	Reclaimed	3.1	2.8	3.2	3.7
Destroyed	16.8	14.7	14.7	14.9	Destroyed	3.5	3.5	3.5	3.5
Recovered	76.2	68.7	70.9	74.8	Recovered	28.6	28.4	30.4	32.9

Notes: Recycling, reclamation and destruction values may not add to recovery totals because some facilities store F-gases indefinitely on-site. Summary totals include PFCs as reported by commercial reclamation and destruction facilities; however, such quantities are negligible, and therefore have not been scaled up because of data limitations.

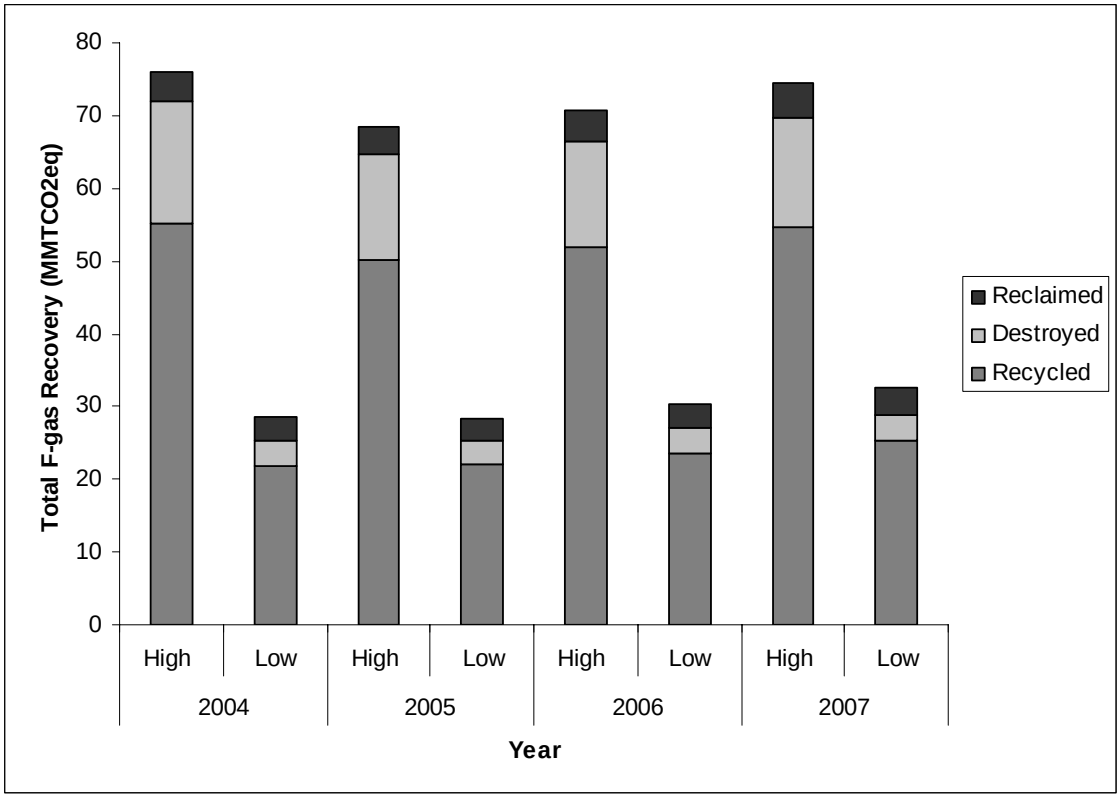
As shown, it is believed that the vast majority of estimated recovered F-gases were recycled, while a small amount was destroyed and only a minimal amount was reclaimed. Two sets of overall totals are shown in the table using the upper and lower bound scenarios developed for the RAC sector. In developing the summary totals, the following considerations on double-counting were addressed:

- On-site and off-site RRD of SF_6 and HFCs, as reported by respondents in the switchgear and fire protection sectors, respectively, were included in the calculations to determine EU-wide estimates for these sectors. Data reported by commercial reclamation and destruction facilities for HFCs and SF_6 were not included in these sector estimates because their activities are considered to be accounted for by the off-site F-gas reclamation and destruction reported by the industry respondents.

- Care was taken to ensure that estimates of HFC-125 and HFC-227ea, which are used in both fire and RAC sectors, were not double-counted. All data on these HFCs reflect on-site reclamation and destruction (by both commercial reclamation/destruction facilities and the fire protection company).

Figure 1 graphically compares the upper and lower bound scenario estimates of F-gas recovery in the EU-27 for 2004-2007.

Figure 1: Comparison of Estimates of F-Gas Recovery ($MMTCO_2eq$) (2004-2007)



7 Findings and Recommendations

This study was designed to estimate levels of F-gas recovery, recycling, reclamation, and destruction during the period of 2004-2007, as well as identify barriers to these activities and possible solutions to overcome them and to facilitate the continued increase in F-gas recovery rates for recycling, reclamation, and destruction in the EU-27. This section presents the major findings of the study, including the cross-sectoral and sector-specific barriers to proper RRRD of F-gases, as well as recommendations for increasing levels of F-gas RRRD.

7.1 Findings

7.1.1 F-Gas RRRD Estimates

Despite the dissemination of approximately 350 questionnaires to a variety of stakeholder groups, including trade associations that were asked to further disseminate the questionnaires to their member companies, very few responses were received. Efforts to encourage responses (e.g., follow -up e-mails, deadline extensions, meetings with selected industry representatives) did not improve responsiveness. Considering the inherent challenge in obtaining data from the large and geographically-dispersed population of equipment operators that are responsible for the recovery and subsequent treatment of F-gases, this poor response rate is not entirely unexpected, but certainly disappointing. Because of this circumstance, the EU-wide RRRD F-gas estimates developed for and presented in this study are based on very limited quantitative data reported by industry stakeholders and, hence, highly uncertain.

Given the wide variation in estimated recovery levels reported even within individual sectors, such as in the RAC sector (the largest of the F-gas sectors), estimates can only be used as rough approximations. To address uncertainty, a range of lower and upper bound estimates were developed for the RAC sector, as this sector constitutes the largest sector using F-gases.

The low survey response rate may be indicative of RRRD activities overall—i.e., the low response rate may signify low levels of historical F-gas recovery. Certainly, the very low number of responses from F-gas users that included quantitative data indicates that stakeholder groups have not historically tracked and recorded these activities. In undertaking this study, one of the identified challenges at the outset was determining estimates of recovery and recycling of F-gases; quantifying the amount of F-gases recovered from equipment is complex given the diverse nature of the industrial sectors, the variable size of end users (i.e., large multinational corporations, SMEs), and the differences in service practices. One important finding of this study is that the use of reclamation and destruction data are the appropriate indicators of F-gas recovery and recycling levels, since it is reclamation/destruction activities that can be and typically are more closely tracked. However, even these data are subject to uncertainty, as it has not been and continues not to be required that all facilities that perform F-gas reclamation and destruction *on-site* report such data to the Commission.

7.1.2 Barriers

Many questionnaire respondents indicated that there were significant barriers to recovery, recycling, reclamation, and/or destruction of F-gases in the EU-27. Perceived and real barriers include those relating to technical, infrastructure, economic, regulatory, and informational concerns, as summarized below.

- **Infrastructure Barriers:** Respondents stated that currently there is a lack of capacity in some Member States relating to F-gas purity testing, reclamation, and/or destruction. The lack of F-gas testing facilities undermines F-gas recovery because service companies without a specialised laboratory are often unable to determine if recovered fluids can be reclaimed or if

they must be destroyed. Moreover, it is often difficult to find an appropriate testing facility to provide such testing services, and expensive to procure such services if they are available. Similarly, access to reclamation and destruction facilities poses a challenge particularly for those Member States without any such facilities. Based on information gathered for this report, there are no known commercial reclamation facilities in at least eight Member States, and no destruction facilities in nine Member States.

However, increasing the number of facilities to support these practices across the EU may pose a challenge under current market/regulatory conditions. For example, according to industry respondents, reclamation facilities are associated with high investment costs and a low return on the initial investment. Furthermore, if current volumes of F-gas suitable for reclamation are low, as is the case for SF_6 use in the switchgear sector and appears to also be the case for HFCs in the RAC sector, there is no incentive for companies to establish reclamation facilities. Consequently, within the switchgear sector, some companies offer SF_6 destruction as a service, even if the gas quality is technically still acceptable for reclamation.

- **Technical Barriers:** One technical barrier reported by respondents is that recycled refrigerants are not typically preferred in the market place because of their lower quality and performance characteristics attributable to the inability to meet original equipment manufacturer (OEM) specifications. A number of questionnaire respondents reported another technical barrier with respect to recovered F-gas blends. In particular, recovered refrigerant blends are difficult to recycle because end users have purity requirements for the refrigerants used in their equipment, which require the use of virgin or reclaimed fluids. Moreover, respondents noted that many reclamation facilities will not accept refrigerant blends containing HFCs because blends are difficult to separate and it may not be possible to reformulate blends to manufacturers' specifications given the proprietary nature of the formulation and governing patent laws. Reconstituting with the proper lubricant oils is also complex.

- **Economic Barriers:** Several industry questionnaire respondents in the refrigeration/AC and switchgear sectors noted the cost and lack of financial assistance to facilitate the purchase and operation of equipment for the recovery and recycling of F-gas as a barrier—especially for smaller companies. Current EU regulations do not provide financial incentives to minimize these costs or those associated with labour (since F-gas recovery is time-consuming).

  For recovered F-gases that are too contaminated for recycling, end-users must pay for reclamation or destruction. Not only are companies typically charged a fee to bring contaminated fluids to reclamation or destruction facilities, they must also pay for transportation. And, with limited access to reclamation and destruction facilities, transborder waste shipment is often required, which triggers administrative requirements that can be costly and time-consuming (see regulatory barriers described below). The burden associated with reclamation/destruction is particularly heavy for small quantities of F-gases; one questionnaire respondent stores F-gases on-site until 0.5 metric tonnes are collected, to render shipment for reclamation/destruction economically viable. For facilities that are not able to accumulate this amount of material, or that do not have storage space, cost-effectiveness will be more difficult to achieve.

- **Regulatory Barriers:** Per Regulation (EC) 1013/2006 on shipments of waste, the shipment of F-gas refrigerant sent for disposal or reclamation within the EU-27 requires prior written notification and consent, which is perceived as a barrier by industry stakeholders because of the paperwork required. Additionally, survey respondents perceived a lack of standardized regulations across the EU-27, claiming that Member States have implemented different policies in order to comply with EC regulations, which complicates the transfer of F-gases

within the EU. In actuality, there are no differences in the procedures to be followed by each Member State per Regulation (EC) No 1013/2006, although some countries may have transitional arrangements in place and/or may interpret articles of the regulation differently. The Commission conducts regular meetings with the Member State correspondents and stakeholders on waste shipments to try to address this problem, and drafts guidelines to assist in the interpretation of the regulation.

- **Informational Barriers:** Questionnaire respondents noted that there is a general lack of industry and customer awareness and dissemination of knowledge regarding the need to recover F-gases, the methods by which to recover F-gases, and what should be done with F-gases once they are recovered. For example, according to two survey respondents, there is confusion about whether some or all F-gases can legally be recycled and reclaimed. One company respondent in the refrigeration/AC sector reported a lack of understanding of regulatory requirements even among regulators, noting that agencies responsible for licensing operators in the waste sector were not well versed with requirements pertaining to F-gases. Similarly, in the high-voltage switchgear sector, there is industry uncertainty as to whether reclaimed SF_6 must be treated as waste according to national legislation. Poor knowledge of the regulations and a lack of technical knowledge about proper techniques/practices results in low recovery rates, and hence, increased emissions.

  In addition, there are informational barriers associated with the location of nearest reclamation/destruction facilities. According to respondents, it can be difficult for companies to identify the nearest suitable reclamation/destruction facility, particularly in Member States with few or no such facilities. In some Member States, even country representatives responsible for F-gas regulations/activities are not aware of which facilities, if any, perform F-gas reclamation and destruction within their borders, and/or whether those facilities can meet reclamation specifications and destruction efficiency requirements. This uncertainty effectively limits the extent of F-gas reclamation and destruction activities. While this study has helped identify the names and locations of F-gas reclamation and destruction facilities across the EU-27 (see *Annex C: List of F-Gas Reclamation* Facilities), more work is needed to develop a comprehensive listing. Specifically, a concerted effort between Member States and/or industry will be needed in some Member States.

7.2 Recommendations

Recommendations to overcome the real and perceived barriers associated with F-gas RRRD activities and to improve the certainty of historical and future F-gas RRRD estimates are presented below.

Remove Cost Burden

RRRD related cost impacts to the end-users should be minimised. In short, creating economic incentives—or at least removing disincentives—is important for increasing levels of reclamation and destruction across the EU. Therefore, the EC should consider the following schemes:

- Mandate F-gas producer responsibility for the take-back of unwanted F-gases for the purpose of reclamation or destruction, allowing users to return recovered F-gases to producers (through the supply chain) at no-cost. Carbon credits may also represent a potential funding source to be explored by F-gas producers—should F-gas destruction projects be approved by carbon trading platforms. Finally, destruction of F-gases could be used as an offset for production allowances, should there be a cap placed on HFC production in the future.
- Offer a rebate on the return of recovered F-gases to create an incentive for F-gas recovery. A number of countries have implemented mandatory reclamation/destruction requirements on F-gases (e.g., Norway, France, Australia) and have experienced incremental increases in the

amount of gases returned for reclamation/destruction.[44] Such refund schemes are often funded by levies placed on newly produced/imported F-gases.[45]

Further study would be needed to evaluate existing schemes and funding options in place to determine the most appropriate design and infrastructure for any such scheme across the EU-27.

Increase Awareness

Member State governments and companies/technicians must be universally aware of the locations of reclamation and destruction facilities within their State and beyond. This report provides an excellent starting point for developing this information, but Member States should play a role in expanding upon it and in providing assistance in education in the following capacities:

- Work with national trade associations representing the F-gas sectors to educate their members about where reclamation/destruction facilities can be found, and what procedures are needed to safely and legally ship the F-gases.
- Provide a clearinghouse of information, such as a website, with a listing of the reclamation and destruction facilities, EU-wide and national legislations that directly and indirectly impact RRRD activities, points of contact, and guidance materials.
- Pursue outreach efforts through the supply chain to ensure information is reaching all stakeholders down to the F-gas servicing sector, where many small operations exist.

Clarify/Expedite Regulatory Requirements within the EU-27

Both real and perceived legal barriers must be overcome to facilitate recovery and shipment of recovered F-gases for the purposes of reclamation and destruction. As many Member States do not have their own reclamation or destruction facilities, it is imperative that end-users in these countries are able to ship their recovered F-gases for reclamation and destruction easily and without great expense. Moreover, while the Commission conducts regular meetings with Member States and stakeholders on waste shipments, drafts guidelines to assist in the interpretation of these regulations, and lists competent Member State authorities who can provide guidance to stakeholders as needed,[46] some legal misinterpretation and confusion remains. Accordingly, the EC should take the following steps to ensure that EC regulations allow for clear, non-burdensome transport of F-gases for reclamation and destruction:

- Conduct outreach/education to further clarify the requirements triggered under Regulation (EC) 1013/2006 when used F-gases are shipped within the Community for the purpose of reclamation or destruction. In particular, in order to reduce the perceived barriers, the EC, the European Chemicals Agency (ECHA) and other relevant bodies should develop joint guidance on how to interpret Regulation (EC) 1013/2006, as they pertain to the recovery, reclamation, and destruction of F-gases, and make such guidance accessible to industry by posting on the EUROPA website and disseminating widely through key industry associations.
- Reconsider and amend its classifications of waste under Regulation (EC) 1013/2006 to allow for the inter-MS shipment of F-gases that can be safely transported (i.e., all F-gases except for spent solvents) for reclamation or destruction to occur without triggering notification/consent

[44] For example, in France, where reclaimed refrigerant totals have been gathered, there has been a significant increase in the efficiency of the recovery program. In 1992, without any regulation, only 200 MT of recovered refrigerant (CFCs and HCFCs) were reclaimed. In 1993, after making recovery mandatory and carrying out a deposit-refund scheme, the quantity grew to 300 MT, and the number of refrigeration companies concerned doubled from 200 to 400 (out of 2,500). Government incentives were necessary to reach full development of recovery schemes (RTOC, 2006).

[45] For example, in Australia, import levies apply to imports of F-gases (and ODS) in bulk and to those contained in pre-charged equipment. The current import and manufacture levy rates for F-gases are approximately US$140 per metric ton (ICF, 2008b).

[46] See http://ec.europa.eu/environment/waste/shipments/lists.htm.

requirements under waste regulations. In the coming months, the Commission will begin considering proposals from Member States to include additional "green"-listed wastes in Annex IIIB of Regulation (EC) 1013/2006; the shipments of such wastes would not have to undergo the notification procedure. Therefore, this represents an important opportunity for amending the waste classification of recovered F-gases and overcoming current barriers related to compliance with notification procedures.

Ensure Adequate Reclamation/Destruction Capacity

Additional capacity in certain Member States and/or streamlined procedures for trans-border shipments (discussed above) may be required. Individual Member States will need to assess national capacity against demand for reclamation/destruction,[47] to ensure that stakeholders in their countries have feasible means of reclamation/destruction by taking the following actions:

- Conduct stakeholder consultations to determine reclamation/destruction capacity in each MS and assess the national need for additional reclamation/destruction infrastructure.[48]
- Assess whether it will be more economically and environmentally feasible to build new facilities, upgrade existing ones, or ship recovered F-gases to neighbouring countries with existing facilities. This analysis may be appropriate for those Member States that do not have sufficient in-country capacity, as well as those without any capacity. In addition, Member States should identify (e.g., through targeted analysis and consulting with national trade associations and other industry representatives) the most suitable infrastructure to meet national demand for reclamation/destruction services—be it through the establishment of collection points for bulk F-gases, enhanced coordination between neighbouring countries, or other related activities.
- Consider providing initial incentives, such as grants or low-interest loans, to help reclamation facilities develop initially, should one or more new in-State reclamation facility be deemed necessary.

Refine Historical Estimates and Mandate Company Reporting

A more effective method to collect data on levels of F-gas RRRD must be identified and implemented in order to improve historical estimates presented in this study and more accurately track changes over time. While operators of refrigeration/AC and fire protection equipment are now obliged under Article 3(6) of Regulation (EC) No 842/2006 to maintain records of inter alia recovered quantities, there are no reporting procedures in place to ensure that the fates of recovered quantities are accounted for. Further, a more simplistic indicator to assess changes in levels of F-gas recovery must be adopted because of the difficulty in tracking and obtaining data on F-gas recovery and recycling. As such, the Commission should use reclamation and destruction data as indicators of the effectiveness of F-gas recovery and related regulations by pursuing the following action:

- Require annual reports on F-gas reclamation and destruction, by gas, from all facilities that perform F-gas reclamation and destruction *on*-site.

[47] If the EC adopts a producer responsibility scheme, such an assessment by Member States would not be needed, as producers would be responsible for securing adequate reclamation/destruction capacity.
[48] Note that existing high-performance facilities may be upgraded to handle F-gases in certain instances.

8 References

Barrault and Clodic. 2008. "Quantites recuperees et projection futures." In *Colloque effet de serre VII - Reglementation fluides frigorigenes - la fin du R22 & fluides a bas GWP*. Organised by AFCE (alliance froid climatisation environnement), 9 October 2008, Paris, France.

ASSURE (European Association for the Responsible use of HFCs in Fire Protection). 2008. Personal communication between Tony Richards and ICF International. June 2008.

Cefic. 2008. Personal communication between Veronique Garny and ICF International. June 2008.

Cigre. 2003. SF_6 Recycling Guide (Revision 2003) Task Force B3.02.01, August 2003.

Ecofys GmbH. 2006. "Recovery, Recycling and Destruction (RRD) of CFCs, HCFCs, HFCs and PFCs in their Main Applications within the EU-25." Final Report: Confidential. Prepared on behalf of the European Fluorocarbon Technical Committee (EFCTC).Prepared by Jochen Harnisch, Jochen Fröhlich and Sina Wartmann. 20 October 2006.

Energy Information Administration (EIA). 2007. "International Energy Annual 2005." Table 6.2 World Total Net Electricity Consumption 1980-2005. Accessed 15 August 2008. Available at: http://www.eia.doe.gov/iea/elec.html.

Harnisch, Jochen et al. 2003. "Risks and Benefits of Fluorinated Greenhouse Gases in Techniques and Products under Special Consideration of the Properties Intrinsic to the Substances." Study prepared for the German Environmental Protection Agency, Forderkennzeichen 201 64 315, Cologne/Neuremberg: ECOFYS GmbH. 31 December 2003. Available at: <www.umweltbundesamt.de>.

Hughes Associates. 2008. Personal communication between Chris Hanauska, Hughes Associates, Inc., and ICF International. 27 August 2008.

ICF International. 2008a. "Review of the Availability of HCFCs and Feasible Alternatives in the EU 27 Beyond 2010." Confidential report prepared for the European Commission. June 2008.

ICF International. 2008b. "Study on the Collection and Treatment of Unwanted Ozone-Depleting Substances in Article 5 and Non-Article 5 Countries." Prepared for the Multilateral Fund Secretariat of the Montreal Protocol. Available at: <http://ozone.unep.org/Meeting_Documents/oewg/28oewg/ICF_Study_on-Unwanted_ODS-E.pdf.> May 2008.

ICF International. 2008c. Meeting held between ICF International and representatives of the European Partnership for Energy and the Environment (EPEE), the Air conditioning and Refrigeration European Association (AREA), DuPont, Solvay, Daikin, and the European Commission. Wednesday 4 June 2008.

IPCC (Intergovernmental Panel on Climate Change). 2003. "IPCC Third Assessment Report: Climate Change 2001." Section 6.12.2 Direct GWPs Available at <http://www.grida.no/climate/ipcc_tar/wg1/248.htm>.

NPI. 1999. "Emission Estimation Technique Manual for Solvent Recycling." National Pollutant Inventory, July 1999. Available at <http://www.npi.gov.au/handbooks/approved_handbooks/pubs/fsolvent.pdf>.

ICF International. 2006. "Minimum Qualification Requirements for Personnel in the European Community Involved in the Containment and Recovery of Fluorinated Greenhouse Gases (F-Gases) and Ozone Depleting Substances (ODS)." Confidential report prepared for the European Commission. September 2006.

Motor Cabin Air Conditioning Committee (MCACC). 2008. Email communication between ICF International and MCACC. 25 March 2008.

RTOC. 2006. "2006 Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee." Available at: <http://ozone.unep.org/teap/Reports/RTOC/rtoc_assessment_report06.pdf>.

Solvay Fluor GmbH. 2008. Email correspondence from Ewald Preisegger to Marios Avraamides (European Commission). 12 November 2008.

Annex A: Questionnaires

Questionnaires are provided in Annex A in the following order:

(1) Member States

(2) Commercial F-gas reclamation companies

(3) Commercial F-gas destruction companies

(4) F-gas producers/importers/exporters

(5) Selected industry associations in F-gas sectors

Additionally, qualitative questionnaires are subsequently provided, which include those developed for:

(6) The refrigeration and air conditioning sector

(7) The solvents sector

(8) The fire protection sector

Questionnaire on the Recovery, Recycling, Reclamation and Destruction of Fluorinated Greenhouse Gases in the EU-27 (2004-2007)

To be completed by Member State representatives

Instructions

Please respond to all questions to the best of your ability. Where check boxes have been provided, please check all boxes that apply.

Submission

Please complete this survey by **21 March 2008**, and return to **Pamela Mathis** at:

Email: ECsurvey_FGas@icfi.com

Fax: +1.415.677.7177

Address: ICF International

394 Pacific, 2nd Floor

San Francisco, CA 94111

I. Facilities that Reclaim F-Gases in Your Member State

1. Several reclamation facilities have been identified in the EU-27, as listed in Attachment 1. Please review the accuracy of any contact information provided for reclamation facilities in your State, and notify ICF of any updates or corrections at ECsurvey_FGas@icfi.com.

2. If additional F-gas reclamation facilities exist in your Member State, please provide contact information for all such facilities. If more than three facilities exist, append additional pages.

Facility #1	*Facility #2*	*Facility #3*
Name:	Name:	Name:
Technical Contact:	Technical Contact:	Technical Contact:
Mailing Address:	Mailing Address:	Mailing Address:
Telephone Number:	Telephone Number:	Telephone Number:
Fax Number:	Fax Number:	Fax Number:
Email Address:	Email Address:	Email Address:
Website Address:	Website Address:	Website Address:

3. Are recovered F-gases in your Member State sent to reclamation facilities in *other* EU Member States? If yes, please identify the names and locations (city/country) of those facilities, if known.

☐ Yes	☐ No	☐ Unknown
Facility #1		
Name:		
City, Country:		
Facility #2		
Name:		
City, Country:		

II. Facilities that Destroy F-Gases in Your Member State

4. Several destruction facilities have been identified in the EU-27, as listed in Attachment 1. Please review the accuracy of any contact information provided for destruction facilities in your State, and notify ICF of any updates or corrections at ECsurvey_FGas@icfi.com.

5. If additional F-gas destruction facilities exist in your Member State, please provide contact information for all such facilities. If more than three facilities exist, append additional pages.

Facility #1	*Facility #2*	*Facility #3*
Name:	Name:	Name:
Technical Contact:	Technical Contact:	Technical Contact:
Mailing Address:	Mailing Address:	Mailing Address:
Telephone Number:	Telephone Number:	Telephone Number:
Fax Number:	Fax Number:	Fax Number:
Email Address:	Email Address:	Email Address:

Website Address:	Website Address:	Website Address:
6. Are recovered F-gases in your Member State sent to destruction facilities in *other* EU Member States? If yes, please identify the names and locations (city/country) of those facilities to the extent that it is known.		
☐ Yes *Facility #1* Name: City, Country: *Facility #2* Name: City, Country:	☐ No	☐ Unknown

7. Does your Member State have any national data on quantities of F-gases destroyed during the years 2004 through 2007?	
☐ Yes If yes, please provide data (by year and F-gas type, if possible): *If preferred, you may attach a copy of these data along with the submittal of your completed survey.*	☐ No

III. Trade Associations and Companies in the Fire Protection Sector in Your Member State

8. Please provide contact information for all *national trade associations* that represent the *fire protection industry* in your Member State, if any. If more than three associations exist, append additional pages.

Association #1	*Association #2*	*Association #3*
Name:	Name:	Name:
Technical Contact:	Technical Contact:	Technical Contact:
Mailing Address:	Mailing Address:	Mailing Address:
Telephone Number:	Telephone Number:	Telephone Number:
Fax Number:	Fax Number:	Fax Number:
Email Address:	Email Address:	Email Address:
Website Address:	Website Address:	Website Address:

9. Please provide contact information for all *companies* in the *fire protection industry* in your Member State that may use F-gases, if any. If more than three companies exist, append additional pages.

Company #1	*Company #2*	*Company #3*
Name:	Name:	Name:
Technical Contact:	Technical Contact:	Technical Contact:
Mailing Address:	Mailing Address:	Mailing Address:
Telephone Number:	Telephone Number:	Telephone Number:
Fax Number:	Fax Number:	Fax Number:
Email Address:	Email Address:	Email Address:
Website Address:	Website Address:	Website Address:

IV. Trade Associations and Companies in the Solvent Sector in Your Member State

10. Please provide contact information for all *national trade associations* that represent the solvents industry in your Member State, if any. If more than three associations exist, append additional pages.

Association #1	*Association #2*	*Association #3*
Name:	Name:	Name:
Technical Contact:	Technical Contact:	Technical Contact:
Mailing Address:	Mailing Address:	Mailing Address:
Telephone Number:	Telephone Number:	Telephone Number:
Fax Number:	Fax Number:	Fax Number:
Email Address:	Email Address:	Email Address:
Website Address:	Website Address:	Website Address:

11. Please provide contact information for all *companies* in the solvents industry in your Member State that may use F-gases, if any. If more than three companies exist, append additional pages.

Company #1	*Company #2*	*Company #3*
Name:	Name:	Name:
Technical Contact:	Technical Contact:	Technical Contact:
Mailing Address:	Mailing Address:	Mailing Address:

Telephone Number: Fax Number: Email Address: Website Address:	Telephone Number: Fax Number: Email Address: Website Address:	Telephone Number: Fax Number: Email Address: Website Address:

V. Refrigeration and Air Conditioning in Your Member State

12. Please describe the relevant actors involved in the refrigeration/AC sector of your country in terms of:

Number of producers:

Number of importers:

Number of gas distributors:

Number of contractors:

Number of relevant waste handlers:

Number of destruction facilities:

Their respective interaction in relation to recovery, recycling, reclamation and destruction:

VI. Recycling, Recovery, Reclamation and Destruction Information for Your Member State

13. What type of quantitative information on recycling, recovery, reclamation and destruction is available in your country? Please provide copies or complete the information below, if possible.

Reporting obligations of MS under Art. 16(6) of EU Regulation 2037/2000:

National statistics:

Performance evaluation of voluntary schemes:

Market data:

Any printed reports:

Any additional experts recommended for discussion?:

VII. Challenges and Barriers

14. Does your Member State have any national laws or regulations in place that limit or restrict the *reuse (recycling or reclamation)* of recovered F-gases? For example, is the recycling of recovered F-gases prohibited?

☐ Yes If yes, please describe how the re-use of F-gases is limited/restricted (provide specific legal references if possible):	☐ No

15. Does your Member State have any national laws or regulations in place that limit or restrict the *destruction* of F-gases?

☐ Yes If yes, please describe how the destruction of F-gases is limited/restricted (provide specific legal references if possible):	☐ No

16. What, if any, barriers exist in the EU-27 that hinder F-gas recycling, reclamation and destruction today? Please be as specific as possible in describing perceived barriers.[49] Please also specify if the identified barriers pertain to your Member State and/or to the EU-27 in general.	
Barriers to RECYCLING	
Barriers to RECLAMATION	
Barriers to DESTRUCTION	
17. Do you have any suggestions for overcoming these barriers, so that future amounts of F-gases recovered for recycling, reclamation, or destruction can be increased?	

Thank you for your participation!

[49] Barriers may be legal, logistical, economic, or informational in nature. Examples may include: laws related to the collection, treatment, and/or trade of used F-gases and the associated burden of paperwork; insufficient recovery equipment; capacity of reclamation/destruction facilities in-country; high costs of transport and reclamation relative to the resale value of reclaimed F-gases; and lack of awareness regarding where and how to send used F-gases for reclamation/ destruction.

Questionnaire on the Recovery and Reclamation of F-Gases in the EU-27 During 2004-2007

To be completed by representatives of F-gas reclamation facilities

Instructions

Please complete this questionnaire by **28 March 2008** and return to **Pamela Mathis** at:

Email: ECsurvey_FGas@icfi.com

Fax: +1.415.677.7177

Address: ICF International
394 Pacific, 2nd Floor
San Francisco, CA 94111

I. Contact Information

Company Name:	
Address:	
Postal Code:	
Country:	
Contact Person:	
Phone Number:	
Fax Number:	
Email Address:	

II. Reclamation of F-Gases at Your Facility

1. Between 2004 and 2007, has your facility reclaimed "F-gases" (i.e., HFCs, PFCs, SF_6)?

☐ Yes
If Yes, please complete the remainder of this questionnaire.

☐ No
If No, but you intend to reclaim F-gases in 2008 or beyond, please skip to Section III. If you do not intend to reclaim F-gases in future, please skip to Section IV.

2. What are the quantities of F-gases reclaimed by your facility over the last four years? Please complete the table below with best estimates and append additional pages if more space is needed.

General F-Gas Type	Specific F-Gas Type	Kilogrammes Collected			
		2004	2005	2006	2007
HFCs & HFC blends	HFC-134a				
	HFC-152a				
	HFC-227ea				
	HFC-245fa				
	R-404a				
	R-407c				
	R-410a				
	R-507a				
	Other:				
	Other:				
PFCs	Perfluoromethane (CF_4)				
	Perfluoroethane (C_2F_6)				
	Perfluoropropane (C_8F_8)				
	Other:				
	Other:				
SF_6					

3. From 2004 to 2007, what was the average price (per kg) charged to customers for F-gas reclamation? If this cost varied significantly by F-gas type, please explain.

Average reclamation price: € /kg

Additional explanation if cost varied by F-gas type:

4. Do you expect F-gas reclamation costs to change significantly in future?

☐ Yes ☐ No

If yes, please explain:

5. On average, approximately what percent of F-gases received by your facility/ies between 2004 through 2007 was *not* reclaimable? If this percent varied significantly by F-gas type, please explain.

% not reclaimable

Additional explanation if percent varied by F-gas type:

6. What were the primary reasons for which F-gases were not reclaimable? For example, is there a minimum purity level that must be met, and/or are there only specific F-gases that are of high enough economic value to be cost-effectively reclaimed? Please explain.

7. Approximately what percent of the total amount of F-gases collected for reclamation during 2004 through 2007 were received from outside of your Member State?

%

If this varied by F-gas type, please explain:

8. If any F-gas quantities were received from outside of your Member State, please indicate the source country/ies.

Country/ies:

9. From what sector do the majority of recovered F-gases originate? Please indicate the *approximate* percent of F-gases collected for reclamation from each source to the best of your ability.

Sector	HFCs	PFCs	SF_6
Stationary refrigeration, air conditioning, and heat pump equipment	%	%	
Mobile refrigeration and air conditioning equipment	%	%	
Stationary equipment containing F-gas-based solvents	%	%	
Stationary fire protection systems and fire extinguishers	%	%	
High voltage switchgear			%
F-gas containers at end of life (refillable and non-refillable)	%	%	%
Other products and equipment, including mobile equipment	%	%	%

10. What is the fate of F-gases that cannot be reclaimed? Please estimate the percent that each stream represents and indicate if this breakdown varies by F-gas type and/or year.

% Destroyed on-site

% Sent off-site for destruction (If so, please specify where:)

% Stored

% Returned to source

% Other (please specify:)

Does this vary significantly by F-gas type?

☐ Yes ☐ No

If yes, please explain:

Has this varied significantly by year (2004-2007)?

☐ Yes ☐ No

If yes, please explain:

III. Reclamation Technologies in Use

11. What reclamation technology is in use at your facility?

12. What is the current annual reclamation capacity of your facility? If capacity varies by F-gas type, please explain.

kg/year

Explanation if capacity varies by F-gas type:

IV. Challenges	
13. What, if any, barriers exist in the EU-27 that hinder F-gas recycling, reclamation and destruction today? Please be as specific as possible in describing perceived barriers.[50]	
Barriers to RECYCLING	
Barriers to RECLAMATION	
Barriers to DESTRUCTION	
14. Do you have any suggestions for overcoming the barriers indicated above, so that future levels of F-gases recovered for reclamation can be increased?	
15. Additional comments regarding the recovery and reclamation of F-gases throughout the EU-27:	

Thank you for your participation!

[50] Barriers may be legal, logistical, economic, or informational in nature. Examples may include: laws related to the collection, treatment, and/or trade of used F-gases and the associated burden of paperwork; insufficient recovery equipment; capacity of reclamation/destruction facilities in-country; high costs of transport and reclamation relative to the resale value of reclaimed F-gases; and lack of awareness regarding where and how to send used F-gases for reclamation/ destruction.

Questionnaire on the Recovery and Destruction of F-Gases in the EU-27 During 2004-2007

To be completed by representatives of F-gas destruction facilities

Instructions

Please complete this questionnaire by **14 April 2008** and return to **Pamela Mathis** at:

Email: ECsurvey_FGas@icfi.com

Fax: +1.415.677.7177

Address: ICF International
394 Pacific, 2nd Floor
San Francisco, CA 94111

I. Contact Information

Company Name:	
Address:	
Postal Code:	
Country:	
Contact Person:	
Phone Number:	
Fax Number:	
Email Address:	

II. Destruction of F-Gases at Your Facility

1. Between 2004 and 2007, has your facility destroyed "F-gases" (i.e., HFCs, PFCs, SF_6)?

☐ Yes
If Yes, please complete the remainder of this section.

☐ No
If No, but you intend to destroy F-gases in 2008 or beyond, please skip to Section III. If you do not intend to destroy F-gases in future, please skip to Section IV.

2. What are the quantities of F-gases collected for destruction by your facility over the last four years? Please complete the table below with best estimates and append additional pages if more space is needed.

General F-Gas Type	Specific F-Gas Type	Kilogrammes Collected			
		2004	2005	2006	2007
HFCs & HFC blends	HFC-134a				
	R-404a				
	R-407c				
	R-410a				
	Other:				
	Other:				
PFCs	Perfluoromethane (CF_4)				
	Perfluoropropane (C_8F_8)				
	Other:				
	Other:				
SF_6					

3. From 2004 to 2007, what was the average price (per kg) charged to customers for F-gas destruction? If this cost varied significantly by F-gas type, please explain.

Average destruction price: € /kg

Additional explanation if cost varied by F-gas type:

4. Do you expect F-gas destruction costs to change significantly in future?

☐ Yes ☐ No

If yes, please explain:

5. Approximately what percent of the total amount of F-gases collected for destruction during 2004 through 2007 were received from outside of your Member State?

%

If this varied by F-gas type, please explain:

6. If any F-gas quantities were received from outside of your Member State, please indicate the source country/ies.

Country/ies:

7. From what sector do the majority of recovered F-gases originate? Please indicate the *approximate* percent of F-gases collected for destruction from each source to the best of your ability.

Sector	HFCs	PFCs	SF_6
Stationary refrigeration, air conditioning, and heat pump equipment	%	%	
Mobile refrigeration and air conditioning equipment	%	%	
Equipment containing F-gas-based solvents	%	%	
Fire protection systems and fire extinguishers	%	%	
High voltage switchgear			%

F-gas containers at end of life (refillable and non-refillable)	%	%	%
Other products and equipment, including mobile equipment	%	%	%

8. What is the fate of F-gases that cannot be destroyed? Please estimate the percent that each stream represents and indicate if this breakdown varies by F-gas type and/or year.

% Stored

% Returned to source

% Other (please specify:)

If this varies significantly by F-gas type or by year (2004-2007), please explain:

III. Destruction Technologies in Use

9. What destruction technology is in use at your facility?

10. What is the current annual destruction capacity of your facility? If capacity varies by F-gas type, please explain.

kg/year

Explanation if capacity varies by F-gas type:

IV. Challenges

11. What, if any, barriers exist in the EU-27 that hinder F-gas recycling, reclamation and destruction today? Please be as specific as possible in describing perceived barriers.[51]

Barriers to RECYCLING

Barriers to RECLAMATION

Barriers to DESTRUCTION

12. Do you have any suggestions for overcoming the barriers indicated above, so that future levels of F-gases recovered for destruction can be increased?

13. Additional comments regarding the recovery and destruction of F-gases throughout the EU-27:

Thank you for your participation!

[51] Barriers may be legal, logistical, economic, or informational in nature. Examples may include: laws related to the collection, treatment, and/or trade of used F-gases and the associated burden of paperwork; insufficient recovery equipment; capacity of reclamation/destruction facilities in-country; high costs of transport and reclamation relative to the resale value of reclaimed F-gases; and lack of awareness regarding where and how to send used F-gases for reclamation/destruction.

Questionnaire on the Reclamation and Destruction of F-Gases for Producers, Importers, and Exporters in the EU-27 during 2004-2007

Instructions

Please respond to all questions to the best of your ability. We recognise that not all companies will have the necessary data to answer all of the questions. **At a minimum, all companies should respond to the general questions in Section III.** Note that all questions should be answered with respect to *all of your company's facilities*; please complete only one questionnaire per *company.*

Submission

Please complete this survey by **30 May 2008**, and return to **Pamela Mathis** at:

Email: ECsurvey_FGas@icfi.com **Address:** ICF International

Fax: +1.415.677.7177 394 Pacific, 2nd Floor San Francisco, CA 94111

I. Contact Information

Company Name:	
Address:	
Postal Code:	
Country:	
Contact Person:	
Phone Number:	
Fax Number:	
Email Address:	

II. Company Profile

Is your company a producer, importer, and/or exporter of F-gases?

- ☐ Producer
- ☐ Importer
- ☐ Exporter

III. General

1. Has your company implemented any changes (e.g., to production processes or business procedures) to improve F-gas recovery rates since the enactment of Regulation (EC) No 842/2006? If so, please explain.
2. Does your company take back used F-gases or F-gas cylinders from customers? If so, what is typically done with it (e.g., recycled, reclaimed, destroyed), and has the fate of used F-gases/F-gas cylinders changed since the enactment of Regulation (EC) No 842/2006?
3. What, if any, barriers have historically hindered F-gas refrigerant recycling, reclamation and/or destruction in the EU-27? Have these barriers continued to pose a problem since the enactment of Regulation (EC) No 842/2006?

IV. Detailed Information on F-Gas Recovery

We recognise that not all companies will have data readily available to answer the questions below; please respond to the best of your ability.

4. What were the approximate quantities of F-gases collected from customers or otherwise *recovered* for recycling, reclamation, and destruction by your company from 2004-2007?

F-Gas Type	Kilogrammes of Recovered F-Gas (including blends)			
	2004	2005	2006	2007
HFCs				
PFCs				
SF_6				

5. Approximately what percent of F-gases collected from customers or otherwise recovered by your company was recycled vs. reclaimed vs. destroyed during 2004-2007?

F-Gas Type	Recycled	Reclaimed	Destroyed
HFCs	%	%	%
PFCs	%	%	%
SF_6	%	%	%

If the above percentages varied significantly by year from 2004-2007, please explain:

If the above percentages varied significantly by F-gas type, please explain:

6. From where did the majority of recovered F-gases originate from 2004-2007? Please indicate the *approximate* percent of each F-gas type that was collected from each source.

	HFCs	PFCs	SF_6
Stationary refrigeration, air conditioning, and heat pump equipment	%	%	
Mobile refrigeration and air conditioning equipment	%	%	
Equipment containing F-gas-based solvents	%	%	
Fire protection systems and fire extinguishers	%	%	
High voltage switchgear			%
Refillable and non-refillable F-gas containers	%	%	%
Other (please specify:)	%	%	%
Other (please specify:)	%	%	%

V. Detailed Information on F-Gas Reclamation

We recognise that not all companies will have data readily available to answer the questions below; please respond to the best of your ability.

7. Between 2004 and 2007, did your company reclaim F-gases either in-house or by sending recovered F-gases to a second party?

☐ Yes
If Yes, please complete the remainder of this Section.

☐ No
If No, please skip to Section IV.

8. Please indicate quantities of F-gas refrigerants reclaimed on-site during 2004-2007, and append additional pages if more space is needed.

F-Gas Type	Specific F-Gas Type	Kilogrammes Reclaimed On-Site (including blends)			
		2004	2005	2006	2007
HFCs / HFC Blends	HFC-23				
	HFC-43-10mee				
	HFC-125				
	HFC-134a				
	HFC-152a				
	HFC-227ea				
	HFC-236fa				
	HFC-245ca				
	HFC-245fa				
	HFC-365mfc				
	R-404A				
	R-407C				
	R-410A				
	R-507				
	Other:				
	Other:				
PFCs	Perfluoromethane (CF_4)				
	Perfluoroethane (C_2F_6)				
	Perfluoropropane (C_3F_8)				
	Perfluoro-butane (C_4F_{10})				
	Perfluoro-pentane (C_5F_{12})				
	Perfluoro-hexane (C_6F_{14})				
	Other:				
	Other:				
SF_6					

9. Were any F-gases sent off-site for reclamation by your company during 2004-2007?

☐ Yes
If Yes, please specify quantities by F-gas type:

☐ No

10. If your company sent any F-gases to a second party for reclamation, please provide contact information for the second party(ies). If more than one second party reclaimer was used, please provide additional information below.

Name of Second Party:
Email Address:
Mailing Address (include country):

Contact information for additional second party reclaimers:

VI. Detailed Information on F-Gas Destruction

We recognise that not all companies will have data readily available to answer the questions below; please respond to the best of your ability.

11. Between 2004 and 2007, did your company destroy F-gases (either in-house or by sending recovered F-gases to a second party)?

☐ Yes	☐ No
If Yes, please complete the remainder of this Section.	*If No, please skip to Section V.*

12. Please indicate quantities of F-gases destroyed on-site from 2004-2007, and append additional pages if more space is needed.

F-Gas Type	Specific F-Gas Type	Kilogrammes Destroyed On-Site (including blends)			
		2004	2005	2006	2007
HFCs / HFC Blends	HFC-23				
	HFC-43-10mee				
	HFC-125				
	HFC-134a				
	HFC-152a				
	HFC-227ea				
	HFC-236fa				
	HFC-245ca				
	HFC-245fa				
	HFC-365mfc				
	R-404A				
	R-407C				
	R-410A				
	R-507				
	Other:				
	Other:				
PFCs	Perfluoromethane (CF_4)				
	Perfluoroethane (C_2F_6)				
	Perfluoropropane (C_3F_8)				
	Perfluoro-butane (C_4F_{10})				
	Perfluoro-pentane (C_5F_{12})				
	Perfluoro-hexane (C_6F_{14})				
	Other:				
	Other:				
SF_6					

13. Were any F-gas refrigerants sent off-site for destruction by your company during 2004-2007?

☐ Yes	☐ No
If Yes, please specify quantities by F-gas type:	

14. If your company sent any F-gases to a second party for destruction, please provide contact information for the second party(ies). If more than one second party destruction facility was used, please provide additional information below.

Name of Second Party:

Email Address:

Mailing Address (include country):

Contact information for additional second party destruction facilities:

VII. Additional Comments?

Thank you for your participation!

Questionnaire on the Recovery of F-Gases From the Refrigeration/Air conditioning Sector in the EU-27 during 2004-2007

To be completed by representatives of companies using, servicing, disposing, or manufacturing refrigeration/air conditioning equipment

Instructions

Please complete this questionnaire by **14 April 2008**, and return to **Pamela Mathis** at:

Email: ECsurvey_Fgas@icfi.com

Fax: +1.415.677.7177

Address: ICF International

394 Pacific, 2nd Floor

San Francisco, CA 94111

I. Contact Information

Company Name:	
Address:	
Postal Code:	
Country:	
Contact Person:	
Phone Number:	
Fax Number:	
Email Address:	

II. Company Profile

Main Activity/Services:	☐ Large commercial/industrial user of refrigeration/AC equipment ☐ Refrigeration/AC servicing company ☐ Refrigeration/AC equipment disposal/decommissioning company ☐ Refrigeration/AC equipment manufacturer
Type of Equipment (refrigeration/ air conditioning sector):	☐ Stationary (specify:) ☐ Mobile (specify:)
Number of Employees:	

III. F-Gas Recovery

1. What were the approximate quantities of F-gas refrigerants *recovered* for recycling, reclamation, destruction, and storage by your company during 2004-2007? While data on quantities of F-gases recovered may not be readily available, please complete the table below approximating as best as possible.

2. What were the approximate quantities of F-gas refrigerants *recovered* for recycling, reclamation, destruction, and storage by your company during 2004-2007? While data on quantities of F-gases recovered may not be readily available, please complete the table below approximating as best as possible.

F-Gas Type	Kilogrammes of Recovered F-Gas			
	2004	2005	2006	2007
HFCs				
PFCs				

3. Approximately what percent of F-gas refrigerants recovered by your company during 2004-2007 was recycled vs. reclaimed vs. destroyed?

F-Gas Type	Recycled	Reclaimed	Destroyed
HFCs	%	%	%
PFCs	%	%	%

If the above percentages varied significantly by year from 2004-2007, please explain:

If the above percentages varied significantly by F-gas type, please explain:

4. For how long on average is recovered F-gas stored on-site prior to it being recycled, reclaimed, or destroyed?

5. If your company services or decommissions equipment, from what percent of jobs is recovered F-gas refrigerant of a high enough purity level that it can be reused without requiring reclamation?

From Servicing:

- ☐ 0%
- ☐ 1-10%
- ☐ 10-25%
- ☐ 25-50%
- ☐ 50-75%
- ☐ 75-100%

From Decommissioning:

- ☐ 0%
- ☐ 1-10%
- ☐ 10-25%
- ☐ 25-50%
- ☐ 50-75%
- ☐ 75-100%

6. From what sector(s) did the majority of F-gases recovered by your company originate during 2004-2007? Please indicate the *approximate* percent of each F-gas type that was collected from each source.

Source Sector	HFCs	PFCs
Household refrigeration	%	%
Retail food refrigeration	%	%
Refrigerated transport	%	%
Industrial process refrigeration	%	%
Cold storage warehouses	%	%
Motor vehicle air conditioning (MVAC)	%	%
Chillers	%	%
Residential and small commercial AC/heat pumps	%	%
Refrigerant containers at end of life	%	%

7. Approximately what percent of F-gases recovered by your company is recovered at equipment servicing or disposal, or from other sources?

% from equipment servicing
% from equipment disposal
% Other (please specify:)

If the above percentage varied significantly by year from 2004-2007, please explain:

If the above percentage varied significantly by end-use, please explain:

8. Approximately what percent of cylinders in use by your company during the period 2004-2007 were refillable vs. non-refillable?

% Refillable
% Non-refillable

If the above percentages varied significantly by year from 2004-2007, please explain:

9. During the period 2004-2007, what was done with empty refrigerant containers that were (a) refillable and (b) non-refillable?

Refillable Containers:
% Sent back to producer
% Stored at your facilities
% Other (Specify:)

Non-Refillable Containers
% Brought to a scrap yard
% Sent back to producer
% Stored at your facilities
% Other (Specify:)

If the above percentages varied significantly by year from 2004-2007, please explain:

10. Which of the following best characterises the state of refrigerant recovery among your national industry historically (2004-2007) and currently (since Regulation (EC) No 842/2006)?

Historical Recovery Levels (2004-2007):

☐ > 95% recovery rate - refrigerant recovery is the industry standard

☐ 75% recovery rate - the majority of industry recovers from every job

☐ 50% recovery rate – most of the industry recovers where feasible, typically from larger equipment only

☐ 25% recovery rate - some of the industry recovers from larger equipment only

☐ <10% recovery rate - a small share of the industry recovers where feasible

☐ Other? Please describe:

Current Recovery Levels:

☐ > 95% recovery rate - refrigerant recovery is the industry standard

☐ 75% recovery rate - the majority of industry recovers from every job

☐ 50% recovery rate – most of the industry recovers where feasible, typically from larger equipment only

☐ 25% recovery rate - some of the industry recovers from larger equipment only

☐ <10% recovery rate - a small share of the industry recovers where feasible

☐ Other? Please describe:

IV. F-Gas Reclamation

11. Between 2004 and 2007, did your company send F-gas refrigerants offsite for reclamation?

☐ Yes
If Yes, please complete the remainder of this Section.

☐ No
If No, please skip to Question 13.

12. Please indicate quantities of F-gas refrigerants sent off-site (i.e., to a second party) for reclamation during 2004-2007.

F-Gas Type	Specific F-Gas Type	Kilogrammes Sent for Reclamation			
		2004	2005	2006	2007
HFCs	HFC-134a				
	R-404A				
	R-407C				
	R-410A				
	R-507A				
	Other (specify:)				
	Other (specify:)				
PFCs	Specify:				
	Specify:				

13. Please provide contact information for the second party(ies) reclaimer(s).

Name of Reclaimer:

Email Address:

Mailing Address:

Contact information for additional reclaimers:

14. Were any F-gas refrigerants reclaimed on-site by your company during 2004-2007?

☐ Yes
If Yes, please specify quantities by F-gas type:

☐ No

V. F-Gas Destruction

15. Between 2004 and 2007, did your company send F-gas refrigerants to a second party for destruction?

☐ Yes
If Yes, please complete the remainder of this Section.

☐ No
If No, please skip to Question 17.

16. Please indicate quantities of F-gases sent off-site (to a second party) for destruction during 2004-2007.

F-Gas Type	Specific F-Gas Type	Kilogrammes Sent for Destruction			
		2004	2005	2006	2007
HFCs	HFC-134a				
	R-404A				
	R-407C				
	R-410A				
	R-507A				
	Other (specify:)				
	Other (specify:)				
PFCs	Specify:				
	Specify:				

17. Please provide contact information for the destruction company/ies.

Name of destruction company:

Email Address:

Mailing Address:

Contact information for additional destruction facilities:

18. Were any F-gas refrigerants destroyed on-site by your company during 2004-2007?

☐ Yes
If Yes, please specify quantities by F-gas type:

☐ No

VI. Challenges

19. What, if any, barriers exist in the EU-27 that hinder F-gas refrigerant recycling, reclamation and destruction today? Please be as specific as possible in describing perceived barriers.[52]

Barriers to RECYCLING

Barriers to RECLAMATION

Barriers to DESTRUCTION

20. Do you have any suggestions for overcoming the barriers indicated above, so that future levels of F-gas refrigerants recovered for recycling, reclamation, and destruction can be increased?

21. To better understand the recovery market and any economic barriers at play, please provide available information regarding the costs of F-gas recovery, storage, transport, reclamation, and/or destruction in the table below. If quantitative information is not available, please provide qualitative information on cost or cost-effectiveness.

	Quantitative Information on Cost	Qualitative Information on Cost or Cost Effectiveness
Recovery of F-gases from small equipment	€ /kg	
Recovery of F-gases from large equipment	€ /kg	
Storage of F-gases	€ /	
Transport of F-gases	€ /km	
Processing of recovered F-gases for reclamation	€ /kg	
Destruction of recovered F-gases	€ /kg	

22. Additional comments regarding the recovery/reclamation/destruction of F-gas refrigerants throughout the EU-27:

Thank you for your participation!

[52] Barriers may be legal, logistical, economic, or informational in nature. Examples may include: laws related to the collection, treatment, and/or trade of used F-gases and the associated burden of paperwork; insufficient recovery equipment; capacity of reclamation/destruction facilities in-country; high costs of transport and reclamation relative to the resale value of reclaimed F-gases; and lack of awareness regarding where and how to send used refrigerant for reclamation/ destruction.

Questionnaire on the Recovery of SF_6 used in Medium and High Voltage Switchgear in the EU-27 during 2004-2007

To be completed by representatives of electrical power companies using SF_6

Instructions

Please complete this questionnaire by **14 April 2008,** and return to **Pamela Mathis** at:

Email: ECsurvey_FGas@icfi.com

Fax: +1.415.677.7177

Address: ICF International, 394 Pacific, 2nd Floor, San Francisco, CA 94111

Contact Information

Company Name:	
Address:	
Postal Code:	
Country:	
Contact Person:	
Phone Number:	
Fax Number:	
Email Address:	

Note: If your company operates more than one substation, please answer all questions below with respect to ALL of your company's substations.

SF_6 Recovery and Recycling

1. What were the approximate quantities of SF_6 *recovered* for recycling, reclamation, destruction, and storage by your company during 2004-2007? While data on quantities of SF_6 recovered may not be readily available, please complete the table below approximating as best as possible.

Kilogrammes of SF_6 Recovered			
2004	**2005**	**2006**	**2007**

2. On average, approximately what percent of SF_6 recovered by your company during 2004-2007 was recycled vs. reclaimed vs. destroyed?

Recycled	Reclaimed	Destroyed
%	%	%

If the above percentages varied significantly by year from 2004-2007, please explain:

3. For how long on average is recovered SF_6 stored prior to it being recycled, reclaimed, or destroyed?

4. Between 2004 and 2007, has your company recycled SF_6 (either in-house or by sending recovered SF_6 to a second party)?

☐ Yes — *If Yes, please complete the remainder of this Section.*

☐ No — *If No, please proceed to Question 7.*

5. How are recycling procedures implemented at your company?

☐ Through a systematic maintenance schedule
☐ As prompted through equipment alarm triggers or when potential concerns are identified
☐ Other (specify:)

6. Which of the following best characterises the state of SF_6 recovery among your national industry historically (2004-2007) and currently (since Regulation (EC) No 842/2006)?

Historical Recovery Levels (2004-2007):

☐ > 95% recovery rate; SF_6 is recovered by every electric power company—it's the industry standard
☐ 75% recovery rate; the majority of industry recovers SF_6
☐ 50% recovery rate; roughly half of the industry recovers
☐ 25% recovery rate; some of the industry recovers
☐ <10% recovery rate; a very small share of the industry recovers

Additional comments:

Current Recovery Levels:

☐ > 95% recovery rate; SF_6 is recovered by every electric power company—it's the industry standard
☐ 75% recovery rate; the majority of industry recovers SF_6
☐ 50% recovery rate; roughly half of the industry recovers
☐ 25% recovery rate; some of the industry recovers
☐ <10% recovery rate; a very small share of the industry recovers

Additional comments:

SF_6 Reclamation

7. Between 2004 and 2007, did your company recover SF_6 for reclamation?

☐ Yes — *If Yes, please complete the remainder of this Section.*

☐ No — *If No, please proceed to Section IV.*

8. What were the quantities of SF_6 sent for reclamation (i.e., to a second party) over the last four years?

Kilogrammes Sent for Reclamation			
2004	**2005**	**2006**	**2007**

9. Please indicate the approximate percent of SF_6 sent for reclamation within versus outside of your Member State during 2004-2007, and provide the contact information for the second party/ies that performed the reclamation.

% reclaimed within Member State.

% reclaimed in *another* Member State.

Name of Reclaimer:

Email Address:

Mailing Address:

Contact information for additional reclaimers:

SF_6 Destruction

10. Between 2004 and 2007, did your company recover SF_6 for destruction?

☐ Yes — *If Yes, please complete the remainder of this Section.*

☐ No — *If No, please proceed to Section V.*

11. What were the quantities of SF_6 sent for destruction (i.e., to a second party) over the last four years?

Kilogrammes Sent for Destruction			
2004	**2005**	**2006**	**2007**

12. Please indicate the approximate percent of SF_6 sent for destruction within versus outside of your Member State during 2004-2007, and provide contact information for the second party/ies that performed the destruction.

% destroyed within Member State.

% destroyed in *another* Member State.

Name of Destruction Company:

Email Address:

Mailing Address:

Contact information for additional destruction companies:

Challenges	
13. What, if any, barriers exist in the EU-27 that hinder SF_6 recycling, reclamation and destruction today? Please be as specific as possible in describing perceived barriers.[53]	
Barriers to RECYCLING	
Barriers to RECLAMATION	
Barriers to DESTRUCTION	
14. Do you have any suggestions for overcoming the barriers indicated above, so that future levels of SF_6 gas recovered for reuse, reclamation, and destruction can be increased?	
15. Additional comments regarding the recovery, recycling, and reclamation of SF_6 from electrical equipment throughout the EU-27:	

Thank you for your participation!

[53] Barriers may be legal, logistical, economic, or informational in nature. Examples may include: laws related to the collection, treatment, and/or trade of used SF_6 and the associated burden of paperwork; insufficient recovery equipment; capacity of reclamation/destruction facilities in-country; high costs of transport and reclamation relative to the resale value of reclaimed SF_6; and lack of awareness regarding where and how to send used SF_6 for reclamation/ destruction.

Questionnaire on the Reclamation and Destruction of F-Gases from the Fire Protection Sector in the EU-27 during 2004-2007

To be completed by representatives of companies using, servicing, disposing, or manufacturing fire protection equipment

Instructions

Please complete this questionnaire by **16 April 2008**, and return to **Pamela Mathis** at:

Email: ECsurvey_Fgas@icfi.com
Fax: +1.415.677.7177
Address: ICF International
394 Pacific, 2nd Floor
San Francisco, CA 94111

I. Contact Information

Company Name:	
Address:	
Postal Code:	
Country:	
Contact Person:	
Phone Number:	
Fax Number:	
Email Address:	

II. Company Profile

Main Activity/Services:	☐ Large commercial/industrial user of fire protection equipment ☐ Fire protection servicing company ☐ Other (please specify:)
Type of Equipment:	☐ Portable fire extinguishers ☐ Total flooding systems
Number of Employees:	

III. F-Gas Recovery

1. What were the approximate quantities of F-gases *recovered* for recycling, reclamation, destruction, or storage by your company during 2004-2007? While data on quantities of F-gases recovered may not be readily available, please complete the table below approximating as best as possible.

F-Gas Type	Kilogrammes of Recovered F-Gas			
	2004	2005	2006	2007
HFCs				
PFCs				

2. Approximately what percent of F-gases recovered by your company during 2004-2007 was recycled vs. reclaimed vs. destroyed?

F-Gas Type	Recycled	Reclaimed	Destroyed
HFCs	%	%	%
PFCs	%	%	%

If the above percentages varied significantly by year from 2004-2007, please explain:

If the above percentages varied significantly by F-gas type, please explain:

3. For how long on average is recovered F-gas stored on-site prior to it being recycled, reclaimed, or destroyed?

4. If your company services or decommissions equipment, from what percent of jobs is recovered F-gases of a high enough purity level that it can be reused without requiring reclamation?

From Servicing:
- ☐ 0%
- ☐ 1-10%
- ☐ 10-25%
- ☐ 25-50%
- ☐ 50-75%
- ☐ 75-100%

From Decommissioning:
- ☐ 0%
- ☐ 1-10%
- ☐ 10-25%
- ☐ 25-50%
- ☐ 50-75%
- ☐ 75-100%

5. Approximately what percent of F-gases recovered by your company is recovered at equipment servicing or disposal, or from other sources?

% from equipment servicing

% from equipment disposal

% Other (please specify:)

If the above percentage varied significantly by year from 2004-2007, please explain:

If the above percentage varied significantly by end-use, please explain:

6. Which of the following best characterises the state of F-gas recovery among your national industry historically (2004-2007) and currently (since Regulation (EC) No 842/2006)?

Historical Recovery Levels (2004-2007):	Current Recovery Levels:
☐ > 95% recovery rate – F-gas recovery is the industry standard	☐ > 95% recovery rate – F-gas recovery is the industry standard
☐ 75% recovery rate - the majority of industry recovers from every job	☐ 75% recovery rate - the majority of industry recovers from every job
☐ 50% recovery rate – most of the industry recovers where feasible, typically from larger equipment only	☐ 50% recovery rate – most of the industry recovers where feasible, typically from larger equipment only
☐ 25% recovery rate - some of the industry recovers from larger equipment only	☐ 25% recovery rate - some of the industry recovers from larger equipment only
☐ <10% recovery rate - a small share of the industry recovers where feasible	☐ <10% recovery rate - a small share of the industry recovers where feasible
☐ Other? Please describe:	☐ Other? Please describe:

IV. F-Gas Reclamation

7. Between 2004 and 2007, did your company send F-gases offsite (to a second party) for reclamation?

☐ Yes	☐ No
If Yes, please complete the remainder of this Section.	*If No, please skip to Question 10.*

8. Please indicate quantities of F-gases *sent* off-site for reclamation during 2004-2007.

F-Gas Type	Specific F-Gas Type	Kilogrammes Sent for Reclamation			
		2004	2005	2006	2007
HFCs	HFC-23				
	HFC-125				
	HFC-227ea				
	HFC-236fa				
	Other (specify:)				
	Other (specify:)				
PFCs	Perfluoromethane (CF_4)				
	Perfluoroethane (C_2F_6)				
	Perfluoropropane (C_3F_8)				
	Other (specify:)				

9. Please provide contact information for the second party(ies) reclaimer(s).

Name of Reclaimer:
Email Address:
Mailing Address:
Contact information for additional reclaimers:

10. Were any F-gases reclaimed on-site by your company during 2004-2007?

☐ Yes	☐ No
If Yes, please specify quantities by F-gas type:	

V. F-Gas Destruction

11. Between 2004 and 2007, did your company send F-gases off-site (to a second party) for destruction?

☐ Yes	☐ No
If Yes, please complete the remainder of this Section.	*If No, please skip to Question 14.*

12. Please indicate quantities of F-gases sent off-site for destruction during 2004-2007.

F-Gas Type	Specific F-Gas Type	Kilogrammes Sent for Destruction			
		2004	2005	2006	2007
HFCs	HFC-23				
	HFC-125				
	HFC-227ea				
	HFC-236fa				
	Other (specify:)				
	Other (specify:)				
PFCs	Perfluoromethane (CF_4)				
	Perfluoroethane (C_2F_6)				
	Perfluoropropane (C_3F_8)				
	Other (specify:)				

13. Please provide contact information for the destruction company/ies.

Name of destruction company:
Email Address:
Mailing Address:
Contact information for additional destruction facilities:

14. Were any F-gases destroyed on-site by your company during 2004-2007?

☐ Yes	☐ No
If Yes, please specify quantities by F-gas type:	

VI. Challenges

15. What, if any, barriers exist in the EU-27 that hinder F-gas recycling, reclamation and destruction today? Please be as specific as possible in describing perceived barriers.[54]

Barriers to RECYCLING

Barriers to RECLAMATION

Barriers to DESTRUCTION

16. Do you have any suggestions for overcoming the barriers indicated above, so that future levels of F-gases recovered for recycling, reclamation, and destruction can be increased?

17. To better understand the recovery market and any economic barriers at play, please provide available information regarding the costs of F-gas recovery, storage, transport, reclamation, and/or destruction in the table below. If quantitative information is not available, please provide qualitative information on cost or cost-effectiveness.

	Quantitative Information on Cost	Qualitative Information on Cost or Cost Effectiveness

[54] Barriers may be legal, logistical, economic, or informational in nature. Examples may include: laws related to the collection, treatment, and/or trade of used F-gases and the associated burden of paperwork; insufficient recovery equipment; capacity of reclamation/destruction facilities in-country; high costs of transport and reclamation relative to the resale value of reclaimed F-gases; and lack of awareness regarding where and how to send used F-gases for reclamation/ destruction.

Recovery of F-gases	€ /kg	
Storage of F-gases	€ /	
Transport of F-gases	€ /km	
Processing of recovered F-gases for reclamation	€ /kg	
Destruction of recovered F-gases	€ /kg	
18. Additional comments regarding the recovery/reclamation/destruction of F-gases throughout the EU-27:		

Thank you for your participation!

Questionnaire on the Reclamation and Destruction of F-Gases from the Solvents Sector in the EU-27 during 2004-2007

To be completed by representatives of companies using F-gas solvents

Instructions

Please complete this questionnaire by **16 April 2008**, and return to **Pamela Mathis** at:

Email: ECsurvey_Fgas@icfi.com

Fax: +1.415.677.7177

Address: ICF International
394 Pacific, 2nd Floor
San Francisco, CA 94111

I. Contact Information

Company Name:	
Address:	
Postal Code:	
Country:	
Contact Person:	
Phone Number:	
Fax Number:	
Email Address:	

II. Company Profile

Main Activity/Services:	☐ Commercial/industrial user of solvents ☐ Other (please specify:)
Type of Application:	☐ Metal cleaning ☐ Electronics cleaning ☐ Precision cleaning
Number of Employees:	

III. F-Gas Recovery

1. What were the approximate quantities of F-gases *recovered* for recycling, reclamation, destruction, or storage by your company during 2004-2007? While data on quantities of F-gases recovered may not be readily available, please complete the table below approximating as best as possible.

F-Gas Type	Kilogrammes of Recovered F-Gas Collected			
	2004	2005	2006	2007
HFCs				
PFCs				

2. Approximately what percent of F-gases recovered by your company during 2004-2007 was recycled vs. reclaimed vs. destroyed?

F-Gas Type	Recycled	Reclaimed	Destroyed
HFCs	%	%	%
PFCs	%	%	%

If the above percentages varied significantly by year from 2004-2007, please explain:

If the above percentages varied significantly by F-gas type, please explain:

3. For how long on average is recovered F-gas stored on-site prior to it being recycled, reclaimed, or destroyed?

4. Which of the following best characterises the state of F-gas recovery among your national industry historically (2004-2007) and currently (since Regulation (EC) No 842/2006)?

Historical Recovery Levels (2004-2007):

- ☐ > 95% recovery rate; F-gas recovery is the industry standard
- ☐ 75% recovery rate; the majority of industry recovers
- ☐ 50% recovery rate; roughly half of the industry recovers
- ☐ 25% recovery rate; some of the industry recovers
- ☐ <10% recovery rate; a very small share of the industry recovers

Current Recovery Levels:

- ☐ > 95% recovery rate; F-gas recovery is the industry standard
- ☐ 75% recovery rate; the majority of industry recovers
- ☐ 50% recovery rate; roughly half of the industry recovers
- ☐ 25% recovery rate; some of the industry recovers
- ☐ <10% recovery rate; a very small share of the industry recovers

IV. F-Gas Reclamation

5. Between 2004 and 2007, did your company send F-gases off-site for reclamation?

☐ Yes
If Yes, please complete the remainder of this Section.

☐ No
If No, please skip to Section V.

6. Please indicate quantities of F-gases sent off-site (i.e., to a second party) for reclamation during 2004-2007.

F-Gas Type	Specific F-Gas Type	Kilogrammes Sent Off-Site for Reclamation			
		2004	2005	2006	2007
HFCs	HFC-365mfc				
	HFC-4310mee				
	Other (specify:)				
	Other (specify:)				
PFCs	Perfluoropentane (C_5F_{12})				
	Perfluorohexane (C_6F_{14})				
	Other (specify:)				
	Other (specify:)				

7. Please provide contact information for the second party(ies) reclaimer(s).

Name of Reclaimer:
Email Address:
Mailing Address:
Contact information for additional reclaimers:

8. Were any F-gases reclaimed on-site by your company during 2004-2007?

☐ Yes
If Yes, please specify quantities by F-gas type:

☐ No

V. F-Gas Destruction

9. Between 2004 and 2007, did your company send F-gases off-site (to a second party) for destruction?

☐ Yes
If Yes, please complete the remainder of this Section.

☐ No
If No, please skip to Question 12.

10. Please indicate quantities of F-gases sent off-site for destruction during 2004-2007.

F-Gas Type	Specific F-Gas Type	Kilogrammes Destroyed Off-Site			
		2004	2005	2006	2007
HFCs	HFC-365mfc				
	HFC-4310mee				
	Other (specify:)				
	Other (specify:)				
PFCs	Perfluoropentane (C_5F_{12})				
	Perfluorohexane (C_6F_{14})				
	Other (specify:)				
	Other (specify:)				

11. Please provide contact information for the destruction company/ies.

Name of destruction company:
Email Address:
Mailing Address:
Contact information for additional destruction facilities:

12. Were any F-gases destroyed on-site by your company during 2004-2007?

☐ Yes
If Yes, please specify quantities by F-gas type:

☐ No

VI. Challenges
13. What, if any, barriers exist in the EU-27 that hinder F-gas recycling, reclamation and destruction today? Please be as specific as possible in describing perceived barriers.[55]
Barriers to RECYCLING
Barriers to RECLAMATION
Barriers to DESTRUCTION
14. Do you have any suggestions for overcoming the barriers indicated above, so that future levels of F-gases recovered for recycling, reclamation, and destruction can be increased?
15. Additional comments regarding the recovery/reclamation/destruction of F-gases throughout the EU-27:

Thank you for your participation!

[55] Barriers may be legal, logistical, economic, or informational in nature. Examples may include: laws related to the collection, treatment, and/or trade of used F-gases and the associated burden of paperwork; insufficient recovery equipment; capacity of reclamation/destruction facilities in-country; high costs of transport and reclamation relative to the resale value of reclaimed F-gases; and lack of awareness regarding where and how to send used F-gases for reclamation/ destruction.

Key Qualitative Information on F-Gas Recovery from the Refrigeration/Air-Conditioning (RAC) Sector in the EU-27 during 2004-2007

Contact Information	
Company Name:	
Address:	
Contact Person:	
Phone Number:	
Email Address:	

Company Profile	
Main Activity/Services:	☐ Large commercial/industrial user of refrigeration/AC equipment ☐ Refrigeration/AC servicing company ☐ Refrigeration/AC equipment disposal/decommissioning company ☐ Refrigeration/AC equipment manufacturer
Type of Equipment (refrigeration/ air-conditioning sector):	☐ Stationary (specify:) ☐ Mobile (specify:)
Number of Employees:	

For Large RAC Users, Servicing Companies, Equipment Disposal/Decommissioning Companies:

1. Once refrigerant is recovered, what is typically done with it (e.g., recycled, reclaimed, destroyed)? If you have any information regarding quantities of refrigerant recycled, reclaimed or destroyed, please provide it.

2. How would you characterise the state of refrigerant recovery among your national industry both before and after implementation of Regulation (EC) No 842/2006? For example, is refrigerant recovery universally practiced, somewhat common, or generally rare among the industry, and how has this changed over time? Please respond in your own words or by checking the appropriate boxes below.

   Note: "recovery rate" should be interpreted as the percent of jobs across the industry from which refrigerant is recovered.

Historical Recovery Levels (2004-2007):	Current Recovery Levels:
☐ > 95% recovery rate - refrigerant recovery is the industry standard	☐ > 95% recovery rate - refrigerant recovery is the industry standard
☐ 75% recovery rate - the majority of industry recovers from every job	☐ 75% recovery rate - the majority of industry recovers from every job
☐ 50% recovery rate – most of the industry recovers where feasible, typically from larger equipment only	☐ 50% recovery rate – most of the industry recovers where feasible, typically from larger equipment only
☐ 25% recovery rate - some of the industry recovers from larger equipment only	☐ 25% recovery rate - some of the industry recovers from larger equipment only
☐ <10% recovery rate - a small share of the industry recovers where feasible	☐ <10% recovery rate - a small share of the industry recovers where feasible
☐ Other? Please describe:	☐ Other? Please describe:

For Large RAC Users, Servicing Companies, Equipment Disposal/Decommissioning Companies:
3. What, if any, barriers have historically hindered F-gas refrigerant recycling, reclamation and/or destruction in the EU-27? Have these barriers continued to pose a problem since the enactment of Regulation (EC) No 842/2006?

For Equipment Manufacturers:
1. What is done to maximise F-gas recovery during the manufacturing process (i.e., to minimise emissions)?
2. Have you implemented any changes to improve F-gas recovery rates since the enactment of Regulation (EC) No 842/2006? If so, please explain.
3. Does your company recover any refrigerant from the equipment you produce (e.g., through a producer responsibility scheme)? If so, please respond to questions 1, 2, and 3 in the section above.

Key Qualitative Information on F-Gas Recovery from the Solvents Sector in the EU-27 during 2004-2007

1. Once F-gases are recovered, what is typically done with them (e.g. recycled, reclaimed, destroyed)? If you have any information regarding quantities of F-gases recycled, reclaimed or destroyed, please provide it.

2. How would you characterize the state of F-gas recovery among your industry both before and after implementation of Regulation (EC) No 842/2006? For example, is recovery universally practiced, somewhat common, or generally rare among the industry, and how has this changed over time? Please respond in your own words or by checking the appropriate boxes below.

Historical Recovery Levels (2004-2007):	Current Recovery Levels:
☐ > 95% recovery rate - recovery is the industry standard	☐ > 95% recovery rate - recovery is the industry standard
☐ 75% recovery rate - the majority of industry recovers from every job	☐ 75% recovery rate - the majority of industry recovers from every job
☐ 50% recovery rate – most of the industry recovers where feasible, typically from larger equipment only	☐ 50% recovery rate – most of the industry recovers where feasible, typically from larger equipment only
☐ 25% recovery rate - some of the industry recovers from larger equipment only	☐ 25% recovery rate - some of the industry recovers from larger equipment only
☐ <10% recovery rate - a small share of the industry recovers where feasible	☐ <10% recovery rate - a small share of the industry recovers where feasible
☐ Other? Please describe:	☐ Other? Please describe:

3. What, if any, barriers have historically hindered F-gas recycling, reclamation and/or destruction in the EU-27? Have these barriers continued to pose a problem since the enactment of Regulation (EC) No 842/2006?

Key Qualitative Information on F-Gas Recovery from the Fire Protection Sector in the EU-27 during 2004-2007

For Fire Protection Equipment Users, Servicing Companies, Equipment Disposal/Decommissioning Companies:

1. Once F-gases are recovered, what is typically done with them (e.g. recycled, reclaimed, destroyed)? If you have any information regarding quantities of F-gases recycled, reclaimed or destroyed, please provide it.

2. How would you characterize the state of F-gas recovery among your industry both before and after implementation of Regulation (EC) No 842/2006? For example, is recovery universally practiced, somewhat common, or generally rare among the industry, and how has this changed over time? Please respond in your own words or by checking the appropriate boxes below.

Historical Recovery Levels (2004-2007):	Current Recovery Levels:
☐ > 95% recovery rate - recovery is the industry standard	☐ > 95% recovery rate - recovery is the industry standard
☐ 75% recovery rate - the majority of industry recovers from every job	☐ 75% recovery rate - the majority of industry recovers from every job
☐ 50% recovery rate – most of the industry recovers where feasible, typically from larger equipment only	☐ 50% recovery rate – most of the industry recovers where feasible, typically from larger equipment only
☐ 25% recovery rate - some of the industry recovers from larger equipment only	☐ 25% recovery rate - some of the industry recovers from larger equipment only
☐ <10% recovery rate - a small share of the industry recovers where feasible	☐ <10% recovery rate - a small share of the industry recovers where feasible
☐ Other? Please describe:	☐ Other? Please describe:

3. What, if any, barriers have historically hindered F-gas recycling, reclamation and/or destruction in the EU-27? Have these barriers continued to pose a problem since the enactment of Regulation (EC) No 842/2006?

For Equipment Manufacturers:

1. Has your company implemented any changes (e.g., to manufacturing processes or personnel practices/ training) to improve F-gas recovery rates since the enactment of Regulation (EC) No 842/2006?

2. Does your company recover any F-gases from the equipment you produce (e.g., through a producer responsibility scheme)? If so, please respond to questions 1, 2, and 3 in the section above.

Annex B: List of Industry Associations Contacted for this Study

F-Gas Sector	Associations Contacted
Stationary Refrigeration/AC	• Confederation of the Food and Drink Industries of the European Union (CIAA) • European Cold Storage and Logistics Association (ECSLA) • Air Conditioning and Refrigeration Industry Board (ACRIB) • Air Conditioning and Refrigeration European Association (AREA) • Domestic Appliance Service Association (DASA) • International Institute of Refrigeration (IIR) • Transfrigoroute International • Heating and Ventilating Contractors' Association (HVCA) • Verband der Automobilindustrie e.V. (VDA) • European Partnership for Energy and the Environment (EPEE) • Swedish Refrigeration Foundation (KYS)
Mobile Refrigeration/AC	• Motor Cabin Air Conditioning Committee (MCACC) • European Automobile Manufacturers Association (ACEA) • MAC Partners Europe • European Council for Motor Trades and Repairs (CECRA)
Switchgear	• Coordinating Committee for the Associations of Manufacturers of Industrial Electrical Switchgear and Control gear in the European Union (CAPIEL) • Association of the electricity industry in Europe (EURELECTRIC) • International Council on Large Electric Systems (CIGRE) • Energy Networks Association
Solvents	• European Chlorinated Solvents Association (ECSA) • European Federation of Chemical Distributors (Europe) • European Council of the Paint, Printing Ink and Artists' Colours Industry (CEPE) (Europe) • European Chlorinated Solvents Assn (Europe) • European Technical Association for Protective Coatings (ETAPC) (Europe) • Association of European Adhesives Manufacturers (FEICA)(Europe) • Association of the Austrian Chemical Industry (Austria) • Bulgarian Chamber of Chemical Industry (Bulgaria) • Association of Chemical Industry (Czech Republic) • Federation of Estonian Chemical Industry (Estonia) • Chemical Industry Federation of Finland (Finland) • Association of the Dutch Chemical Industry (ADCI) (Netherlands) • Chemical Industries Association (CCIS) (Slovenia) • Spanish Chemical Industry Association (FEIQUE) (Spain) • Solvents Industry Association (UK) • British Chemical Distributors and Traders Association (UK) • British Coatings Federation (UK) • ReSolv (UK) • SCHP (Czech Republic) • European Solvents Industry Group (Belgium) • Solventis BVBA (Belgium) • Solventis Ltd (UK) • Mayeri Industries AS (Estonia) • Esto Cheb (Czech Republic) • FASS (Czech Republic) • Other national associations or individual companies to be identified through MS

Annex C: List of F-Gas Reclamation Facilities

Reclamation Facility	Member State
AVE Beteiligungsverwaltungs-GesmbH	Austria
NÖ Kühlgeräte Entsorgungsges.mbH	Austria
Saubermacher DienstleistungsAG	Austria
Chemogas	Belgium
COGAL	Belgium
Mebrom	Belgium
Cool Star	Bulgaria
Institute of Refrigeration & Air Conditioning JSC	Bulgaria
EKOTEZ spol. s.r.o.	Czech Republic
Esto Cheb, s.r.o.	Czech Republic
KaS, s.r.o.s	Czech Republic
Estonian Environmental Research Centre	Estonia
Avantec	France
CALORIE FLUOR (ex CALORIE)	France
CREALIS	France
GAZECHIM FROID	France
PDR	Germany
RCN Chemie Gmbh	Germany
Solvay Fluor	Germany
TEGA	Germany
Westfalen	Germany
Első Vegyi Industria	Hungary
Boz Carta Snc	Italy
Ecocentro SpA	Italy
ECOEL SRL	Italy
ECOPOLIS 2000 SRL	Italy
Eureco Srl – European Ecology International	Italy
FG Soc. Coop. Arl	Italy
General Gas	Italy
Guido Tazzetti & C. S.p.A	Italy
Metalchem Bertelli Srl	Italy
Puli Ecol Recuperi Srl	Italy
RESIT SRL	Italy
SIRA	Italy
Tazzetti Fluids	Italy
Tred Livorno SpA, Tred Sud Srl, and Tred Carpi Srl	Italy
Thermo King	Ireland
SuperDreckskëscht® fir Betriber	Luxembourg
Coolrec	The Netherlands
Eco-collect (part of Climalife/DeHon)	The Netherlands
Uniechemie	The Netherlands
PROZON Foundation (Fundacja Ochrony Warstwy Ozonowej)	Poland
ABC Klima, sro	Slovakia
Chladenie, sro	Slovakia
LTH Škofja Loka d.d.	Slovenia

Reclamation Facility	Member State
Friogas SA	Spain
Gas Servei	Spain
Kimical	Spain
A-Gas UK Ltd	UK
BOC Ltd	UK
Harp International Ltd	UK

Annex D: List of F-Gas Destruction Facilities

Destruction Facility	Member State
Fernwärme Wien GmbH – EBS	Austria
COGAL	Belgium
EKOTEZ spol. s.r.o.	Czech Republic
SPOVO, a.s.	Czech Republic
Cleanodan A/S	Denmark
Dan-Rens I/S	Denmark
Kommunekemi A/S	Denmark
Estonian Environmental Research Centre	Estonia
Ekokem Oy Ab	Finland
SIAP	France
SITA	France
Tredi-Groupe Séché	France
KSR GmbH	Germany
RCN Chemie Gmbh	Germany
Solvay Fluor	Germany
Ecomissio Trading and Servicing Ltd.	Hungary
Első Vegyi Industria	Hungary
Észak-Magyarországi Környezetvédelmi Kft	Hungary
Győri Hulladékégetõ Kft. (Waste Incinerator Ltd, Győr)	Hungary
ONYX Magyarország	Hungary
Boz Carta Snc	Italy
Ecocentro SpA	Italy
ECOEL SRL	Italy
ECOPOLIS 2000 SRL	Italy
Eureco Srl – European Ecology International	Italy
FG Soc. Coop. Arl	Italy
Guido Tazzetti & C. S.p.A	Italy
Metalchem Bertelli Srl	Italy
Puli Ecol Recuperi Srl	Italy
RESIT SRL	Italy
SIRA	Italy
Tred Livorno SpA, Tred Sud Srl, and Tred Carpi Srl	Italy
Akzo Nobel Chemicals bv	The Netherlands
AVR Industrial Waste	The Netherlands
BTC bv	The Netherlands
Coolrec	The Netherlands
Eco-collect (part of Climalife/DeHon)	The Netherlands
Fecupral, spol sro	Slovakia
IEA (International Energy Agency) Heat Pump Centre	Sweden
SAKAB AB	Sweden
Scan Arc Plasma Technologies AB	Sweden
BOC Ltd	UK
Dalkeith Demolition Ltd./International Waste Management Group	UK
Dascem - Europe Ltd.	UK

Destruction Facility	Member State
EMR	UK
Harp International Ltd	UK
Ineos Fluor Ltd	UK
Overton Recycling	UK
P&O Transeuropean Ltd.	UK
PyrosEnvironmental Ltd	UK
Refrigerant Solution	UK
Shanks Waste Solutions	UK
Shore Recycling Ltd.	UK
Technowaste Ltd.	UK
Veolia Environmental Services	UK