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EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Fifty-fourth Meeting
Montreal, 7-11 April 2008

FINAL DRAFT OF THE STUDY ON THE COLLECTION AND TREATMENT OF UNWANTED OZONE-DEPLETING SUBSTANCES IN ARTICLE 5 AND NON-ARTICLE 5 COUNTRIES

PREPARED BY ICF INTERNATIONAL

1. At its Eighteenth Meeting, the Parties to the Montreal Protocol took decision XVIII/9 on the “Review of draft terms of reference for case studies called for under decision XVII/17 on environmentally-sound destruction of ozone-depleting substances”, as follows:

> “1. To request the Executive Committee to develop consolidated terms of reference taking into account the elements referred to in both the draft terms of reference submitted to the Eighteenth Meeting of the Parties pursuant to decision XVII/17 and the terms of reference developed by the Multilateral Fund secretariat on the collection, recovery, recycling, reclamation, transportation, and destruction of unwanted ozone-depleting substances;
>
> 2. To request the Executive Committee to conduct, as soon as possible, a study based on the resulting terms of reference and to provide a progress report to the Nineteenth Meeting of Parties, with a final report for consideration at the twenty-eighth meeting of the Open-ended Working Group;”

2. The 50th Meeting of the Executive Committee further developed the existing draft terms of reference, contained in its decision 50/42, and requested the Multilateral Fund Secretariat to develop specific terms of reference for a study on the treatment of unwanted ozone-depleting substances, to identify a contractor and to commission the study. As a result of the tender process, the contract has been awarded to ICF International.

3. This document presents the related draft report of ICF international entitled “Study on the Collection and Treatment of Unwanted Ozone-Depleting Substances in Article 5 and Non-Article 5 Countries”.

4. The report will be finalised after the 54th Meeting of the Executive Committee, and will then be forwarded through the Ozone Secretariat for consideration at the Open-Ended Working Group, as requested in decision XVIII/9 of the Meeting of the Parties.

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Study on the Collection and Treatment of Unwanted Ozone-Depleting Substances in Article 5 and Non-Article 5 Countries

Draft Report

March 2008

Prepared by
ICF International

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Executive Summary

Over 190 countries have signed the Montreal Protocol, adopting phase-out schedules for the production and consumption of ozone-depleting substances (ODS). However, many stocks of ODS exist worldwide, such as those held by industrial and commercial users, stored in containers, and installed in old refrigeration and air-conditioning equipment. Indeed, the Intergovernmental Panel on Climate Change in collaboration with the Technology and Economic Assessment Panel (IPCC/TEAP 2005) estimates that there were approximately 5.2 million metric tons of ODS in global banks in 2002. Of these banks, the Montreal Protocol's Technology and Economics Assessment Panel (TEAP) estimates that 1 million metric tons were available for recovery and destruction (TEAP 2002a). To prevent harmful emissions of ODS, which are also potent greenhouse gases, it is critical that unwanted ODS be properly recovered and ultimately destroyed. However, in managing stocks of unwanted ODS, countries faces many challenges, including informational, economic, logistical, and legal barriers. This is especially true in Article 5 countries, where resources are more limited.

The overall objective of this study is to obtain comprehensive knowledge from non-Article 5 countries to be used as a guide by Article 5 countries in establishing appropriate management systems for the treatment of unwanted ODS. The report aims to provide insight into the relevant framework conditions (cultural, legal and economic) under which different approaches have been established in non-Article 5 countries, and how these conditions and lessons learned may apply to Article 5 countries that may decide to adopt similar practices. In addition, the report aims to provide comprehensive understanding of the challenges faced by Article 5 countries vis-à-vis the destruction of ODS (both in bulk and in equipment), and how such challenges may influence the successful application of non-Article 5 ODS destruction strategies in Article 5 countries.

To do so, this study assesses ODS management programs and procedures in place in the following nine countries: Australia, Canada, the Czech Republic, Colombia, Germany, India, Japan, the United Kingdom, and the United States. The findings presented in this report are based on a desk study, questionnaires, and field visits that were conducted in November through December of 2007.

Program Approaches

In the two Article 5 countries reviewed in this report—Colombia and India—the management of used/unwanted ODS is still in its nascent stage, with initial programs for training technicians and disbursing ODS recovery equipment underway, but procedures for the collection, reclamation, and destruction of ODS are not yet established. In the non-Article 5 countries whose practices were reviewed for this report, ODS management strategies have been developed and are being carried out with varying levels of success. All have passed a ban on the venting of ODS and have required the licensing of technicians that work with ODS (at least those in the refrigeration/AC sector). Additionally, some countries have established standards for the recovery of refrigerant and foam from appliances at disposal and/or implemented special requirements to address the commercial refrigeration/AC sector. The legislative approaches of the non-Article 5 case study countries are summarized in Exhibit ES-1.

Exhibit ES-1: Comparison of Legislative Approaches in Non-Article 5 Case Study Countries

Country	Ban on Venting ODS Refrigerants	License/ Certification Required for Refrigeration/ AC Technicians	Commercial Refrigeration/AC Equipment		Domestic Refrigerated Appliances		
			Explicit Requirement to Recover Refrigerant Prior to Building Demolition	Reporting Requirements for Refrigerant Recovery Operators in the Commercial Sector	Foam Recovery Required at Appliance Disposal	Standard for Refrigerant Recovery at Appliance Servicing and Disposal	Standard for Foam Recovery at Appliances Disposal
Australia	✓	✓					
Canada	✓	✓					
Czech Rep.	✓	✓			✓		
Germany	✓	✓			✓	✓	✓
Japan	✓	✓	✓	✓	✓ [a]	✓	
UK	✓	✓			✓	✓	✓
US	✓	✓				✓	

[a] Japan requires the recovery of all fluorocarbons, not just ODS, during the disposal of appliances
[b] Industry (not regulatory) standards apply to the recovery of refrigerant in Japan.

In addition to the regulatory approaches noted above, many of the non-Article 5 case study countries have implemented a range of other approaches to collect and dispose of unwanted ODS. In particular:

Domestic Appliance Disposal –The three European Community countries and Japan have passed laws requiring producer responsibility programs, mandating the recovery of both refrigerant and foam ODS. The US has launched a voluntary partnership program to properly recycle refrigerators and recover ODS refrigerant and foam.

Bulk ODS Disposal –Australia and Canada have implemented producer responsibility programs in which rebates are provided for the return of used refrigerant; the collected refrigerant is destroyed.

Mobile Air Conditioners –Japan has passed a law requiring the recovery and destruction of fluorocarbons from MACs, as well as the recycling of parts at vehicle end of life. In response, industry has implemented a recycling program under which end of life vehicles are sent to registered recovery operators, who recover ODS and are paid based on the number of MACs and quantity of refrigerant recovered.

Halon Banking – In the three European Community countries and Australia, the use of halons is banned in all non-critical uses, while the US and Japan allow its use in existing systems until 2017. Many countries have established central halon banks, where halon is purified and stored for critical use or destruction. Critical uses are generally closely monitored in order to prevent misuse. Specifically, Australia, Canada, the Czech Republic, Japan, the US, and the UK all have established halon banks of some form.

Key Findings

The key findings derived based on the desk study, country visits, and country questionnaires reflect lessons learned in non-Article 5 countries that may be applicable for the management of unwanted ODS in Article 5 countries, as well as factors that may be important for Article 5 country governments to consider when creating a strategy for managing unwanted ODS. These factors include the country's size, economy, regulatory frameworks, institutional capacity, geography, population, transportation infrastructure, and awareness of environmental issues. The major findings of the study are:

- The experience of the countries assessed in this study shows that regulations are necessary for any ODS management scheme, but are not sufficient to ensure the proper disposition of ODS, be it wanted or unwanted. The success of regulations is closely tied to (a) industry outreach to build a strong base of support among stakeholders, (b) education/training to ensure that requirements are understood, and (c) enforcement structures (including incentives to recover and disincentives for not doing so) to ensure compliance.
- In developing a strategy for managing unwanted ODS, several scoping decisions must be made at the country level, including those related to: (1) whether to recover ODS refrigerant alone or to also recover ODS blowing agents in foam; (2) which sectors to include, since not all equipment types lend themselves equally to cost-effective ODS recovery; and (3) whether to develop capabilities for reclamation and/or destruction of collected non-recyclable ODS.
- The cost of unwanted ODS recovery and reclamation or destruction is a primary obstacle in achieving better ODS management in Article 5 countries. Namely, it is difficult to impose burdensome requirements on developing or struggling economies. Thus, generating cash flow by creating economic incentives for recovery, reclamation, and destruction is vital to the success of a used/unwanted ODS management strategy.
- Country geography and infrastructure are key considerations in developing unwanted ODS management strategies, as much of the effort and cost of reclaiming or destroying ODS is a result of transportation needs. The establishment of bulk ODS or appliance collection programs beyond urban areas may not be economically viable or beneficial from an environmental (climate) perspective.
- Exporting ODS for destruction often can lead to delays, backlog issues, and administrative complications with international conventions (e.g., Basel). For countries with large quantities of unwanted ODS, the best option may be to pursue destruction and/or reclamation options domestically. For cost efficiency, upgrading existing destruction facilities can help reduce the burden associated with developing an "unwanted ODS" management scheme. For countries with smaller quantities of unwanted ODS, new facilities will not be cost-effective to build or operate, and so export requirements need to be clarified and streamlined.

Recommendations

Based on the experiences and lessons learned from the seven non-Article 5 countries and two Article 5 countries reviewed in this study, there are a number of approaches and program designs that can be adopted to achieve success. While the "recipe" for success will depend on unique country circumstances, overarching recommendations that apply to all countries are listed below. Ultimately, it must be recognized that the term "unwanted" ODS is relative; although "unwanted" ODS materials largely pose a burden to Article 5 countries in terms of their ultimate disposition, they can in fact have value. Realizing and extracting the value in "unwanted" ODS is critical for stimulating their recovery and cost-effective disposition.

Scope of Unwanted ODS Management

1. Article 5 countries should target specific sectors for ODS recovery/reclamation/destruction, since such activities may not be financially viable in all sectors. The best targets are those sectors where the greatest amounts of locally unwanted ODS exist, and/or where most control can be exerted on stakeholders. Because of the high demand for halon worldwide and the nature of the fire protection sector (i.e., relatively few players, generally high industry standards for responsible use), the refrigeration/AC and appliance foam sectors warrant the most attention in terms of developing ODS

end-of-life management strategies in Article 5 countries.[1] In particular, commercial sector applications, especially those where individual facilities comprise a large installed base, are likely to be some of the most cost effective opportunities.

2. Any management schemes that address refrigerant, foam, and/or halon should address all substances—i.e., ODS and HFCs—to maximize environmental benefit and ensure long-term sustainability of any programs and markets that are developed on their basis. Specifically, the facilities and procedures developed to handle ODS are largely applicable to the high-GWP HFCs.

Regulations, Enforcement, and Education

3. Countries should enact regulations that specifically prohibit venting of ODS and require the use of recovery equipment (at least in key sectors); a legal mandate is needed for any ODS management scheme, regardless of the type selected (e.g., even product stewardship schemes), to ensure a level-playing field. However, if regulation is selected as the primary means for managing ODS (e.g., if end-users are held legally responsible for ensuring proper destruction of unwanted ODS with no accompanying market-based incentives or producer responsibility regimes to organize/facilitate the process), a strong enforcement regime is needed, particularly if cost dynamics may be a disincentive for compliance.

4. Technician certification in the refrigeration and air conditioning sector should be mandatory. Linking certification/licensing to refrigerant purchase has been highly successful means for ensuring the training of technicians in the servicing sector in non-Article 5 countries. It is also important to provide training and conduct outreach efforts for those who deal with equipment at end of life; in many Article 5 countries, training may be most needed for scrap metal collectors. Such training should be addressed under Phase-out Management Plans (including TPMPs) or through HCFC Phase-out activities.

5. In any unwanted ODS management approach, accountability is key; the program must balance the need for recordkeeping/reporting requirements with the administrative burden that these requirements will entail. At a minimum, reclamation companies, destruction facilities, and appliance demanufacturing facilities should record and report data to ensure best practices and allow for program success to be tracked and improved, as needed. Such reporting would provide significant benefit by allowing government and industry to assess national trends and implement policy or programmatic changes needed to increase recovery or plant efficiency.

Program Funding and Economic Incentives

6. It is critical that recovery and reclamation/destruction not impose a cost burden on end-users. At the most basic level, end-users should not have to pay for reclamation/destruction. Creating economic incentives—or at the very least removing disincentives—is important for the success of an unwanted ODS management strategy. For example, countries could consider offering a rebate on the return of used ODS, but must have sufficient monitoring and enforcement to ensure that this does not lead to problems, such as illegal ODS imports or fraudulent return of non-ODS substances. In order to provide these incentives, however, funding will be needed.

7. Such funding options currently being used in non-Article 5 countries include ODS levies (e.g., tax per kg of refrigerant imports/production), municipal taxes, and taxes on new equipment. In addition, new funding options should be pursued at the international level in the form of (a) direct assistance to

[1] The experience with halon in both non-Article 5 and Article 5 countries is an example of how economic value can drive recovery if incentives are realized.

Article 5 countries from the Multilateral Fund (MLF), and/or (b) through the Clean Development Mechanism (CDM) or other carbon trading platforms—if credits are issued for ODS destruction using an approved methodology. Currently, neither the MLF nor the CDM have mandates to conduct these activities; the MLF is mandated to fund only the phaseout of ODS consumption and production, not disposal; and the CDM is mandated to only accept projects that reduce emissions of chemicals listed in Kyoto's "basket" of chemicals, which does not include ODS. Therefore, the mandates of the MLF and the CDM should be reviewed and extended to promote the safe disposal of unwanted ODS. In the case of the MLF, consideration may need to be given to include ODS disposal in its mandate and, potentially, broader chemical management issues. For example, in countries where an ODS-containing appliance decommissioning program is appropriate, e.g., in countries with more than 1 million refrigerators disposed per year, the MLF could consider funding incremental costs associated with the removal and destruction of appliance refrigerant and foam, with co-funding from local industry, government, and/or other multilateral organizations. A combination of new and existing approaches could be used; for example, funds could be used to cover the incremental costs of refrigerant/foam recovery at an appliance recycling facility in an Article 5 country, while recycling fees can be placed on new appliances at the time of purchase to fund annual recycling activities, and revenue from carbon credits (earned through ODS destruction) could be used to finance the disposal of older appliances for which no recycling fee has been collected. Other innovative market-based mechanisms may also be possible, such as the allocation of new ODS "production credits" based on a certain ratio of ODS destruction, while allowing such production credits to be sold if they are not needed in-country. For example, a country that destroys 1,000 metric tons of CFC-12 could earn credit to produce a certain lesser amount of another ODS (e.g., HCFC-22) or sell such production credits to another country that is willing to pay for it. A working group should be established to pursue these ideas.

8. Should the mandate of the CDM or other carbon trading platforms be extended to include ODS destruction, methodologies for ODS destruction for certified emission reductions (CERs) on a GWP-weighted basis should be developed and approved. At least one such methodology has been developed to date. Coordination with the CDM, as well as multilateral/bilateral institutions should be pursued to improve dialogue on these issues. Any such destruction projects should also establish the requirements that may be required for HFC destruction post-2012.

Infrastructure, Equipment, and Geography

9. Recovery equipment and logistics (e.g., containers, transport, storage space) are fundamental to the success of an unwanted ODS management strategy. National collection sites are also needed, as well as access to reclamation and destruction facilities (either in-country, via export, or via mobile units). Very few countries will need their own high-capacity ODS destruction facilities, however, and countries with existing cement kilns may be able to outfit them to handle ODS. Mobile units (operated by private companies) may represent a viable option for destroying locally unwanted ODS, especially for countries that border the sea.

10. The export of ODS for destruction will be the most feasible option for many Article 5 countries, and will require only assistance in rendering Article 5 country governments "Basel-capable." A specific product that may be useful is an outreach communiqué or a newsletter provided through the Multilateral Fund that covers specific interpretation to Article 5 country representatives on an on-going basis. To this end, the Multilateral Fund, its Secretariat, or an appropriate Implementing Agency, might engage in dialogue with the Basel Convention Secretariat to ensure that requirements are clear, categories of wastes and non-wastes are defined, and procedures for export streamlined to the extent feasible.

11. An international "clearinghouse" function could be provided through the Multilateral Fund to match supply with demand by connecting countries requiring ODS destruction to countries that have available capacity—with an effort to minimize transport distances and maximize effectiveness. Comprehensive data would be needed to identify and monitor global destruction capacity, and a web-based platform may be helpful to allow users—be they private companies or country governments—to easily locate nearby destruction facilities able to accept their ODS waste, and provide the necessary tools/resources to facilitate the transaction. By having a global clearinghouse, small quantities can be bulked up for maximum cost-effectiveness. Alternatively, countries with unwanted ODS (in some cases unused stockpiles or reclaimed material) may be able to identify customers willing to purchase such materials for on-going critical uses. Proceeds could then be used to offset other ODS destruction activities or implementation of alternatives.

Producer Responsibility Approaches

12. Producer responsibility schemes, also known as extended producer responsibility or product stewardship schemes, impose accountability over the entire life cycle of products introduced on the market. In the context of ODS, this means that firms that produce, import and/or sell bulk ODS or ODS-containing equipment are required to be financially or physically responsible for such products after their useful life. They must either take back spent products and manage them through reuse, recycling or safe disposal, or delegate this responsibility to a third party. Such schemes can be regulated or voluntary. These programs generally work well when there are few players involved (i.e., producers/importers) to allow for effective organization/management of the scheme. They also work best in countries where there is a strong public, a strong government, or both. Specifically, for voluntary producer responsibility schemes, there must be significant public pressure and/or a credible threat of regulatory action for programs to be successful. For producer responsibility schemes mandated by law, strong government is needed to ensure compliance through verification/enforcement activities and collaboration with industry. For government-mandated producer responsibility schemes, governments may collect fees and/or establish program criteria, but should allow industry to take the lead on setting up and administering programs, with third party auditing. Bottom-line-oriented companies that are familiar with the equipment/products are best suited to establish and run cost-effective programs for meeting the requirements set by national governments. Producer responsibility schemes are most effective when they are supported by a legal mandate, since this creates a level playing field, so that all producers must share the responsibilities and costs.

13. Producer schemes for bulk ODS or ODS-containing appliances should address both ODS and HFCs, for program longevity and maximum environmental benefit, and should require recordkeeping/reporting and routine audits, but avoid over-reporting to minimize burden. In addition, producer responsibility schemes for bulk ODS should ban disposable cylinders to ensure appropriate infrastructure for ODS collection, and should include an option for recycling/reclamation, for example, by building-in incentives for the recovery of unmixed, recyclable/reclaimable used refrigerant that is (or will be) in high demand (e.g., by offering a rebate).

1. Introduction and Purpose

More than 190 countries have now signed the Montreal Protocol, a landmark international agreement to restore the Earth's deteriorating stratospheric ozone layer. The global success of this effort to protect our environment requires that the world's developed (non-Article 5) and developing (Article 5) countries eliminate emissions to the atmosphere of most ozone depleting substances (ODS). Chlorofluorocarbons (CFCs) are some of the most damaging ODS, and their phaseout in Article 5 countries is expected to be achieved by 2010. The production phaseout schedule for Article 5 countries, and for non-Article 5 countries, is shown in Exhibit 1-1.

Exhibit 1-1: Production phaseout schedule of the Montreal Protocol

Ozone Depleting Substance	Non-Article 5	Article 5
Halons	January 1, 1994: full phaseout	January 1, 2010: full phaseout
CFCs	January 1, 1996: full phaseout	January 1, 2010: full phaseout
Carbon tetrachloride	January 1, 1996: full phaseout	January 1, 2010: full phaseout
HBFCs	January 1, 1996: full phaseout	January 1, 1996: full phaseout
Methyl chloroform	January 1, 1996: full phaseout	January 1, 2015: full phaseout
Chlorobromomethane	January 1, 2002: full phaseout	January 1, 2002: full phaseout
Methyl bromide	January 1, 2005: full phaseout	January 1, 2015: full phaseout
HCFCs	January 1, 1996: Freeze at baseline (1989 HCFC levels + 2.8% of 1989 CFC levels)	January 1, 2013: Freeze at baseline (average 2009/2010)
	January 1, 2004: cut by 35%	January 1, 2015: cut by 10%
	January 1, 2010: cut by 75%	January 1, 2020: cut by 35%
	January 1, 2015: cut by 90%	January 1, 2025: cut by 67.5%
	January 1, 2020: cut by 99.5% (can only be used for refrigerator/AC servicing after this date)	January 1, 2030: cut by 97.5%, (can only be used for refrigerator/AC servicing after this date)
	January 1, 2030: full phaseout	January 1, 2040: full phaseout

Source: UNEP 2000, UNEP 2007, UNEP DTIE 2002

However, as CFCs and other ODS are phased out of production, large stocks of equipment containing these substances—especially refrigeration and air-conditioning (AC) equipment—continue to be used worldwide. As these units reach the end of their useful lifetimes, it is critical that any remaining ODS contained in that equipment be fully recovered for recycling/reclamation or destruction.

From a market perspective, the recycling/reclamation of ODS refrigerant will be essential to satisfy after-market servicing demand in Article 5 countries post-2010 (and most importantly to avoid shortfalls). Similarly, the recycling/reclamation of halon from decommissioned systems will be important to satisfy demand for critical use applications. Further, from an environmental perspective, the destruction of any unwanted refrigerant, foam, and halon will be essential to avoid the release of ODS to the atmosphere.

Locally "unwanted" ODS in Article 5 countries can include ODS contained in old equipment or storage containers that no longer has a market value, ODS recovered from equipment that is too contaminated (e.g., mixed ODS) for recycling, or material that cannot be reclaimed in-country due to the lack of reclamation infrastructure. These stocks must be collected worldwide and stored properly to minimize leakage. Subsequently, reclamation or destruction must be undertaken as capacity to do so is developed in country, or alternatively, after approved transfer procedures are followed to allow for the export of ODS to approved reclamation or destruction facilities in other countries. To export unwanted ODS for the purpose of destruction, directives under the Montreal Protocol and other relevant treaties (e.g., Basel

Convention, Bamako Convention, Waigani Convention, Central American Agreement) must be adhered to.

According to the Montreal Protocol's Technology and Economics Assessment Panel (TEAP), 1 million metric tons (MT) of ODS were available for recovery and destruction as of 2002 (TEAP 2002a). With regards to HCFCs, IPCC/TEAP (2005) estimates that global banks of these gases are approximately 2,651,000 MT, and this stockpile is projected to grow significantly.

Stocks of installed and stockpiled ODS are widely distributed around the world. CFCs are found in all Article 5 countries, and halons are found in 63 Article 5 countries. Other ODS are also widely scattered around the globe.

Within any given country, quantities of locally unwanted ODS are likely to be widely scattered as well. For example, domestic refrigerators may each contain a small amount of ODS and are distributed across millions of individual households. In addition to ODS in use in equipment, industrial or commercial facilities may have phased out their use of ODS but may have tanks or cylinders of obsolete materials (virgin or used) in storage, awaiting disposal or reclamation. In some countries, customs officials have confiscated illegal imports of ODS and, depending on national legislation, may be storing tanks or containers indefinitely. In many cases of storage, leakage may be occurring, and over time, substantial losses can be seen, especially when storage is in original containers in locations where temperature and moisture are not controlled (e.g., warehouses, fields).

The purpose of this report is to develop an information resource for Article 5 countries in their efforts to establish appropriate management systems for the treatment of unwanted ODS. To this end, this study assesses the ODS management programs and procedures in place in nine countries (two developing and 7 developed) to provide guidance and perspective on the types of management systems that have been effective (or not) in non-Article 5 countries and which of the historical strategies could potentially be successfully replicated in Article 5 regions, taking into consideration the particular circumstances of Article 5 countries (e.g., geographic size and population, relative amount of ODS, institutional capacity, infrastructure, etc.). The countries reviewed in this report include: Australia, Canada, the Czech Republic, Colombia, Germany, India, Japan, the United Kingdom, and the United States. Based on the successes achieved and challenges faced in these countries, this report provides recommendations as to how Article 5 countries could best handle their stocks of unwanted ODS.

The remainder of the report is organized as follows:

- Chapter 2 provides background information regarding the amount of ODS available for recovery and destruction, including a discussion on barriers to recovery;
- Chapter 3 details the methodologies used to complete this study;
- Chapter 4 provides an overview of approaches implemented in the nine case study countries to manage stocks of used ODS;
- Chapter 5 describes the programs employed to reclaim or destroy used ODS in the five Non-Article 5 case study countries;
- Chapter 6 describes the programs employed to reclaim and destroy used ODS in the two Article 5 case study countries;

- Chapter 7 describes the Basel Convention and other regional conventions affecting the movement of ODS waste;
- Chapter 0 summarizes the major findings of this study;
- Chapter 9 presents recommendations on the management of used and unwanted ODS;
- Appendices A and B provide an in-depth look at the ODS recycling, reclamation, and destruction programs in place in each of the case study countries, organized into Non-Article 5 countries and Article 5 countries;
- Appendix C provides the surveys disseminated to Article 5 and Non-Article 5 countries;
- Appendix D provides a list of individuals that were interviewed for this study;
- Appendix E provides a list of known commercial ODS destruction facilities worldwide, as well as information on destruction technologies, capacities, and costs; and
- Appendix F lists information that is required for reporting shipments under the Basel Convention.

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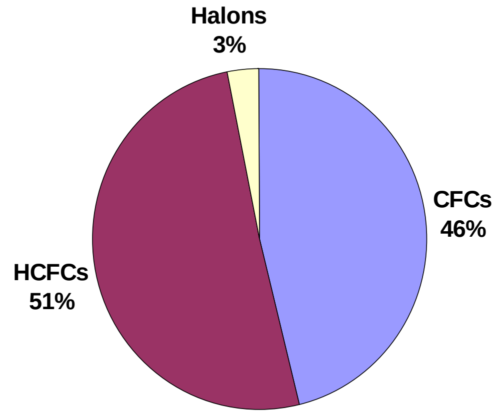
2. Background

The Intergovernmental Panel on Climate Change in collaboration with the Technology and Economic Assessment Panel (IPCC/TEAP 2005) estimates that there were approximately 5.2 million metric tons (MT) of ODS in global banks in 2002. Approximately 40 percent of these banks are installed in the refrigeration and stationary and mobile air conditioning (AC) sector. The remaining 60 percent is found in the foams, medical aerosols, fire protection, and other[2] sectors. As shown in Exhibit 2-1, HCFCs comprise the largest portion of ODS banks.

Exhibit 2-1:
Breakout of ODS Banks in Metric Tons, by ODS Type (2002)



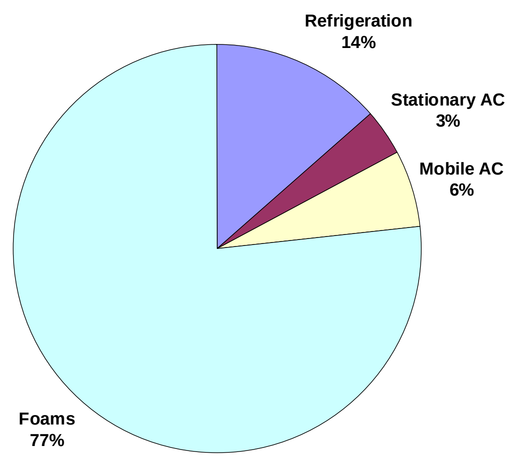
Source: IPCC/TEAP (2005)

Of course, not all of the ODS in banks can be recovered and made available for recycling, reclamation, or destruction. For example, ODS solvents and aerosols may not always be recovered as they are used in emissive applications. Moreover, for those ODS that can be recovered, the feasibility of doing so varies by ODS type/application. Foam blowing agents from buildings and appliances, for example, require a large specific effort to recover, although it can be done in practice.

The largest source of accessible ODS that can most easily recovered is in the refrigeration/AC sector. The Multilateral Fund (2006) estimated that in 2010, the worldwide "reachable" bank of CFCs will comprise 514,652 MT, 50% of which will be refrigerant and 50% will be contained in foams. This will translate into a flow of nearly 23,000 MT of CFCs accessible for recovery per year.

CFCs and HCFCs. According to IPCC/TEAP (2005), in 2002, banks of CFCs were estimated at 2.4 million MT. As shown in Exhibit 2-2, the majority of these banks are found in foams (77 percent).

Exhibit 2-2:
CFC Banks, by Sector (2002)



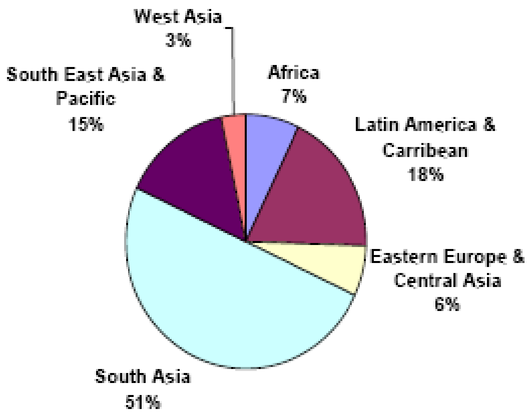
Source: IPCC/TEAP (2005)

According to estimates from the Multilateral Fund (2006), by 2010, there will be 765,000 MT of CFC stocks, with nearly 515,000 MT "accessible" (i.e., technically recoverable) for proper disposal. Already, significant quantities of CFCs are in storage in all Article 5 countries, much of which are contaminated and in need of destruction (an estimated 5.4 MT per Article 5 country, on average). Exhibit 2-3 presents the breakout of CFC banks, by region, estimated to be accessible worldwide in 2010. As shown, the stocks of accessible CFCs are steadily decreasing, which underscores the need to recover and reclaim or destroy CFCs today, before they are lost to the atmosphere. (Multilateral Fund 2006)

[2] "Other" includes solvents but excludes non-medical aerosols.

Exhibit 2-3:
Total Reachable CFC Banks, by Article 5 Region (2010)

Total: 514, 652 MT



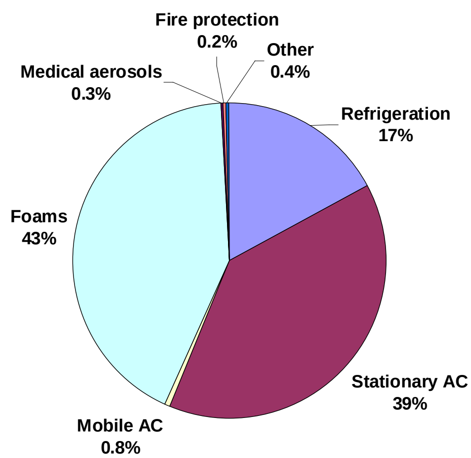
Source: Multilateral Fund (2006).

While CFCs currently comprise the majority of ODS available to be potentially recovered and destroyed in Article 5 countries, there are also significant quantities of HCFCs which will need to be properly handled. IPCC/TEAP (2005) estimated that in 2002, worldwide, banks of HCFCs in all sectors comprised almost 2.7 million MT—of which nearly 60% was installed in the refrigeration/AC sector, as shown in Exhibit 2-4.

Because the Montreal Protocol does not begin to cut the production and consumption of HCFCs in Article 5 countries until 2015, and because new HCFC equipment will continue to be placed on the market until 2030, the quantities of contaminated HCFCs that will need to be properly managed in Article 5 countries will grow for decades to come.

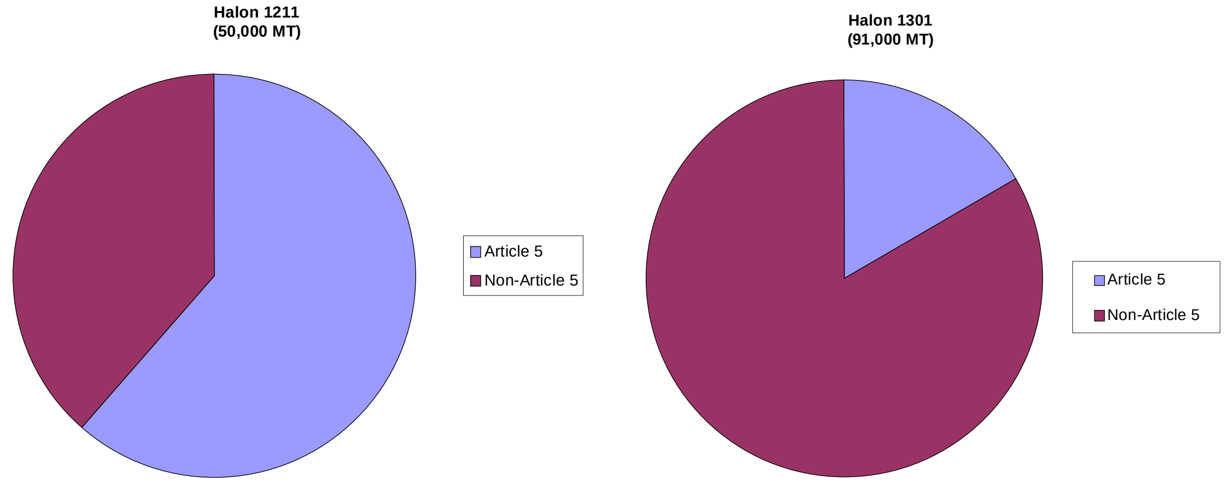
Halons. Halons also represent an important source of ODS that must be properly recovered for reuse or destruction when phased out of fire protection equipment. Halons have high ozone depletion potentials (ODPs) and require a low specific effort to recover. In 2005, global banks of halon 1301 were estimated at 50,000 MT, with 8,380 MT held by Article 5 countries. Global banks of halon 1211 were estimated at 91,000 MT, with 55,894 MT held by Article 5 countries (HTOC 2006). A total of 63 Article 5 countries hold these banks, with an average stock of 2.9 MT per country (Multilateral Fund 2006). As shown in Exhibit 2-5, non-Article 5 countries hold a greater portion of halon 1301 (approximately 83 percent of global halon 1301 banks) while Article 5 countries hold a greater portion of halon 1211 (approximately 61 percent of global halon 1211 banks).

Exhibit 2-4:
HCFC Banks, by Sector (2002)



Source: IPCC/TEAP (2005)

Exhibit 2-5:
Banks of Halon 1301 and 1211 in Article 5 and Non-Article 5 Countries



Source: Multilateral Fund (2006).

By 2010, global halon banks are expected to decline to 48,800 MT (Multilateral Fund 2006), implying some loss due to use, leakage and retirement. It is therefore critical to maintain systems properly to reduce leaks, to make sure they are serviced correctly to minimize emissions, and stored to prevent venting.

2.1 Barriers to Recovery

The proper and efficient recovery and collection of ODS from banks for reuse or destruction is a complex issue that requires a comprehensive solution. A large number of barriers prevent the efficient collection of ODS contained in equipment and in bulk, including barriers that are informational, financial, technological, logistical, and legal in nature.

At the most basic level, persons dealing with ODS—be it in equipment or in bulk—must have an understanding of the environmental hazards posed by ODS, and of the technical means by which to prevent their release to the environment. This requires stakeholder outreach, technician training, and mass education.

Next, tools and infrastructure are needed to recover, transport, store, reclaim and destroy ODS. Additionally, the costs associated with such tools and infrastructure are significant. For example, ODS recovery from domestic appliances requires central collection points, temporary storage facilities, recycling plants, and destruction facilities, as well as transportation between each of the facilities. In some

> End of Life Management
>
> Through the proper decommissioning of ODS-containing equipment and bulk ODS, greater quantities of ODS will be available to reclaim or destroy.
>
> *Household appliances*—When disposing of household appliances (e.g., refrigerators, freezers, and window air conditioners), the refrigerant charge should be properly recovered. In addition, the foam blowing agent should be recovered to the extent possible.
>
> *Bulk ODS*—When disposing of bulk ODS, care should be taken to minimize leakage when transferring ODS between cylinders. Bulk ODS should be reclaimed or destroyed as soon as possible to minimize emissions that typically occur when ODS is held in storage for long periods of time.
>
> *Halon*—When decommissioning fire suppression systems, halons should be properly recovered prior to reclamation or destruction. After recovery, halons should be reclaimed or destroyed as soon as possible to minimize emissions that typically occur when ODS is held in storage for long periods of time.

countries, geographic distribution is a major concern, with some stocks of ODS located in remote locations hundreds of kilometers apart. Previous reports have shown that the cost to recover and recycle foam contained in domestic refrigerators can cost between $10 and $20 per unit—equivalent to $30 to $60 per kilogram of ODS (IPCC/TEAP 2005, TEAP 2002a). (In contrast, historical funding from the Multilateral Fund has typically been capped at $15 per kilogram of ODS phased out on an ODP-weighted basis [TEAP 2002a]). For HCFC-based residential systems, the lower ODP will make these costs even higher on an ODP-weighted basis. Recovery of ODS from building foams is even more complex and expensive.

Construction and operating costs for ODS destruction facilities can also be expensive, representing an obstacle for countries to develop capacity to destroy their own stocks of unwanted ODS. In 1992, UNEP recommended that destruction capacities for pilot plants be at least 10 kg per hour. Assuming that such facilities run for 6,000 hours per year, this would translate into roughly 60 metric tons of ODS destroyed per year by pilot plants. However, to lower the barriers to new plant construction, the TEAP revised this recommendation to a minimum of 1 kg per hour, to allow for smaller, cheaper plants to be constructed and scaled up later, if appropriate. The TEAP notes that mobile units now exist that can destroy hazardous material at rates of 5 kg per hour, which may reduce capital costs of destruction facilities (TEAP 2002b).

Current destruction facilities are believed to have adequate capacity to handle future ODS waste streams (Multilateral Fund 2006). For countries without existing capacity, however, exporting ODS for destruction to other countries presents additional challenges due to international waste conventions. According to TEAP (2002a), all ODS—whether under high pressure or not—is regulated by international hazardous waste conventions. If the ODS is transported under high pressure, it must be labeled and treated as a dangerous substance, adding further transport restrictions.

Finally, several international conventions regulate the international movement of ODS: the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal,*[3] the Central American Agreement, and the Waigani Convention. Under these agreements, parties are generally prohibited from exporting waste to or importing it from non-party countries. In addition, some of the agreements require that extensive administrative procedures be followed prior to exporting waste to another party, which requires a high level of effort and cost. For many countries without adequate institutional capacity, the legal and administrative burdens imposed by these agreements effectively serve as a disincentive for exporting ODS for destruction.

[3] ODS in appliances and in bulk is covered under the Basel Convention's definition Y45 (organohalogen compounds). Additionally, all ecotoxic materials, broadly defined, are covered under section H12.

3. Methodology

The methodology used in conducting this study relied on a desk study, questionnaires, and field visits that were conducted from November–December 2007. Each of these project components are discussed in further detail below.

3.1 Desk Study

As a first step, literature and internet research was conducted to identify reports related to current and future stocks of ODS contained in appliances and bulk ODS, as well as barriers to the proper management and destruction of ODS. The following reports were reviewed:

- IPCC/TEAP Special Report on Safeguarding the Ozone Layer and the Global Climate System (IPCC/TEAP 2005)
- ODS Destruction in the United States (EPA 2007a)
- ODS Destruction in the United States and Abroad (EPA 2007b)
- Report of the Fifteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer (UNEP 2004)
- Report of the Meeting of Experts to Assess the Extent of Current and Future Requirements for the Collection and Disposition of non-Reusable and Unwanted ODS in Article 5 Countries (Multilateral Fund 2006)
- Reports of the UNEP Technology and Economic Assessment Panel:
    - 2002 Report of the Task Force on Destruction Technologies (TEAP 2002b)
    - 2002 Report of the Task Force on Collection, Recovery and Storage (TEAP 2002a)
    - 2006 Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee (RTOC 2006)
    - 2006 Report of the Halons Technical Options Committee (HTOC 2006)
- Revised Report of the Study on ODS Disposal Options in Article 5 Countries (Japanese Ministry of the Environment 2006)
- UNEP DTIE OzonAction Clearinghouse Information Paper: Global Directory of Halon Banks (UNEP DTIE 2006)

Selected technical presentations and workshop proceedings were also reviewed, including:

- "Dealing with Unwanted ODS" presented by Erik Pedersen at the 11th Annual Financial Agents Workshop in Washington, DC (26-27 March 2007) (Pedersen 2007); and
- ODS Recovery and Disposal Workshop Proceedings in Asia and the Pacific Region (6 November 2004) (Japanese Ministry of the Environment 2004.)

In addition, preliminary internet research on legislation and programs related to the management of unwanted ODS was conducted prior to the country visits (discussed further in Section 3.3).

3.2 Questionnaires

After conducting an initial literature review, two sets of questionnaires were developed for Article 5 and non-Article 5 countries, which were disseminated to the nine countries selected for this study: Australia, Canada, the Czech Republic, Colombia, Germany, India, Japan, the United Kingdom, and the United States. These questionnaires were disseminated via email in August 2007 for non-Article 5 countries, and in October 2007 to Article 5 countries.

The non-Article 5 country questionnaire (presented in Appendix C), included two parts; the first (Part A) focused on the collection, handling, and disposal of refrigerated appliances, while the second (Part B) focused on the collection and destruction of unwanted bulk ODS. The surveys solicited information on national regulations, infrastructure and procedures in place, data on recovered ODS, challenges, and lessons learned.

The questionnaire developed for Article 5 countries solicited similar information as that designed for non-Article 5, but with a greater focus on challenges and needs, and less on current infrastructure and practices in place. The questionnaire developed for Article 5 countries is presented in Appendix C as well.

3.3 Country Visits

Country visits were conducted from October 2007 through December 2007 after receiving completed questionnaires from each country. Exhibit 3-1 summarizes the dates of each country visit.

Exhibit 3-1:
Schedule of Country Visits

Country	Visit Occurred
Australia	Early November
Canada	Mid November
Colombia	Early December
Czech Republic	Early November
Germany	Mid November
India	Late December
Japan	Mid November
United Kingdom	Mid November
United States	Mid December

During the country visits, interviews were conducted with government representatives and industry stakeholders. In addition, a variety of facilities relevant to the proper management of ODS were visited, including:

- Appliance recycling plants;
- Refrigerant wholesalers;
- Fluorocarbon destruction facilities;
- Fluorocarbon reclamation facilities;
- Halon banks; and
- MAC recovery operators;

A complete list of individuals interviewed during these visits is provided in Appendix D.

4. Overview of Program Approaches

A number of approaches have been implemented worldwide to manage stocks of used or unwanted ODS. In the two Article 5 countries reviewed in this report—Colombia and India—the management of used/unwanted ODS is still in its nascent stage, with initial programs for training technicians and disbursing ODS recovery equipment underway, but procedures for the collection, reclamation, and destruction of ODS not yet established. For example, India has trained thousands of technicians on a voluntary basis on how to recycle and reclaim refrigerant, and is establishing 27 reclamation centers that are expected to be in operation by 2009. However, there is no mandate to recover ODS at service and disposal (i.e., no venting prohibition), and refrigerant recovery equipment is not widely available. Similarly, in Colombia, legislation effectively introduces a ban on ODS venting and a number of recovery units have been purchased and distributed to technicians, but there is no capacity to centrally store, reclaim, or destroy recovered ODS. Currently, any quantities of ODS recovered by technicians and companies is stored indefinitely on site (at multiple locations); implementing a program to transport such ODS to a central location for destruction or reclamation—either by developing in-country capacity or by exporting it to approved facilities abroad—will entail significant cost. But the *status quo* can lead to environmental harm through slow leakage as well as inadvertent or intentional venting.

In the non-Article 5 countries reviewed in this report—Australia, Canada, Czech Republic, Germany, Japan, the United Kingdom, and the United States—ODS management strategies have been developed and are being carried out with varying levels of success. In the refrigeration/air-conditioning (AC) sector—the most significant ODS sector for the purpose of this report—all of these seven non-Article 5 countries have regulatory frameworks in place that prohibit the venting of ODS refrigerant and mandate the training and certification of personnel working on equipment that contain ODS. These legal requirements establish the basic infrastructure for ODS recovery and treatment by educating key stakeholders about why and how ODS must be safely managed. All of these countries also require certain standards for refrigerant recovery practices and/or refrigerant recovery equipment (e.g., minimum recovery efficiency levels). To enforce these laws, several countries (e.g., Japan, United States) have compliance and verification regimes in place at the government level.

Moreover, several countries reviewed in this study have promulgated regulations to exert control in certain sectors above what most others have done. For example, to increase refrigerant recovery from the commercial sector, Japan requires refrigerant recovery technicians to report annually to prefecture governments on the amount of refrigerant recovered from commercial refrigeration/AC units. Japan also places responsibility and reporting requirements on the construction/demolition industry to check for fluorocarbon refrigerant in buildings before they are demolished or renovated. Similarly, in the domestic appliance sector, Japan and the EU countries mandate the removal and destruction of ODS foam. These legislative approaches are summarized in Exhibit 4-1.

Exhibit 4-1:
Comparison of Legislative Approaches in Non-Article 5 Case Study Countries

Country	Ban on Venting ODS Refrigerants	License/ Certification Required for Refrigeration/ AC Technicians	Commercial Refrigeration/AC Equipment		Domestic Refrigerated Appliances		
			Explicit Requirement to Recover Refrigerant Prior to Building Demolition	Reporting Requirements for Refrigerant Recovery Operators in the Commercial Sector	Foam Recovery Required at Appliance Disposal	Standard for Refrigerant Recovery at Appliance Servicing and Disposal	Standard for Foam Recovery at Appliances Disposal
Australia	✓	✓					
Canada	✓	✓					
Czech Rep.	✓	✓			✓		
Germany	✓	✓			✓	✓	✓
Japan	✓	✓	✓	✓	✓[a]	✓[b]	
UK	✓	✓			✓	✓	✓
US	✓	✓				✓	

[a] Japan requires the recovery of all fluorocarbons, not just ODS, during the disposal of appliances.
[b] Industry (not regulatory) standards apply to the recovery of refrigerant in Japan.

The ODS management approaches employed by the non-Article 5 countries reviewed in this report have varied by ODS sector, and in many cases, have gone beyond command-and-control tactics. As shown in Exhibit 4-2, most countries have applied robust and innovative approaches for collecting and reclaiming/destroying ODS from a particular sector. For example, several countries have implemented product stewardship schemes (PSS) (also known as extended producer responsibility schemes), whereby producers, importers, and/or sellers of bulk ODS or ODS-containing equipment are required to be financially or physically responsible for taking back spent products and managing them through reuse, recycling or safe disposal. In particular, Australia and Canada have developed PSS for the commercial refrigeration/AC sector (i.e., bulk refrigerant), while the EU countries have developed PSS for the domestic appliance sector, and the United States has initiated a voluntary program for the domestic appliance sector. Japan is the only country to implement a PSS in two ODS sectors: domestic appliances and motor vehicles.

Exhibit 4-2:
Non-Regulatory Approaches Employed in the Refrigeration/AC Sector in Non-Article 5 Countries

Country	Bulk Refrigerant (Commercial Sector)	Domestic Appliances	Mobile Air Conditioning (MAC)
Australia	PSS, $$	-	-
Canada	Voluntary PSS, $	-	-
Czech Republic	-	PSS, $	-
Germany	-	PSS, $	-
Japan	-	PSS	PSS
UK	-	PSS, $	-
US	-	Voluntary Program	-

PSS= Product stewardship scheme (mandated by law, unless otherwise stated)
$= financial burden removed from end-user (i.e., zero cost)
$$= financial incentive provided to end-user (i.e., financial gain)

To collect and manage bulk refrigerant, both Australia and Canada have implemented product stewardship schemes for the collection and destruction of ODS, funded through a levy on the production/import of virgin/reclaimed refrigerant. However, these programs differ in several important aspects. First, Australia's program is mandated by law, whereas the scheme in Canada is a voluntary industry initiative[4] (with 95% of industry participating). Second, Australia's program provides a rebate on the return of used refrigerant, whereas Canada's program simply allows technicians to return it at no cost. In addition, Australia's program applies to all fluorocarbon refrigerants, including HFCs, while Canada's program applies exclusively to ODS refrigerants (i.e., CFCs and HCFCs).

The collection and management of ODS from domestic appliances is most tightly controlled in Japan and the EU countries, where producer responsibility schemes are mandated by law. In the Czech Republic, Germany, and the UK, appliance demanufacturing facilities are subject to extensive regulation to ensure maximum ODS recovery efficiency, although regulatory enforcement with such laws varies between member states within the European Community. In Japan, demanufacturing facilities and destruction facilities are inspected multiple times each year to ensure compliance with standards.

In the United States, where laws require the recovery of refrigerant from domestic appliances, a voluntary program has been initiated to ensure compliance with this law and also recover ODS foams. The voluntary program targets retailers, municipalities, utilities, and other entities with potential appliance collection networks (e.g., the military and universities). Benefits of the program for partners range from energy savings and greenhouse gas emission reductions (in the case of utilities and municipalities), to positive branding/green marketing (in the case of retailers). In addition, partners may be eligible for carbon offset credits through the Chicago Climate Exchange (CCX)[5] or other carbon trading platforms. The voluntary program, in place for about one year, has 12 partners that are collectively projected to collect over 1 million refrigerators/freezers per year (roughly 8% of those disposed nationwide) using technologies similar to those in use in Europe and Japan.

Japan is the only country reviewed in this study that has implemented a rigorous program for the collection and reclamation/destruction of refrigerant from the MAC sector. Specifically, Japan requires that disposed vehicles be collected by registered collection operators, transferred to registered recovery operators to remove refrigerant, and then transferred to permitted dismantling and shredding operators. Recovery operators must keep records of the quantities and types of fluorocarbons recovered, and submit annual reports to local governments. A limited liability intermediate corporation was established by industry to ensure vehicles and fluorocarbons from MACs are disposed of in an environmentally safe and economical manner. Vehicle recycling operations are funded in part by consumers who must pay a fee at the time of vehicle purchase; for consumers with vehicles purchased prior to the enactment of the law (in 2005), they must pay the vehicle recycling fees at the time of periodic vehicle inspection/re-registration, or at the time of vehicle disposal—whichever occurs first.

Finally, it should be noted that national market forces, driven by national policies, also influence levels of ODS recovery. For example, in the United States, there is a strong reclamation "culture" due to the fact

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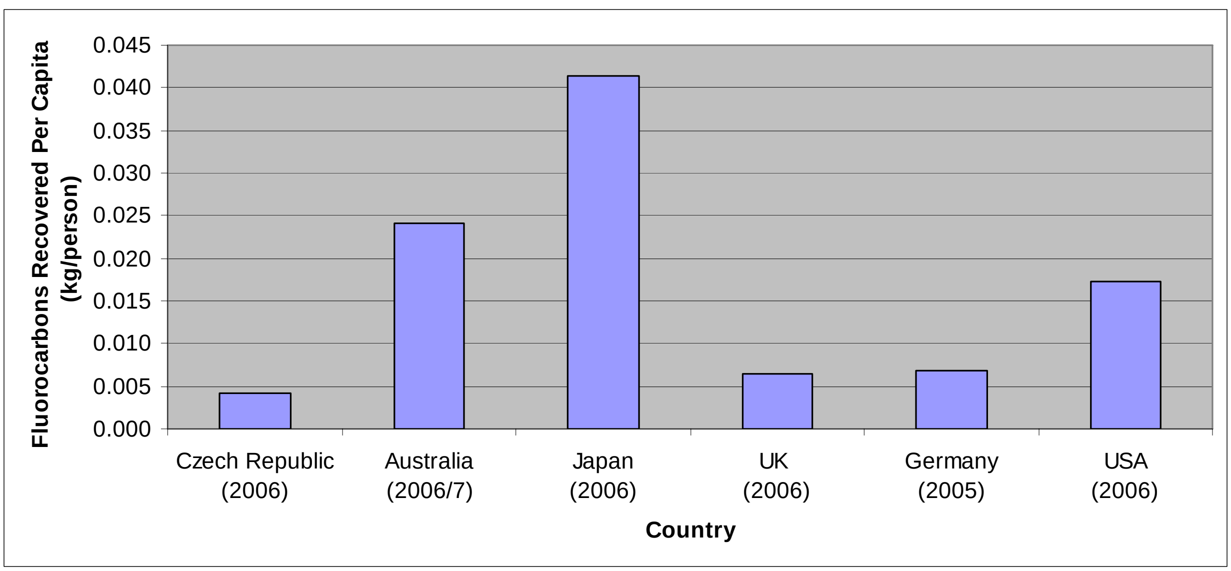
[4] The Canadian Federal Government supports the Extended Producer Responsibility scheme but it does not mandate it. However, voluntary industry participation is a key element of the Canadian Council of Environment Minister's (CCME's) CFC and Halon Disposal Strategy, which Environment Canada has been working on with the provinces and territories.

[5] The CCX is North America's only active voluntary, legally binding integrated trading system to reduce emissions of all six major greenhouse gases with offset projects worldwide. Beginning January 1, 2007, the CCX has allowed its members to redeem ODS destruction offset "credits" through the proper destruction of phased out ODS in a licensed hazardous waste combustor.

that there is no restriction on the reuse of ODS refrigerant; thus, once ODS are phased out and supply becomes increasingly scarce, the market value of ODS increases in response, which in turn provides an economic incentive for technicians to recover (since money can be earned on the return of used ODS in high demand). Currently, the price of CFC-12 in the US remains high (though it has declined in recent years), and savvy business people are already anticipating future scarcities of HCFC-22 in response to the pending phaseout and have begun to stockpile recovered HCFC-22 for future reclamation and sale. Additionally, retail prices for HCFC-22 have risen dramatically in the last year, creating further incentive to recover, recycle and reuse. In Japan, demand for CFCs is no longer high, but reclamation of HCFC-22 is on the rise. Similarly, in Canada, there is little demand for CFCs due to the refill bans instituted by most provinces, but HCFC-22 reclamation is expected to grow in the coming years. In Australia, the demand for CFCs is also very low, but no infrastructure is currently in place to reclaim HCFC-22. In EU countries, used CFCs have no market value since they are prohibited from reuse.

Ideally, the success of the national policies and programs in place in the non-Article 5 countries reviewed in this study could be evaluated based on the levels of ODS recovered for destruction or reclamation. However, comprehensive data on recovery, destruction, and reclamation are not readily available for most countries. Exhibit 4-3 presents the latest *available* data on fluorocarbon recovery for destruction/ reclamation by country. It should be emphasized that the data shown are not parallel across countries: data from the three EU countries represent ODS/HFC refrigerant and foam recovered from domestic appliances; data from Australia represent ODS/HFC refrigerant collected in bulk, largely from the commercial sector; data from Canada represent ODS refrigerant collected in bulk, largely from the commercial sector; data from Japan represent ODS/HFC refrigerant and foam collected from the appliance, commercial, and MAC sectors; and data from the United States represent all types of domestic ODS reclaimed and destroyed at US facilities (i.e., may include refrigerant, foams, or solvents).

Exhibit 4-3:
Fluorocarbons Recovered Per Capita, Based on Latest Data Available[a]

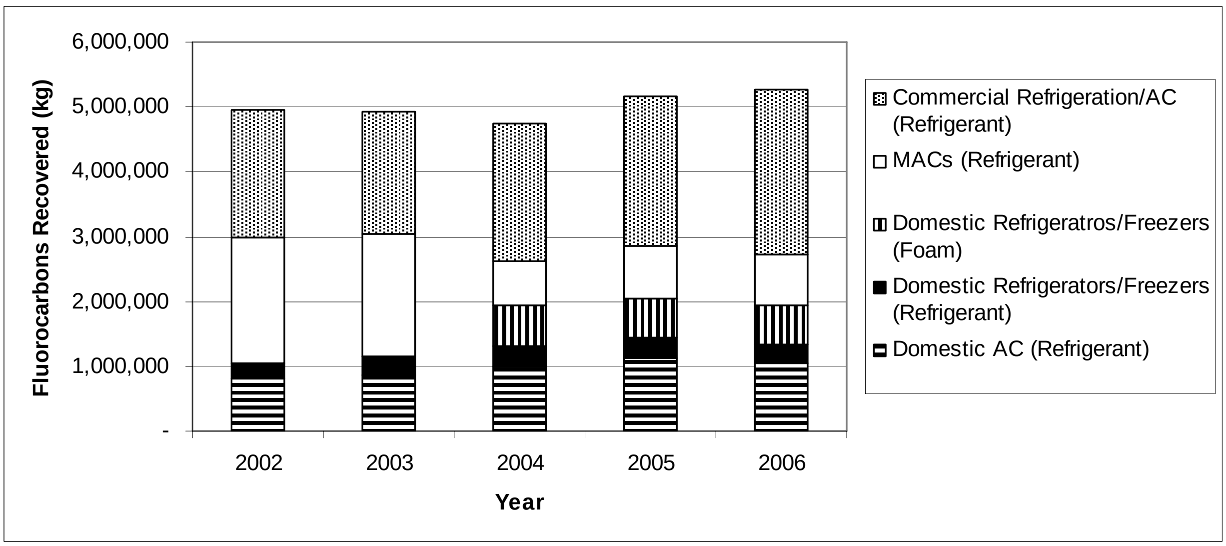


[a] Data shown are not parallel across countries: data from the Czech Republic, UK, and Germany represent ODS/HFC refrigerant and foam recovered from domestic appliances; data from Australia represent ODS/HFC refrigerant collected in bulk, largely from the commercial sector; data from Canada represent ODS refrigerant collected in bulk, from the commercial sector; data from Japan represent ODS/HFC refrigerant and foam collected from the residential appliance/AC, commercial, and MAC sectors; and data from the United States represent all types of domestic ODS reclaimed and destroyed at US facilities (i.e., may include

refrigerant, foams, or solvents).

Much can be learned from the data collected in Japan, where comprehensive data are available regarding quantities of ODS and HFC refrigerant and foam that have been reclaimed/destroyed from the commercial, domestic appliance, and MAC sectors (see Exhibit 4-4). In particular, Japan's data illustrate that the largest source of recoverable fluorocarbons is in the commercial refrigeration/AC sector. In addition, the data illustrate the significance of the domestic AC sector, which is a sector that is growing rapidly in Article 5 countries, so will gain significance over time. Significant quantities of fluorocarbons can also be recovered from domestic refrigerators/freezers, but only if foam is recovered in addition to refrigerant. Finally, while the least significant of all sectors, refrigerant recovered from MACs can also be substantial.

Exhibit 4-4:
Fluorocarbons Recovered by Sector in Japan, 2001-2006



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5. Overview of Reclamation and Destruction Activities

The choice to reclaim or destroy used ODS depends on a variety of factors, including (1) the market value of the ODS type; (2) the purity of the ODS sample; (3) the national legal framework; and (4) technical capacity.

In the non-Article 5 countries explored in this report, the preference to reclaim versus destroy varies widely. In the US, the majority of recovered ODS is sent for reclamation, whereas very little is sent for reclamation in Japan, and none is sent for reclamation in Australia. Indeed, there is currently no reclamation facility in operation in Australia (although some capacity exists),[6] while there are 3 reclamation facilities in Canada, 5 in Japan, and 48 in the United States (see Exhibit 5-1). In the Czech Republic, Germany, and the UK, refrigerant recovered from appliance demanufacturing operations is always sent for destruction, though some reclamation capacity exists in these countries. In Germany, ODS recovered from domestic appliances is sometimes sent for reclamation prior to destruction, as certain operators of high-temperature incinerators require purified ODS rather than ODS mixtures for accurate process control and consistent flow rate. Little is known about the extent of reclamation practiced in the commercial refrigeration and air conditioning sector is these three countries.

Exhibit 5-1:
Reclamation and Destruction Capacity in Case Study Countries

	In Country Capacity		Destination of Exports for Destruction, if Any
	Number of Reclamation Facilities in Operation	Number of ODS Destruction Facilities in Operation	
Australia	0	1[b]	--
Canada	3	1	United States
Colombia	0	0	--
Czech Republic	1	1[c]	Germany
Germany	3	6[d]	--
India	2[a]	0	--
Japan	5	80	--
United Kingdom	3	2	--
United States	48	< 10	--

[a] By 2009, 27 more reclamation facilities are planned for construction.
[b] Capacity is 600 MT/year.
[c] Capacity is 40 MT/year.
[d] Six hazardous waste incinerators were operating as of 2002.

Of the Article 5 countries reviewed in this report, India has recently established two reclamation facilities and plans to construct another 27 by 2009. Colombia is exploring the possibility of establishing one small-scale reclamation facility, but none are currently in operation. Neither country currently has any capacity to destroy ODS in-country, although cement kilns could be retrofitted with control devices to accept ODS in a similar fashion to the facility recently established in Indonesia, through funding provided by the Japanese Ministry of the Environment (Japanese Ministry of the Environment 2007b).

[6] One company, Solvents Australia, owns distillation columns designed for reclamation, but the facility has been moth-balled since the 1990s, when the decision was made by Refrigerant Reclaim Australia (RRA) to destroy all unwanted refrigerant. This decision was based on economics; reclamation (estimated at AU$2-4/kg) was simply not viable given the low price of virgin HCFC and HFC refrigerants.

Conversely, all seven of the non-Article 5 countries reviewed in the study have some level of ODS destruction capacity. One large plasma arc facility is used to destroy all unwanted ODS in Australia. This facility has an annual capacity of 600 metric tons. One plasma arc facility is also used to destroy ODS in the United States, as are several hazardous waste incinerators (rotary kilns, fixed hearth units, liquid injection units) and industrial furnaces (cement kilns and lightweight aggregate kilns). Canada uses a high-temperature incinerator to destroy ODS in-country, and also exports unwanted ODS to two destruction facilities in the US. Two high-temperature incinerators are used for ODS destruction in the United Kingdom, while the Czech Republic operates one rotary kiln. In Germany, unwanted ODS is destroyed by local hazardous waste incinerators or sent to Solvay Fluor GmbH for use in gas conversion. During the gas conversion process, ODS is cracked with hydrogen and oxygen in the process of making fluorinated products.

Of note, Japan has 80 ODS destruction facilities in operation as of April 2007. These facilities include the following technologies:

- Cement Kilns/Lime Rotary Kilns (7)
- Nitrogen Plasma Arc (8)
- Rotary Kiln Incineration/Municipal Solid Waste Incinerators (24)
- Liquid Injection Incineration (7)
- Microwave Plasma (5)
- Inductively Coupled Radio Frequency Plasma (1)
- Gas-Phase Catalytic Dehalogenation (1)
- Superheated Steam Reactors (25)
- Solid-Phase Alkaline Reactor (1)
- Electric Furnace (1)

It is expected that most of the destruction facilities in Japan will be operating at or near full ODS destruction capacity in the coming years, if no new capacity is established.

The costs of installing an ODS destruction facility can be significant. Australia's plasma arc which destroys roughly 65 kg/hr cost roughly US$1.4 million (including installation and training), while one of Japan's catalyst dehalogenation facilities that destroys 6 kg/hr has an initial cost of roughly US$360,000. Pedersen (2007) reports that a superheated steam reactor with a 25 kg/hr capacity can cost $500,000, and TEAP (2002b) reports that a microwave plasma of 2 kg/hr capacity costs $60,000.

Modifying existing destruction facilities to handle ODS is more cost-effective, but can also be expensive. Modifications to an existing cement kiln can cost $50,000 (Pedersen 2007). Upgrading a hazardous waste incinerator to handle ODS may be more costly.

Appendix E provides a listing of worldwide ODS destruction facilities and their associated capacities, based on available data/literature.

6. Programs in Place in Non-Article 5 Countries

In order to responsibly manage used or unwanted ODS, non-Article 5 countries have implemented a variety of programs for the collection, transport, storage, reclamation, and destruction of ODS. This section provides a broad overview of such programs in Australia, Canada, the Czech Republic, Germany, Japan, the United Kingdom, and the United States, covering the following sectors: refrigerated appliances, bulk ODS, mobile air conditioning systems, and halon banking. Detailed program descriptions for each country are provided in Appendices A and B.

6.1 Domestic Appliance Disposal

Given that domestic appliances represent one of the largest stocks of refrigeration/AC equipment types currently in use in many countries, it is important to consider how these units may be collected and properly disposed. However, given the small refrigerant charge size of appliances (particularly refrigerators/freezers), and given that refrigerant charge may not be full (to design level) at time of disposal, the removal and destruction of ODS foam from domestic refrigerators/freezers can bring significantly more environmental benefits than the removal of refrigerant alone. As shown in Exhibit 6-1, there may be two to five times more ODS foam blowing agent than refrigerant recoverable from each refrigerator at the time of disposal.

Exhibit 6-1:
Average Quantities of ODS Recovered from Domestic Refrigerators/Freezers

Country	Average ODS Recovered from Refrigerators/Freezers (g)	
	Foams	Refrigerant
Czech Republic	215	40
Germany	312	127
Japan	275	125
United Kingdom	45-90	180-230
United States	450	230

In Australia, Canada, and the United States, regulations require the recovery of refrigerant from appliances at disposal, but not the ODS foam. Appliance recycling efforts in these countries are typically run by municipalities and retailers, with the processes for appliance collection and recycling/disposal varying significantly from one to the other. Some municipalities/retailers provide free pickup, while others charge or require consumers to bring the unit to a central location. In the US and Canada, some local governments have implemented more rigorous requirements for appliance disposal. But national data on appliance collection and recovery rates in these countries are not available.

To promote and track responsible appliance disposal in the United States, the U.S. Environmental Protection Agency has recently initiated a voluntary program for the disposal of refrigerated appliances. The voluntary program partners with municipalities, retailers, utilities, and others to ensure compliance with national laws relating to the treatment of ODS refrigerant and hazardous waste (e.g., PCBs and mercury), while also promoting the proper removal and reclamation/destruction of ODS foam. The program emphasizes the energy savings and climate benefits that can result if a rebate is offered to encourage removal of old units from the electricity grid. Currently, 11 utilities and 1 major retailer have joined the program

Conversely, the Czech Republic, Germany, the UK, and Japan have legislated producer responsibility programs to properly dispose of domestic appliances, with the removal of both refrigerant and foam required by law. Under these programs, appliance manufacturers and importers are responsible for the collection, transport, demanufacture, and recycling/disposal of domestic appliances. In Germany and the Czech Republic, industry coordination is provided by a single association, whereas in the UK and Japan, appliance manufacturers/importers have formed more than one collaborative association to ensure competition and efficiency of recycling operations.

The financing for these appliance recycling programs run by producers varies from country to country. The European Community countries have placed financial responsibility on the producers, and no fee can be charged at the time of disposal; as a result, a recycling fee is added to the purchase price of new appliances. In Japan, end users must pay a fee at the time of appliance disposal. Manufacturers and importers also contribute to the annual operating costs of recycling operations. In Germany, the UK, and Japan, these costs are distributed among manufacturers/importers based on their respective share of originally produced equipment that is processed by the facilities. In the Czech Republic, costs are shared equally by producers, regardless of market share. Additional information on each of these programs is provided below:

- *Czech Republic*: The Czech appliance industry has formed Elektrowin, a. s. Its collection network consists of 1,350 retailers, 465 municipal collection yards, and 2,100 mobile collection operators. Refrigerated appliances are recycled at four Czech demanufacturing centers, with one facility currently accounting for the lion's share (>90%) of throughput. Elektrowin publishes a news letter with information for consumers, publishes detailed annual statistics, and maintains a website which provides information on locations of centers, compliance requirements, and additional program resources.
- *Germany*: Units are collected at approximately 1,500 municipal waste centers known as "Communal Handover Offices." The Federal Environmental Agency directs a selected manufacturer to arrange for the pickup of the waste from these centers, while a national producers' association provides coordination. There are approximately 20 appliance recyclers in Germany.
- *Japan*: Retailers (of which there are roughly 74,000) are required to take back old units from consumers and transport them to one of 380 designated appliance collection sites. At time of disposal, consumers pay a fee that covers collection, transport, and recycling – which costs approximately US$40 for a refrigerator and US$30 for an AC unit. Recycling receipts are issued which allow consumers to track the fate of their old unit, as well as the government to ensure program compliance and success. With funding from consumer fees, the Association for Electric Home Appliances (AEHA) serves as the "Designated Agent" responsible for managing the recycling of appliances produced by unknown manufacturers or ones that are no longer in business. There are 24 refrigerator/freezer recycling facilities and 37 AC recycling facilities in Japan. A newsletter is distributed by one of the group to share technological expertise and promote best practices among these recycling facilities.
- *United Kingdom*: Consumers can drop off their waste appliances at any one of 1,400 municipal collection sites or through appliance retailers. There are 11 refrigerated appliance demanufacturers that recycle the collected units. Appliance manufacturers have organized collection associations for the recycling of waste electronic equipment, with 37 such associations now in operation. Each association or "compliance scheme" has a disposal responsibility proportional to its members' market shares of sales of new electronic/electric equipment—i.e., each compliance scheme must dispose of a predetermined minimum number of units. An industry association that fails to meet its quota can buy tradable credits from another; this has resulted in significant profits for those associations that have been able to sell credits.

6.2 Bulk ODS Disposal

All non-Article 5 countries reviewed in this study have implemented regulations requiring the recovery of refrigerant from commercial equipment at service and disposal. Japan's regulations are the most rigorous, with refrigerant recovery operators in the commercial sector required to submit an annual report to local governments detailing the number of end of life units and the amount of ODS recovered, and over 1,000 on-site inspections for fluorocarbons recovery operators conducted each year. In addition, new regulations in Japan require building dismantlers to check for any commercial refrigerators/air-conditioners containing fluorocarbons and to report on their findings.

Recognizing the cost associated with the destruction of unwanted ODS, which effectively serves as a *dis*incentive for technicians to comply with national no venting regulations, Australia and Canada have implemented programs to facilitate ODS destruction by removing the financial burden from end-users. Specifically, Australia and Canada have industry-run programs that collect and destroy bulk ODS. Both programs are funded by levies placed on the production/import of virgin/reclaimed ODS, but these programs differ in several important aspects: Australia's program is mandated by law, whereas the scheme in Canada is a voluntary industry initiative[7] (although a full 95% of industry participates); Australia's program provides a rebate on the return of used refrigerant, whereas Canada's program simply allows technicians to return it at no cost; and Australia's program applies to all fluorocarbon refrigerants (including HFCs), while Canada's program applies exclusively to ODS refrigerants (i.e., CFCs and HCFCs).

In, the United States, a proposed industry-operated system, Refrigerant Management USA (RM USA), which would include a $1.00 rebate for each pound (not GWP-weighted) of refrigerant that was reclaimed/destroyed at U.S. reclamation/destruction facilities is being considered. The level of the rebate was estimated to counteract disincentives for destruction, including cylinder and destruction costs for contaminated material. More information on each of the two fully operating programs is provided below.

- *Australia*: Australia's product stewardship scheme for bulk refrigerants was established by Refrigerant Reclaim Australia (RRA), a not-for-profit organization that works nationally with the refrigeration industry to recover, reclaim, and destroy ODS and synthetic greenhouse gas refrigerants. Under the program, the seven major bulk ODS importers distribute refrigerant in reusable and returnable cylinders, so that "reclaim" cylinders can be used by technicians to recover and return unwanted refrigerant to any of the 150 collection points across the country—available through the industry's existing wholesaling branch network. Upon return, a bounty of AU$5/kg (US$4.30/kg) is paid to contractors. Wholesaler branch networks are required to conduct tests on each cylinder to verify that it does not contain flammables, water or ammonia (the cheapest commonly available substances, which could be used to cheat the system). Once tested, refrigerant is decanted into bulk storage and transported to RRA's secure bank, where it is destroyed on-site using the plasma-arc process. Prior to destruction, RRA assays every batch of waste refrigerant received from the wholesalers. To date, contamination has not posed a problem for the destruction facility and there has been no evidence of tampering (e.g., boosting refrigerant content with nitrogen or propane to take advantage of rebate system in place). RRA accepts any CFC, HCFC, or HFC refrigerant from any sector (commercial, residential, mobile). RRA also prepares an annual report.
- *Canada*: Bulk ODS in Canada is handled by the industry-led program Refrigerant Management Canada (RMC). Under the program, licensed contractors collect bulk ODS refrigerants and return them to refrigerant wholesalers (distributors), who then record the refrigerant information, store it, and coordinate transportation to one of three RMC approved Collection Service Provider (CSP). CSPs are responsible for performing content and containment tests before bulking and storing the ODS. Once a sufficient volume is collected, the CSP arranges to transport the refrigerant to an RMC-approved disposal partner—which includes one destruction facility in Alberta, and two facilities in

[7] The Canadian Federal Government supports the Extended Producer Responsibility scheme but it does not mandate it. However, voluntary industry participation is a key element of the Canadian Council of Environment Minister's (CCME's) CFC and Halon Disposal Strategy, which Environment Canada has been working on with the provinces and territories.

the United States (Texas and Illinois). On average, refrigerant is stored for 90 days prior to transport for destruction, which is typically 3,000 km away. Monthly reports are submitted to RMC who then aggregates data in a database. RMC accepts only CFC and HCFC refrigerants from the commercial stationary refrigeration/AC sector; it does not accept CFCs or HCFCs from mobile equipment or domestic appliances, nor does it currently accept HFC refrigerants.

6.3 Mobile Air Conditioners

Because of the large and growing number of motor vehicles in operation worldwide, refrigerant recovery from mobile air conditioners (MACs) during service and disposal can be significant. All non-Article 5 countries reviewed in this study prohibit the venting of refrigerant, meaning that they require the recovery of refrigerant from MACs at service and disposal events. In practice, refrigerant recovery at service events is common, since MAC technicians are generally well-trained and recognize the economic benefits of reusing refrigerant. However, in many countries, refrigerant recovery at disposal is not as well controlled, given the large number of disposed vehicles that end up at scrap yards, which are operated by personnel with limited environmental training and/or equipment to recover refrigerant.

In Australia, the refrigerant rebate program run by RRA (described above) provides a financial incentive for the proper destruction of unwanted ODS from the MAC sector ($5/kg). For example, one company in New South Wales, Fluoroclaim, conducts onsite recovery at salvage yards and, in 2007, collected refrigerant from 11,500 vehicles from 5 auction yards around NSW over a 9-month period. Fluoroclaim recovers MAC refrigerant from six vehicles simultaneously using recovery-only devices mounted on the back of a truck. The recovery process takes about 10 minutes for the six vehicles. On average, about 0.5 kg is recovered per vehicle, meaning that Fluoroclaim earns approximately $2.50 per MAC recovery job from RRA. Fluoroclaim typically sends 500 kg of unwanted refrigerant to RRA for destruction each month.

The process for refrigerant recovery from MACs is most systematic in Japan, where a comprehensive producer responsibility program is in place for motor vehicles. Specifically, the Japan Auto Recycling Partnership (JARP) was established by the auto industry to comply with Japanese requirements that vehicle parts be recycled and that fluorocarbons be recovered at vehicle end of life. Under the program, vehicle owners are responsible for returning cars to dealerships and shops that are registered as end-of-life (EOL) handling firms. The EOL handling firms transfer the vehicles to registered recovery operators, of which there are approximately 24,000 nationwide, who remove the refrigerant and send it to one of eight destruction centers. Recovery operators must report annually to the local government on the amounts and types of fluorocarbons recovered. They are paid by JARP based on the number of MACs from which refrigerant is recovered; they are not paid if they recover less than 270 g of refrigerant per system. Once refrigerant is recovered, recovery operators transfer the disposed vehicles to auto dismantlers who recover airbags and other parts for resale or recycling.

The operating costs of Japan's vehicle producer responsibility scheme are funded through consumer fees placed on new vehicles at time of purchase (which ranges from US$60 to US$160, depending on vehicle type). For vehicles purchased before 2005, the fee is paid at time of vehicle re-inspection/registration or at EOL—whichever occurs first.

6.4 Halon Banking

Halons were once widely used in fire extinguishing systems, and many countries—including Australia, Canada, the Czech Republic, Japan, the United States, and the United Kingdom—have established national halon banks to collect and distribute halon to critical users. Indeed, the continued use of halons is prohibited in new and existing uses that are non-critical in the EU and Australia. In the US and Canada, continued use of halon in existing equipment is permitted, as it is in Japan until 2017.

- *Australia:* Australia's National Halon Bank (NHB) was established in 1993 and is owned and operated by the national government. Fire brigades and other industry specialists collect halon free of charge from individuals and small businesses and send it to the NHB. The halon is reclaimed to 99.6% purity and stored for future use in aviation and reasonable maritime uses. Any suspect or mixed batches of halon are destroyed. The Australian Defence Forces maintain a separate stock to meet operational requirements. While most of the country's halon has been decommissioned already, the NHB continues to receive about 10 metric tons/year of waste halon for disposal or reclamation.
- *Canada:* Canada has a virtual Halon Bank, administered by the Underwriters' Laboratories of Canada, that serves as a clearinghouse for halons. The Halon Bank matches halon owners with halon buyers and also provides up-to-date information relating to the conservation and use of halons. The Underwriters' Laboratories has published two standards on the servicing of halon extinguishing systems and on recovery/reconditioning equipment.
- *Czech Republic:* The Czech National Halon Bank is located in Cheb and is operated by the contractor Esto Cheb Ltd., a fire safety company. Halons are sent to the Bank either in pure or contaminated condition, and are reclaimed and then stored in cylinders. Approximately 50% is later used for approved critical uses, and the other 50% is sent to be destroyed. Cylinders in storage are pressure-tested and checked regularly for leaks, and they are tagged and catalogued for tracking. The Bank also offers many related services to users, including training, ODS transportation, consulting, refilling of equipment, installation of new equipment, and retrofits of existing equipment; it is largely financed by the sale of halons to critical use operations, although it was initially co-financed by the State Environmental Fund. Today, the Fund only provides funding for the Bank's outreach/support activities and for the destruction of halons. The capacity of the Bank is 100 metric tons per year, a level that exceeds the domestic demand of the Czech Republic.
- *Japan:* As of January 2006, the Fire Protection and Environment Network (FPEN) manages the halon bank and closely tracks remaining halon installations in buildings and facilities. The Japan Fire Extinguishing Systems Manufacturers Association (JFESMA) developed a voluntary action plan to ensure the recovery and storage of halons and account for future demands and supply needs.
- *UK:* The Halon Users National Consortium was established by halon users in the UK in 1993. A non-profit, HUNC was funded by the subscribing members that recovered and used halon.
- *US:* The Halon Recycling Corporation (HRC) is a voluntary, non-profit trade association that assists halon users in selling and finding halons, and also with maintaining compliance with regulations. The Defense Logistics Agency (DLA) manages the Department of Defense (DoD) halon bank for the U.S. military in order to maintain a reserve of halons 1202, 1211, and 1301 to support "mission critical" requirements when commercial sources are not available. DLA has a policy to rely primarily on DoD turn-ins of recovered halons for future use.

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7. International Conventions Affecting the Movement of ODS Waste

Several international conventions and regional agreements affect the movement of unwanted ODS between countries. These conventions include:

- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal;
- Bamako Convention on the ban of the Import into Africa and the Control of Transboundary Movement of Hazardous Wastes within Africa;
- The Central American Agreement; and
- The Waigani Convention: Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Transboundary Movement and Management of Hazardous Wastes within the South Pacific Region.

This chapter provides a brief overview of each of these conventions and discusses how each one affects the movement of unwanted ODS for reclamation or disposal.

7.1 The Basel Convention

Adopted in 1989 and brought into force in 1992, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (the Basel Convention) was created to control and, ultimately, reduce the movement of hazardous waste between countries, particularly the transfer of hazardous waste from developed to developing countries. The Convention is aimed at protecting human health and the environment from negative impacts caused by the generation, management, transboundary movements and disposal of hazardous and other wastes. Currently, the Convention has 170 member countries (Parties). (Secretariat of the Basel Convention 2008)

The Basel Convention relies on a “Prior Informed Consent” procedure which prohibits the shipment of hazardous wastes between Parties without the prior written consent of the proposed State of import and any States of transit. As part of this procedure, special agreements are required to ship wastes to and from non-Parties. In addition, Parties must ensure that hazardous and other wastes are managed and disposed of in an environmentally sound manner. To achieve this goal, Parties must minimize the quantities of waste that are transported across borders, treat and dispose of wastes as close as possible to where they were generated, and prevent or minimize the generation of wastes at their source. Each Party must establish national legislation to control the movements of hazardous and other wastes and to treat illegal traffic of such wastes as a crime.

Some Key Hazardous Wastes Streams Listed in Annex I to the Basel Convention*

- Arsenic; arsenic compounds
- Asbestos (dust and fibres)
- Cadmium; cadmium compounds
- Hexavalent chromium compounds
- Clinical wastes from medical care hospitals, medical centers and clinics
- Inorganic cyanides, organic cyanides
- Lead; lead compounds
- Mercury; mercury compounds
- PCBs
- Acidic solutions or acids in solid forms
- Basic solutions or bases in solid forms
- Waste substances and articles containing or contaminated with PCBs and/or PCTs and/or PBBs

*As long as they exhibit at least one hazardous characteristic of Annex III.

Wastes as defined by the Basel Convention are "substances or objects which are disposed[8] of or are intended to be disposed of or are required to be disposed of by the provision of national law." Waste is covered by the Convention if it is listed in the category of wastes (Annex 1) which exhibit one of the hazardous characteristics listed in Annex III of the Convention (e.g., toxic, poisonous, explosive, corrosive, flammable, ecotoxic, and infectious). In addition, a waste may also fall under the scope of the Convention if it is defined as or considered a hazardous waste by the exporting country, the importing country, or any of the countries through which it travels. (Basel Convention, Secretariat of the Basel Convention 2005, 2006).

Under the Basel Convention, the obligation to ensure proper waste management is placed on the country that produces the hazardous waste, and upon the country of disposal, upon receipt. Countries that are party to Basel are prohibited from exporting waste to or importing it from non-party countries, unless they have entered into a special agreement for this purpose, which must provide for procedures which are no less environmentally sound that that provided under the Convention.

7.1.1 ODS Under the Basel Convention

ODS are listed in the Basel Convention under category Y45: organohalogen compounds not included under any other category. The Basel Convention would require that wastes containing ODS be managed in an environmentally sound manner, and any movements across boundaries for recycling, which are exempted under Montreal Protocol, must comply with provisions of the Basel Convention (Multilateral Fund 2006). By its Decision III/15, the Conference of the parties to the Basel Convention excluded from the scope of the convention the controlled substances of the Montreal Protocol which are reclaimed and purified to usable purity specifications prescribed by appropriate international and/or national organizations including the International Standards Organization (ISO).

As shown in Exhibit 7-1, twenty-two (22) of the countries that have ratified the Montreal Protocol have not ratified Basel (21 of which are Article 5 countries, 1 of which is a non-Article 5 country)—meaning that countries that have ratified Basel may not import or export waste ODS as identified under category Y45 of Annex I to the Basel Convention from/to these 22 countries unless a special agreement is in place, as discussed above. Further, as of 2006, 45 countries that are party to Basel have banned importation of ODS without a provision for disposal (Multilateral Fund 2006). Thus, the import/export of waste containing ODS is effectively restricted between countries that have ratified the Basel Convention.

Exhibit 7-1:
Montreal Protocol Countries Which Have Not Ratified Basel

Non-Article 5 Countries	Article 5 Countries	
United States	Afghanistan	Palau
	Angola	Sao Tome and Principe
	Central African Republic	Sierra Leone
	Republic of Congo	Solomon Islands
	Fiji	Somalia
	Gabon	Sudan
	Grenada	Suriname
	Haiti	Tonga
	Democratic Peoples Republic of Korea	Tuvalu

[8] "Disposal" (as defined by the Convention) includes operations resulting in final disposal and operations which may lead to resource recovery, recycling, reclamation, direct re-use or alternative uses.

**Exhibit 7-1:
Montreal Protocol Countries Which Have Not Ratified Basel**

Non-Article 5 Countries	Article 5 Countries	
	Laos Myanmar Niue	Vanuatu Zimbabwe

7.1.2 Challenges Related to the Basel Convention

In general, the challenges in properly managing unwanted ODS revolve around who can send what to whom and logistical issues. Aside from countries' prohibitions on the import/export of ODS waste, the shipping of ODS waste (Y45) between two Basel Parties must comply with the obligations of the control regime set out by the Basel Convention. Even when a party consents to a transboundary movement of ODS waste, the prior notification procedure must be followed which may require a high level of effort and administrative cost. (The information that needs to be reported is listed in Appendix F.) As noted by UNEP (2006), "[a]s to technical part requirements, potentially [sic] complications might be created due to the complex notification system…according to the convention, parties are requested not to export hazardous waste without a written consent from the importing country." For many countries, especially those with low institutional capacity, the burden imposed by the Basel Convention of paperwork, transportation, and insurance is perceived as a disincentive for exporting ODS for destruction.

Countries have taken different approaches to address the difficulties in moving ODS waste. For example, according to interviews with representatives of Australia's Department of Environment and Heritage, it is understood that Australia does not interpret ODS waste to fall under the purview of the Basel Convention. Canada does not have enough destruction capacity to handle its ODS waste; therefore, Canada and the US have signed a bilateral agreement which permits the export of ODS waste to the US for destruction.[9]

One solution could be for the Parties to the Basel Convention to decide that all non-solvent ODS[10] are outside of the scope of the Basel Convention and are therefore not subject to its provisions. An alternative is for Parties to establish individual bilateral agreements permitting the transport of ODS waste for destruction under no less stringent procedures than those provided by the Convention. This alternative does not alleviate, however, the paperwork and administrative burdens for the countries involved. A further solution might be for States concerned with hazardous wastes or other wastes having the same physical and chemical characteristics which are shipped regularly to the same disposer via the same States of transit, to use a general notification as is provided under Article 6(6) of the Basel Convention. Another solution could be to provide assistance to Article 5 country governments to help them navigate through the Basel requirements.

[9] This agreement has not formally been communicated as an Article 11 agreement to the Secretariat of the Basel Convention.

[10] Solvents tend to be contaminated with hazardous materials (e.g., metal filings, sludge, resins), whereas refrigerants and halons tend to be non-hazardous gaseous substances.

7.2 Other Regional Conventions

There are three regional conventions that must also be considered when shipping ODS internationally. Each of these conventions prohibits the shipment of hazardous waste from convention parties to non-parties.

The Bamako Convention, adopted by the Organization of African Unity (now the African Union) prohibits the import of hazardous waste from a non-Bamako party entered into force as of March 1999. Bamako uses the same definitions as Basel and covers unwanted ODS refrigerant under category Y45. Under Bamako, all parties must prohibit the import of hazardous waste from a non-Bamako party, effectively preventing the movement of ODS for disposal to any signatory. The following countries have ratified the Bamako Convention (African Union 2007):

- Benin
- Burundi
- Cameroon
- Cote d'Ivoire
- Comoros
- Congo
- Democratic Republic of Congo
- Egypt
- Ethiopia
- Gabon
- Gambia
- Libya
- Mali
- Mozambique
- Mauritius
- Niger
- Senegal
- Sudan
- Tanzania
- Togo
- Tunisia

The Central American Agreement (*Acuerdo Regional Sobre Movimiento Transfronterizo de Desechos Peligrosos [Regional Agreement on the Transfrontier Movement of Hazardous Wastes]*) also uses the same definitions as Basel and covers unwanted ODS refrigerant under category Y45. The Agreement also prohibits Parties from importing hazardous waste from non-party countries. In addition, Parties must take measures to prevent the release of hazardous waste to the environment. Therefore, Parties cannot destroy any ODS from non-parties. The signatories to this agreement are Costa Rica, Honduras, El Salvador, Nicaragua, Guatemala, and Panama.

Finally, the Waigani Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Transboundary Movement and Management of Hazardous Wastes within the South Pacific Region was ratified in 1995 by the Forum Island nations in the South Pacific. The Convention uses the same definitions as Basel, covering ODS under section Y45. The Waigani Convention bans the import of hazardous waste from non-Forum nations. All imports (between Forum nations) require notification to the Convention Secretariat and all shipments must be returned to the exporting country if the shipment cannot be safely completed. The Convention encourages the construction of disposal facilities in Forum nations. The following countries are Forum nations (Waigani Convention 1995):

- Australia
- The Cook Islands
- The Federated States of Micronesia
- Fiji
- Kiribati
- The Marshall Islands
- Nauru
- New Zealand
- Niue
- Palau
- Papua New Guinea
- Samoa
- The Solomon Islands
- Tonga
- Tuvalu
- Vanuatu

Since 2006, associate Forum member territories are New Caledonia and French Polynesia (Pacific Islands Forum Secretariat 2008).

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8. Findings

This section presents the findings that have been derived from the desk study, country visits, and country questionnaires; these findings reflect lessons learned in non-Article 5 countries that may be applicable for the management of unwanted ODS in Article 5 countries, as well as factors that may be important for Article 5 country governments to consider when creating a strategy for managing unwanted ODS. Such factors include the country's size, economy, regulatory frameworks, institutional capacity, geography, population, transportation infrastructure, and awareness of environmental issues.

The remainder of this chapter presents the report findings, organized into the following categories:

- Defining the Scope of Unwanted ODS Management;
- Regulations, Voluntary Programs, and Product Stewardship;
- Cost Considerations; and
- Infrastructure, Equipment, and Geography.

8.1 Defining the Scope of Unwanted ODS Management

In developing a strategy for managing unwanted ODS, several scoping decisions must be made at the country level, including those related to: (1) whether to recover ODS refrigerant alone or to also recover ODS blowing agents in foam; (2) which sectors to include, since not all equipment types lend themselves equally to cost-effective ODS recovery; and (3) whether to develop in-country capabilities for reclamation and/or destruction of collected non-recyclable ODS or to export it for reclamation or destruction.

With these factors in mind, it also is critical for country representatives to understand how on-going needs for ODS may impact decisions relating to the disposition of ODS and ODS alternatives. This perspective applies to Article 5 countries and non-Article 5 countries, or more importantly, to the global interactions that can take place between these countries. Put simply, ODS can be unwanted in one country, but wanted elsewhere. Additionally, if ODS destruction could be made economically viable or profitable, ODS that is today considered "unwanted" may become valuable.

The subsequent findings and recommendations should be considered in light of the prevalence of "unwanted" ODS, global needs for these materials ("wanted" ODS), the role that recovered and reclaimed materials play in reducing demand, the global environmental benefits that accrue from destruction of ODS and their high-GWP replacements, and the various available economic incentives for encouraging proper management.

8.1.1 Appliance Refrigerant and Foam

End-of-life management for refrigerated appliances can include procedures for recovering refrigerant and foam blowing agents. Countries that have mandated foam recovery have recognized the need to capture ODS from foams, and their policies have helped reduce harmful ODS (and greenhouse gas) emissions. The average ODS-based refrigerator contains two to five times as much ODS in the foam as in the refrigerant, and any country that has a program for collecting appliances and recovering refrigerant from them can implement foam recovery as well. Simply collecting the appliances for refrigerant recovery and then shredding the foams without exhaust gas recovery results in the harmful release of much ODS. The tradeoff, however, lies in the cost: foam recovery and destruction can be more expensive than shredding. Another factor to consider is the costs and benefits associated with equipment demanufacturing—from collection and transport to actual destruction of ODS—including energy requirements for building and operating a facility compared to savings in terms of direct ODS and GHG emissions avoided.

8.1.2 Sectoral Considerations

It will not be feasible to recover all ODS from all end uses in all countries. Rather, feasibility will depend on a variety of factors, including availability of recovery equipment, relative amounts of ODS to be recovered, technical training, and awareness. Determining which sectors to target for collection and recovery of ODS is an important scoping decision. The countries assessed in this study have developed a variety of procedures to target the recovery and collection of specific ODS in specific sectors/end uses. For example, Australia and Canada have developed procedures to target the recovery and collection of bulk refrigerant from commercial sectors. The Czech Republic, Germany, the United Kingdom, and Japan have developed procedures to target the mandatory recovery and collection of refrigerant and foam from domestic appliances—as part of broader initiatives to reduce waste from household appliances—while the US is embarking on a voluntary approach with incentives for the appliance sector.[11] The experience of Japan—where programs have been developed to target the commercial refrigeration/AC, domestic appliance, and automobile (MAC) sectors—demonstrates that the most significant quantities of fluorocarbons can be recovered from the commercial sector. No countries have developed robust systems for the collection/destruction of ODS-containing construction foam.

8.1.3 Destruction and Reclamation

In general, countries that are concerned about ODS supply shortages or lack of cost-effective drop-in alternatives (including most Article 5 countries) should not bypass reclamation as a source of material for servicing existing inventories of equipment. Moreover, schemes that include destruction only (e.g., Canada, Australia) may effectively streamline procedures for managing unwanted ODS, but may also lead to undue abandonment of equipment in future. In addition, if costs for recovery, storage, and destruction are high, schemes that require destruction (and ban recycling/reclamation) may lead to venting. Reclamation can be a viable business, though it must operate at the mercy of the market unless economic incentives are created. In the near future, it is likely that CFCs will be profitable for Article 5 countries to reclaim for reuse (as was the case in Australia and Japan, and continues to be the case in the US); in the more distant future, this may be the case for HCFCs.

8.2 Regulations, Voluntary Programs, and Product Stewardship

The experiences of the countries assessed in this study show that regulations are necessary for any ODS management scheme, but are not sufficient to ensure the proper disposition of ODS. The success of regulations is closely tied to (a) industry outreach to build a strong base of support among stakeholders, (b) education/training to ensure that requirements are understood, and (c) enforcement structures (including incentives to recover and disincentives for not doing so) to ensure compliance. While most of the countries assessed in this study have enacted legislation and regulations to prohibit venting of ODS and to require the use of recovery equipment, they have taken different approaches to ensure that regulatory goals are achieved. Some have complemented regulatory programs with voluntary programs, while others have mandated or promoted product responsibility schemes. Each of the various national frameworks in place to manage used/unwanted ODS is described further below.

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[11] Appliance recycling programs achieve environmental benefits well beyond the protection of the ozone layer—including reduced waste through the recycling of metals/plastics/glass, reduced toxics through the proper disposal of PCBs/used oil/mercury, and potentially, enhanced product recyclability through improved product design.

8.2.1 Regulations

The enactment of regulations itself can be challenging, since the policymaking surrounding unwanted ODS will be influenced by various interests. Many countries have developed ODS regulations and supporting implementation with input from the affected industry. This involvement has often resulted in systems that work well for the environment, as well as for the affected industries.

Once a regulatory framework is adopted, in order to be successful, it must be supported by education/training (e.g., technician certification) to ensure that stakeholders understand requirements. To date, countries that have pursued technician training have experienced varying levels of success in building recovery knowledge among refrigerant technicians. Training is generally viewed as a key element for ensuring proper implementation of an ODS recovery program, as it helps boost recovery at the source of the ODS; however, it is difficult to measure the effect that training has on reducing ODS emissions. Moreover, training can be expensive and is not effective unless there are measures to mainstream environment into government as well as civil society; it is therefore extremely difficult to measure the cost-effectiveness of such programs.

In countries where there is a general commitment to responsible waste handling, education on unwanted ODS may be able to piggyback on existing waste outreach efforts. For example, Japan's commitment to processing unwanted ODS properly is complemented by its commitment to the recycling of many classes of waste appliances. Conversely in other countries, where waste disposal has been largely *ad hoc*, ODS programs are likely to be *ad hoc* as well, and this makes educational outreach more challenging.

Likewise, regulations must be enforced if they are to be successful. The credible threat of legal action is a strong incentive for responsible parties to comply with environmental regulations, and the prohibition against venting of ODS is no exception. But even in Japan, where strict regulations and enforcement activity exists, the refrigerant recovery rate in the commercial sector was estimated at only 30% of its potential; while additional regulatory requirements have recently been imposed which are expected to double this recovery rate, such tight regulatory control is unlikely to be feasible in Article 5 countries. Even in non-Article 5 countries, stringent command and control approaches are not universal, and often countries with experience in compliance enforcement are turning to other approaches to encourage responsible behavior.

8.2.2 Voluntary Programs

Alternatives to strict enforcement can be seen in strategies that create incentives for good environmental behavior. These incentives can vary in nature, from lending a "green" public image to offering financial incentives that pay back for costs of correcting environmental externalities.[12] Such programs can work in countries with strong institutions, as well as in countries with weak institutional structures for enforcement and limited regulatory programs. In the US and Canada, voluntary programs to encourage appliance recycling and refrigerant reclamation, respectively, have been met with initial success, as a result of strong public interest/pressure for industry to act responsibly in protecting the environment. Both India and Colombia have launched voluntary technician training and voluntary reclamation programs. It is not clear how successful these programs will be, but if economic incentives to recover and reclaim or destroy used refrigerant can be established, the programs are much more likely to succeed.

[12] Environmental "externality" refers to the environmental effects of an activity not taken into account in its price.

8.2.3 Product Stewardship/Producer Responsibility Schemes

Producer responsibility schemes, also known as extended producer responsibility or product stewardship schemes, impose accountability over the entire life cycle of products introduced on the market. In the context of ODS, this means that firms that produce, import and/or sell bulk ODS or ODS-containing equipment are required to be financially or physically responsible for such products after their useful life. Whether for MACs, bulk ODS from the commercial sector, or domestic refrigerated appliances, producer responsibility schemes have generally been successful in the countries that have implemented them. These producer responsibility schemes have worked well in Australia, Canada, Japan, and European countries, where there are strong national producers or a concentration of large importers. Producers in some countries have developed a "unified" national organization/company for collecting appliances or bulk ODS (e.g., Australia, Canada, Germany), while others have developed multiple organizations/companies to ensure competition and increase efficiency. Some elements of successful programs have included: enacting a legal mandate to level the playing field; ensuring industry participation in setting up and administering the program, with third party auditing; and creating recordkeeping and reporting procedures.

In general, these producer responsibility approaches have yielded large quantities of ODS recovered annually from the disposed units, required little government involvement in maintaining the collection and recovery process, and, owing to the scale of operations, not overburdened consumers with the cost of the process. As a result, this strategy of implementing producer responsibility laws can be very successful for those countries that are able to establish, administer, enforce, and pay for it. Programs have generally worked well when there are few players involved (i.e., producers/importers) to allow for effective organization/management of the scheme. A country with no large producers and hundreds of small importers, however, is unlikely to be able to establish an effective producer responsibility scheme. The schemes also may not work as well in countries where the recycling fee (e.g., $50 for a refrigerator) would be a hardship. Moreover, if a high recycling fee were added to the price of a new refrigerator in Article 5 countries, black markets may be created. In addition, for voluntary product stewardship schemes to be successful, there must be significant public pressure and/or a credible threat of regulatory action.

8.3 Cost Considerations

The cost of recovery and reclamation or destruction is a primary obstacle in achieving better management of unwanted ODS in Article 5 countries. Namely, it is difficult to impose burdensome requirements on developing or struggling economies. For example, it may be difficult to require refrigerant recovery if technicians cannot afford to purchase recovery equipment. Similarly, requirements on consumers to pay for proper recycling of their appliances or refrigerant contained in MACs may be seen as putting a cost burden on poor citizens. Requiring producers to take responsibility for the disposal of appliances, MACs, or bulk ODS may also be seen as a burden—either being too expensive for companies, or, more likely, as a measure that would pass costs on to consumers. The companies themselves may not undertake voluntary programs if they believe there is a significant cost and no payback.

Thus, generating cash flow by creating economic incentives for recovery, reclamation, and destruction is vital to the success of a used/unwanted ODS management strategy. The role of incentives in furthering compliance is particularly important, and can take many forms. For example, incentives in the appliance sector may include consumer rebates on the turn-in of old refrigerators, while incentives in the commercial sector may include free destruction of bulk refrigerant for technicians. Further, if ODS recovery can be made into a profitable practice, the financial incentive can be a stimulus for growth in the recovery rate, or for the development of sustainable businesses. For example, as the need for CFC refrigerant grows in India, it is expected that more technicians will start reclaiming ODS in order to resell what could not otherwise be reused.

Conversely, if market factors create significant financial disincentives for stakeholders to comply with regulations, compliance will be undermined. For example, in the European Community countries of Germany and the UK, the cost burden to store and dispose of unwanted halon was placed on halon owners, which is believed to have led to significant losses in the installed inventory of halon. The experience of the Czech Republic was better in this regard. As a later entrant to the European Community, and with funding from the Czech government and the GEF, a robust halon bank was established and significant repositories reclaimed and stored for future critical use. The halon bank operation also provides other services including decommissioning services, installation of alternative systems, training, and consultancy services.

The same lesson has been learned with regard to the handling of bulk refrigerant and appliances. Charging technicians for the destruction of bulk refrigerant places a heavy economic burden on the individual/service company, which can be minimized if fees are charged instead to importers and producers on the sale of new refrigerant, so that costs can be absorbed through the supply chain. Likewise, for appliances, charging consumers at the time of equipment disposal may create a disincentive for proper disposal, so other funding options should be considered, where possible—such as placing fees on the sale of new equipment, or even funding appliance disposal through municipal taxes. In Japan, a recycling fee is placed on the purchase of new motor vehicles while owners of existing vehicles must pay the recycling fee when they re-register their vehicle.

In some countries, the processes of generating program funding and applying economic incentives have been successfully combined into tax and rebate systems. For example, the Canadian and Australian programs targeting bulk ODS have been successful in placing a tax on imports and production of virgin/reclaimed refrigerants and using the revenue from that tax to fund ODS collection and destruction—and in the case of Australia, even provide rebates for recovered refrigerant. The financial incentive associated with returning refrigerant leads to good recovery practices.

8.4 Infrastructure, Equipment, and Geography

Country geography and infrastructure are key considerations in developing unwanted ODS management strategies. Indeed, much of the effort and cost of reclaiming or destroying ODS is a result of transportation needs. Consideration of the environmental footprint associated with transport (e.g., greenhouse gas emissions) should be weighed against the environmental benefits associated with ODS destruction; if ODS must be transported a significant distance to be destroyed, the quantities transported should be sufficient to maximize the net environmental benefits. Additionally, if transport is difficult because roadways are inadequate, this can impede ODS processing. For example, India's ability to process any ODS collected has been hampered by the fact that it must be shipped long distances to one of only two reclamation facilities. As a result, India is building 27 more reclamation facilities by 2009, hopefully creating an opportunity for improved ODS recovery and reclamation. Conversely, a smaller country or a country with a relatively concentrated population may have an easier time implementing an ODS or appliance collection system. Shipping refrigerant or appliances long distances can become costly, so a collection network that only needs to serve a small area with a dense population will incur fewer costs than one that serves more far-flung users. Indeed, the viability of establishing bulk ODS or appliance collection programs beyond urban areas may not be economically viable or beneficial from an environmental (climate) perspective.

For countries with large quantities of ODS to be destroyed (on the order of 60 MT/year), it can be worthwhile to pursue destruction and reclamation options domestically. It is likely that very few Article 5 countries that do not already have in-country destruction capacity would fit into this category. To the extent possible, use of existing destruction facilities should be maximized and the construction of new destruction facilities should be minimized, in order to reduce cost and environmental impact. Further, there are often problems regarding local acceptance of special waste destruction facilities, which can lead to significant efforts in trying to establish one. Therefore, should additional in-country capacity be needed, upgrading existing destruction facilities (e.g., cement kilns) so that they can handle ODS should be explored prior to any new construction. Approaches may include outfitting existing cement kilns with metering, monitoring, and emission control devices to handle the destruction of ODS wastes; using existing municipal waste incineration facilities to handle ODS foams; and/or working with private vendors that own and maintain mobile reclamation or destruction units.

For countries with smaller quantities of unwanted ODS, new facilities will not be cost-effective to build or operate. Currently, however, exporting ODS for destruction can lead to delays, backlog issues, and administrative complications with international conventions (e.g., Basel). Alternatively, mobile appliance recycling units (appliance shredders with built-in ODS capture system), as well as mobile destruction technologies could offer a viable solution to regions that are isolated from existing destruction infrastructure. The use of mobile technologies may require strong collaboration and coordination between countries to ensure safe disposal of end products, secure the necessary operating permits, and provide qualified personnel.

Technical requirements may also influence how and where recovered ODS is processed. For example, German appliance recyclers can either send recovered ODS to a local hazardous waste incinerator or to one of two reclamation facilities in Germany. For most recyclers, shipping the ODS to one of the two reclamation facilities is more expensive than sending it to a local incinerator, but may be necessary because local incinerators may not accept mixed ODS waste. In addition, German regulations discourage shipping hazardous waste cross-country, while transporting the waste locally is intentionally made much easier. Thus, geographic distance influences German processing of recovered ODS. The Czech Republic is another interesting and related case. ODS wastes are destroyed in country, except halon wastes, which are shipped to nearby Germany. While both the Czech and German facilities are capable of destroying halon, the Czech facility is not currently outfitted to handle the halon decomposition products (specifically bromine gas, which is quite caustic).

Appropriate infrastructure and equipment is also critical for the success of appliance recycling programs and other types of ODS collection schemes. The producer responsibility schemes for domestic appliances observed in case study countries (Czech Republic, Germany, Japan, and the UK) all have thorough collection networks, large-scale appliance demanufacturing plants, extensive transportation networks, and reliable access to demanufacturing facilities. Any scheme for collecting appliances, MACs, or bulk ODS must be backed by similarly efficient systems to process the waste as it comes in.

9. Recommendations

This chapter lays out the recommendations that flow from the investigation of best practices for handling and treatment of locally unwanted ODS gleaned from the desk study and field visits. Lessons learned from the historical development and current implementation of programs in the seven non-Article 5 country visits and the practical challenges and opportunities gleaned from the two Article 5 country visits have been elucidated in Chapter 0, and form the basis for the recommendations provided here.

When reviewing these recommendations, it is important to consider country circumstance and capacity. In particular, certain programs and activities will be effective depending on the characteristics of the country—namely, total population, localized population density, amount of ODS installed or stockpiled, existing recycling/reclamation/destruction capacity, and proximity to destruction/reclamation facilities in neighboring countries. Additionally, the relative importance of the various sectors (e.g., refrigerants and foam in the domestic appliance sector, refrigerants in the commercial and industrial refrigeration/AC sector, refrigerants in the mobile AC sector) that comprise ODS consumption within the country will determine the end-of-life practices that are most appropriate. The following points illustrate the practical considerations at the country level that should be borne in mind when developing an end-of-life ODS management strategy:

- *Volume:* What is the installed base of ODS in your country? What stockpiles exist that are not installed (waste ODS and/or unused material, both of which may be locally unwanted)? What is the stream of ODS being decommissioned on an annual basis? Depending on the volume, various end-of-life options will be appropriate.

- *Sectors:* Where are the main sources of decommissioned materials? Do domestic refrigeration or commercial applications predominate? Having an estimate of the relative and absolute amounts of ODS from these sources will help to determine which practices to consider (e.g., appliance decommissioning, recovery from commercial systems).

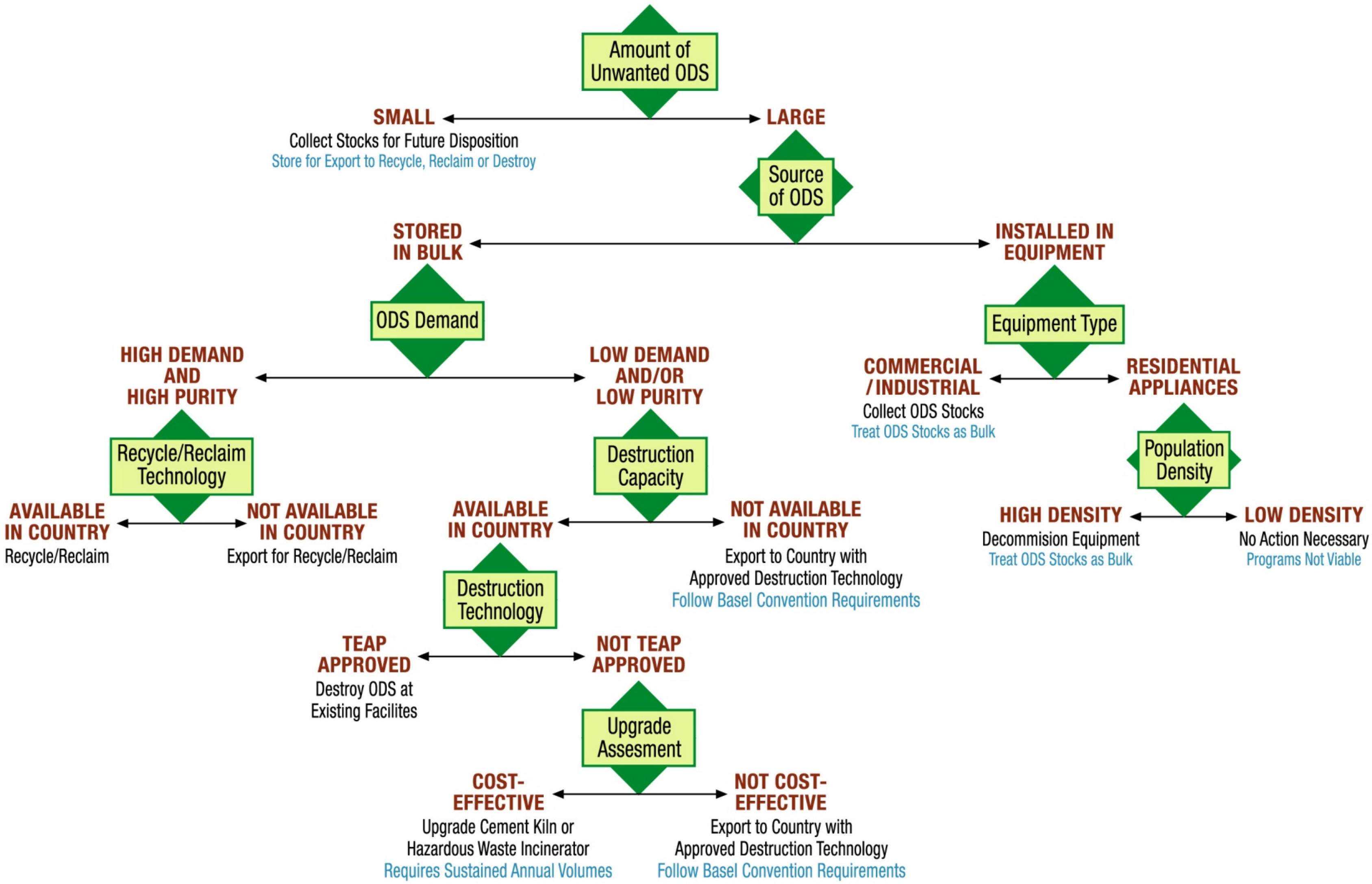
- *Disposition:* What should be done with collected material? Should ODS be stored for future disposition (this is a minimum requirement), recycled, reclaimed, or destroyed? Can these activities be undertaken within the country or must materials be shipped elsewhere for treatment?

Figure 9-1 graphically illustrates the decision path for management of unwanted ODS at the country level.

At a broader level, the most significant opportunity for ensuring the proper management of locally unwanted ODS lies in assigning a value to such "unwanted" materials. In particular, as the phaseout of CFCs, halons, and HCFCs progresses in Article 5 countries, currently "unwanted" ODS may become wanted—if, for example, it can be used to service existing equipment, sold to other countries that require it for essential or critical uses, or perhaps destroyed for certified emission reductions (CERs) on a carbon market. Realizing and extracting the value in "unwanted" ODS is critical for stimulating their recovery and cost-effective disposition.

Based on the experiences and lessons learned from the seven non-Article 5 country and two Article 5 country experiences reviewed in this study, there are a number of approaches and program designs that can be adopted to achieve success. While the "recipe" for success will depend on unique country circumstances and situations, overarching recommendations that apply to all countries are listed below.

Exhibit 9-1:
Decision Tree for Management of Unwanted ODS



Scope of Unwanted ODS Management

1. Article 5 countries should target specific sectors for ODS recovery/reclamation/destruction, since such activities may not be financially viable in all sectors. The best targets are those sectors where most ODS can be recovered with a relatively low-level of effort (i.e., refrigeration/AC, appliance foam, and ODS stockpiles), and/or where most control can be exerted on stakeholders. Because of the high demand for halon worldwide and the nature of the fire protection sector (i.e., relatively few players, generally high industry standards for responsible use), the refrigeration/AC and appliance foam sectors warrant the most attention in terms of developing ODS end-of-life management strategies in Article 5 countries. In particular, recovery from commercial refrigeration/AC applications, especially those where individual facilities comprise a large installed base, are likely to be some of the most cost effective opportunities.

2. Any management scheme that targets refrigerant, foam, and/or fire extinguishing agents should address all substance types, including ODS and HFCs, to maximize environmental benefit and ensure long-term sustainability of any programs and markets that are developed on their basis. Specifically, the facilities and procedures developed to handle ODS are largely applicable to the high-GWP HFCs.

Regulations, Enforcement, and Education

3. Countries should enact regulations that specifically prohibit venting of ODS and require the use of recovery equipment (at least in key sectors); a legal mandate is needed for any ODS management scheme (i.e., a scheme to deal with locally unwanted ODS) regardless of the type selected (e.g., even product stewardship schemes) to ensure a level-playing field. However, if regulation is selected as the primary means for managing end-of-life ODS (e.g., if end-users are held legally responsible for ensuring proper destruction of unwanted ODS with no accompanying market-based incentives or producer responsibility regimes to organize/facilitate the process), a strong enforcement regime is needed, particularly if cost dynamics may be a disincentive for compliance.

4. Technician certification in the refrigeration and air conditioning sector should be mandatory. Linking certification/licensing to refrigerant purchase has been highly successful means for ensuring the training of technicians in the servicing sector in non-Article 5 countries. It is also important to provide training and conduct outreach efforts for those who deal with equipment at end of life; in many Article 5 countries, training may be most needed for scrap metal collectors. Such training should be addressed under Phase-out Management Plans or through HCFC Phase-out activities.

5. In any unwanted ODS management approach, accountability is key; the program must balance the need for recordkeeping/reporting requirements with the administrative burden that these requirements will entail. At a minimum, reclamation companies, destruction facilities, and appliance demanufacturing facilities should record and report data to ensure best practices and allow for program success to be tracked and improved, as needed. Such reporting would provide significant benefit by allowing government and industry to assess national trends and implement policy or programmatic changes needed to increase recovery or plant efficiency.

Program Funding and Economic Incentives

6. It is critical that recovery and reclamation/destruction not impose a cost burden on end-users. At the most basic level, end-users should not have to pay for reclamation/destruction. Creating economic incentives—or at the very least removing disincentives—is important for the success of an unwanted ODS management strategy. For example, countries could consider offering a rebate on the return of used ODS, but must have sufficient monitoring and enforcement to ensure that this does not lead to problems, such as illegal ODS imports or fraudulent return of non-ODS substances. In order to provide these incentives, however, funding will be needed.

7. Such funding options currently being used in non-Article 5 countries include ODS levies (e.g., tax per kg of refrigerant imports/production), municipal taxes, and taxes on new equipment. In addition, new funding options should be pursued at the international level in the form of (a) direct assistance to Article 5 countries from the Multilateral Fund (MLF), and/or (b) through the Clean Development Mechanism (CDM) or other carbon trading platforms—if credits are issued for ODS destruction using an approved methodology. Currently, neither the MLF nor the CDM have mandates to conduct these activities; the MLF is mandated to fund only the phaseout of ODS consumption and production, not disposal; and the CDM is mandated to only accept projects that reduce emissions of chemicals listed in Kyoto's "basket" of chemicals, which does not include ODS. Therefore, the mandates of the MLF and the CDM should be reviewed and extended to provide funding mechanisms for the safe disposal of unwanted ODS. In the case of the MLF, consideration may need to be given to include ODS disposal in its mandate and, potentially, broader chemical management issues. For example, in countries where an ODS-containing appliance decommissioning program is appropriate, e.g., in countries with more than 1 million refrigerators disposed per year, the MLF could consider funding incremental costs associated with the removal and destruction of appliance refrigerant and foam, with co-funding from local industry, government, and/or other multilateral organizations. A combination of new and existing approaches could be used; for example, funds could be used to cover the incremental costs of refrigerant/foam recovery at an appliance recycling facility in an Article 5 country, while recycling fees can be placed on new appliances at the time of purchase to fund annual recycling activities, and revenue from carbon credits (earned through ODS destruction) could be used to finance the disposal of older appliances for which no recycling fee has been collected. Other innovative market-based mechanisms may also be possible, such as the allocation of new ODS "production credits" based on a certain ratio of ODS destruction, while allowing such production credits to be sold if they are not needed in-country. For example, a country that destroys 1,000 metric tons of CFC-12 could earn credit to produce a lesser amount of another ODS (e.g., HCFC-22), or sell such production credit to another country that is willing to pay for it. A working group should be established to pursue these ideas.

8. Should the mandate of the CDM or other carbon trading platforms be extended to include ODS destruction, methodologies for ODS destruction for certified emission reductions (CERs) on a GWP-weighted basis should be developed and approved. At least one such methodology has been developed to date. Coordination with the CDM, as well as multilateral/bilateral institutions should be pursued to improve dialogue on these issues. Any such destruction projects should also establish the requirements that may be required for HFC destruction post-2012.

Infrastructure, Equipment, and Geography

9. Recovery equipment and logistics (e.g., identifying cylinders or tanks for storage, transporting ODS-containing equipment or cylinders once material is recovered, securing climate-controlled storage space for recovered ODS) are fundamental to the success of an unwanted ODS management strategy. National collection sites are also needed, as well as access to reclamation and destruction facilities (either in-country, via export, or via mobile units). Very few countries will need their own high-capacity ODS destruction facilities, however, and countries with existing cement kilns may be able to outfit them to handle ODS. Mobile units (operated by private companies) may represent a viable option for destroying locally unwanted ODS, especially for countries that border the sea.

10. The export of ODS for destruction will be the most feasible option for many Article 5 countries, and will require only assistance in rendering Article 5 country governments "Basel-capable." A specific product that may be useful is an outreach communiqué or a newsletter provided through the Multilateral Fund that covers specific interpretation to Article 5 country representatives on an on-going basis. To this end, the responsible entity (i.e., Multilateral Fund, its Secretariat, or an appropriate Implementing Agency) might engage in dialogue with the Basel Convention Secretariat

to ensure that requirements are clear, categories of wastes and non-wastes are defined, and procedures for export streamlined to the extent feasible.

11. An international "clearinghouse" function could be provided through the Multilateral Fund to match supply with demand by connecting countries requiring ODS destruction to countries that have available capacity—with an effort to minimize transport distances and maximize effectiveness. Comprehensive data would be needed to identify and monitor global destruction capacity, and a web-based platform may be helpful to allow users—be they private companies or country governments—to easily locate nearby destruction facilities able to accept their ODS waste, and provide the necessary tools/resources to facilitate the transaction. By having a global clearinghouse, small quantities can be bulked up for maximum cost-effectiveness. Alternatively, countries with unwanted ODS (in some cases unused stockpiles or reclaimed material) may be able to identify customers willing to purchase such materials for on-going critical uses. Proceeds could then be used to offset other ODS destruction activities or implementation of alternatives.

Producer Responsibility Approaches

12. Producer responsibility schemes generally work well when there are few players involved (i.e., producers/importers) to allow for effective organization/management of the scheme. They also work best in countries where there is a strong public, a strong government, or both. Specifically, for voluntary producer responsibility schemes to succeed, there must be significant public pressure and/or a credible threat of regulatory action for programs to be successful. For producer responsibility schemes mandated by law, strong government is needed to ensure compliance through verification/enforcement activities and collaboration with industry. For government-mandated producer responsibility schemes, governments may collect fees and/or establish program criteria, but should allow industry to take the lead on setting up and administering programs, with third party auditing. Bottom-line-oriented companies that are familiar with the equipment/products are best suited to establish and run cost-effective programs for meeting the requirements set by national governments. Producer responsibility schemes are most effective when they are supported by a legal mandate, since this creates a level playing field, so that all producers must share the responsibilities and costs.

13. Producer schemes for bulk ODS or ODS-containing appliances should address both ODS and HFCs, for program longevity and maximum environmental benefit, and should require recordkeeping/reporting and routine audits, but avoid over-reporting to minimize burden. In addition, producer responsibility schemes for bulk ODS should ban disposable cylinders to ensure appropriate infrastructure for ODS collection, and should include an option for recycling/reclamation, for example, by building-in incentives for the recovery of unmixed, recyclable/reclaimable used refrigerant that is (or will be) in high demand (e.g., by offering a rebate).

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Appendix A: Non-Article 5 Country Case Studies

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I. Australia

1. Introduction

1.1 Country Information

With an area of 7,686,850 sq km, Australia is the world's smallest continent but sixth-largest country. The country's population of roughly 21 million concentrated along the eastern and southeastern coasts, as presented in Exhibit I-1. The majority of Australia's 7.1 million households live in state capitals (see Exhibit I-2).

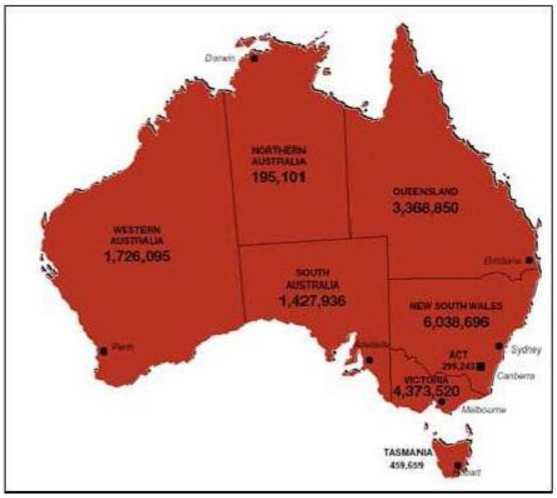

Exhibit I-1. Population of Australia by State (2006) Source: Australian Bureau of Statistics (2007).

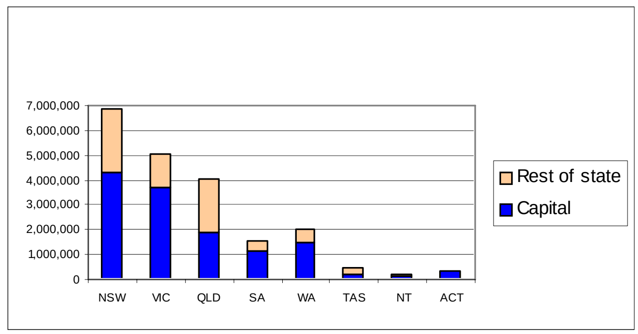

Exhibit I-2. Estimated Australian Population in State Capitals (2006) Source: Australian Bureau of Statistics (2007).

1.2 ODS Market Characterization

Refrigerants account for the greatest share of ODS use in Australia, with HCFCs representing the majority of both the country's refrigerant inventory and consumption. It is estimated that in excess of 11,000 metric tons of HCFCs are installed in existing refrigeration/air-conditioning (AC) equipment (see Exhibit I-3), with HCFC-22 representing 98% of this installed base. More than 2,500 MT of HCFC-22 were imported into Australia in 2005/2006 (in equipment and in bulk), representing an estimated 44% of all refrigerant imports, as shown in Exhibit I-4.[13] As the HCFC phaseout draws near, HCFC consumption will be forced to decline; the next HCFC import quota reduction will occur in 2008.

Over 60% of refrigerant imports in Australia are received in bulk, while the remainder is pre-charged in equipment. The major bulk refrigerant importers are:

- Actrol Parts Pty Ltd
- A-Gas (Australia) Pty Ltd

[13] There are no refrigerant producers in Australia; therefore, net imports represent total refrigerant consumption.

- Arkema Pty Ltd
- BOC Ltd
- Du Pont (Australia) Ltd
- Heatcraft Australia Pty Ltd
- Orica Australia Ltd

Exhibit I-3: Estimated HCFC Refrigerant Bank in Australia

Industry/Application Segment	Dominant Refrigerant	Estimated Bank (Metric Tons)
Commercial AC	R-22	2,488
	R-123	232
Residential & Light Commercial AC	R-22	6,953
Small & Medium Commercial Refrig.	R-22	555
Supermarket/Industry Systems	R-22	202
Cold Storage & Process Refrig.	R-22	576
Total		11,006

Source: Australian Department of Environment (2007a).

Exhibit I-4: Estimated Net Import of Refrigerants 2005/2006[a]

Imported Refrigerant	Net Imports (Metric Tons)
In Bulk	
HCFC-22	1,780
HFC-134a	1,613[b]
HCFC-123	28[c]
HCFC-142b	59[c]
HCFC-124	16[c]
Subtotal	*3,496*
In Equipment	
HCFC-22	750
HFC-134a	650
HFC-401a	25
HFC-404a	24.5
HFC-407a in equipment	11.4
HFC-407c in equipment	153
HFC-410A	802
Subtotal	*2,262.9*
TOTAL	5,759

[a] In addition to refrigerants, 422 metric tons of HCFC-141b foam blowing agent was also imported in bulk in 2005.

[b] HFC-134a is reported separately, all other bulk HFCs are aggregated and reported by CO2-e. In 2006, 2,959 ktCO2-eq of other HFC refrigerants and solvents were imported in bulk.

[c] 2006 data are not available yet; figures shown are for 2005.

Source: Australian Department of Environment (2007b).

The Australian market for domestic refrigeration and small AC equipment is almost entirely supplied by imports. Only six refrigeration/AC equipment manufacturers operate in Australia, producing primarily larger split systems and smaller roof mounted systems (>15 kW) in close control applications, as well as some customized systems for specialized applications. An estimated 35% of the product in these small commercial systems is manufactured in Australia.

There are nearly 700 importers of pre-charged refrigeration/AC equipment in Australia, with the top 20 importers representing the majority of the market. Most of the leading international manufacturers of refrigeration/AC equipment supply imported product to the Australian market, where they maintain distribution and service arms. Many small importers also source AC products from manufacturers in China. These importers tend to supply the market on a seasonal basis with smaller, lower priced products. Within recent years, sales of split system AC equipment have increased dramatically, with more than 100 brands of such systems available on the Australian market.

Halons are only used in a small number of fire extinguishing systems, as the government mandated the decommissioning of all halon systems by 31 December 1995. Halons are no longer imported into Australia, except under permit in pre-charged fire extinguishing system onboard aircraft. A small number of fire extinguishing systems use HCFCs (e.g., NAF-S, NAF-P), but these systems will gradually be replaced when cylinders come due for inspection, and the price of HCFCs increases (in response to tightening HCFC import quotas). HFC-227ea is now the predominant agent used in volatilizing liquid fire extinguishers.

2. Relevant Legislation and Regulations

All legislation applicable to the handling and disposal of ODS are included in the following Acts:

- *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* (amended in December 2003, July 2005, and August 2005)
- *Ozone Protection and Synthetic Greenhouse Gas (Import Levy) Act 1995* (2003)
- *Ozone Protection and Synthetic Greenhouse Gas (Manufacture Levy) Act 1995* (2003)

The *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* mandates the phase-out of ODS and, among other things, provides for the responsible management of ODS and SGG to minimize their impact on the atmosphere. In addition, Section 45B of the Act provides for a prohibition on the venting of refrigerants. Together the Acts control the manufacture, import and export of all ODS.[14] The 2003 amendments to the Act incorporate synthetic greenhouse gases (SGGs) and, following delegation of power from the states, provides authority to regulate the sale, purchase, use, storage and disposal of ODS and SGGs. They also control imports of pre-charged refrigeration and AC equipment containing HFC and HCFC refrigerants (as of 2004), and grant the Commonwealth the power to create a nationally consistent system to control the end-uses of these gases.

In short, legislation established the following requirements, each of which are described further below:

- Licensing fees for the import, export, and manufacture of ODS and SGGs

[14] Specific ODS controlled are: chlorofluorocarbons (CFCs); halon 1211, 1301 and 2402; carbon tetrachloride; methyl chloroform; hydrobromofluorocarbons (HBFCs); hydrochlorofluorocarbons (HCFCs); methyl bromide; and bromochlormethane (BCM). Two types of SGGs are controlled: hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

- Participation of refrigerant importers in a product stewardship scheme
- Import levies on ODS and SGG
- Reporting requirements for importers
- Technician licensing in the refrigeration/AC and fire protection sectors
- Trading authorization for the purchase of ODS and SGG

There are four types of licenses that are issued for the import, export, or manufacture of ODS and SGGs, as shown in Exhibit I-5. Licensing fees range from AU$3,000 to AU$15,000. As of April 2004, importers of pre-charged refrigeration/AC equipment containing HCFCs and HFCs must also obtain a license. Licenses are valid for up to two years, except for Essential Use Licenses which are valid up to one year, and are managed by the Australian Government.

Exhibit I-5: Licenses for the Import, Export, and Manufacture of ODS and SGGs

License Type	Description	Period of Validity (Years)	Cost (AU$)	Cost (Approximate US$ Equivalent)[a]
Controlled Substances License	Importers, exporters, or manufacturers of HCFCs, HFCs, PFCs, and methyl bromide	2	AU$15,000	~US$13,100
Essential Use License	Importers, exporters, and manufacturers of CFCs, halons, methyl chloroform, carbon tetrachloride, and BCMs; only granted for a strictly limited range of uses approved by the parties to the Montreal Protocol	$\leq$ 1	AU$3,000	~US$2,570
Used Substance License	Importers and exporters of used/recycled HCFCs, methyl bromide, BCMs, CFCs, halons, carbon tetrachloride, and methyl chloroform	2	AU$15,000	~US$13,100
Pre-Charged Equipment License	Importers of pre-charged refrigeration/AC equipment containing HCFCs and HFCs	2	AU$3,000	~US$2,570

[a] Exchange rate retrieved December 17, 2007 (UCC 2007).

As a condition of refrigerant import licenses, importer must participate in an approved product stewardship scheme (discussed in detail in Section 4).

Import levies and reporting requirement also apply to imports of bulk ODS and, as of 2004, to bulk SGGs and ODS/SGGs contained in pre-charged equipment. The current import and manufacture levy rates are presented in Exhibit I-6 (applicable to bulk and pre-charged equipment). According to the law, the number of pre-charged units, mass of charge and type of gas must be reported.

Exhibit I-6: ODS and SGG Import Levies (on Bulk and Pre-Charged Equipment)

Controlled Substance	Levy Rate (AU$)	Levy Rate (Approximate US$ Equivalent)[a]
HCFCs	$3,000 per ODP ton	US$2,570 per ODP ton
Synthetic Greenhouse Gases (including HFCs)	$165 per ton	US$140 per ton
Methyl Bromide	$135 per ton	US$115 per ton

[a] Exchange rate retrieved December 17, 2007 (UCC 2007).

Also under the 2003 amendment, technician licensing became mandatory beginning July 2005. Previously, the use of ODS and, to a lesser extent, SGG, was regulated at the state level and a voluntary industry operated national technician licensing scheme was in place. State based regulation was replaced by the national scheme in 2005, with strong support from industry and state governments.[15] The new law requires technician handling ODS and SGG refrigerants to obtain an Australia-wide competency-based license to operate; without a license, they may not purchase ODS/SGG refrigerant. Four types of technician licenses are specified for refrigeration/AC technicians, as presented in Exhibit I-7. The Australian Government charges a technician licensing fee of AU$100, which must be renewed every 2 years. Temporary licenses valid for one year were issued to working technicians without adequate qualifications. Several one-year transitional licenses are also available in other industry-specific sectors until competency requirements are established (e.g., aviation, marine, transport).

Exhibit 1-7: Refrigeration and Air-Conditioning Technician Licenses

License	Entitlement of Licensee
Full refrigeration and air conditioning license	To handle a refrigerant for any work in the refrigeration and air conditioning industry, other than the automotive industry
Automotive air conditioning license	To handle a refrigerant for any work on air conditioning equipment fitted to the cabin of a motor vehicle
Restricted split system air conditioning installation and de–commissioning license	To handle a refrigerant for the installation and de–commissioning of a single–head split system of less than 18kW
Restricted domestic refrigeration and air conditioning appliances license	To handle a refrigerant for any work on domestic refrigeration or air conditioning equipment

The mandatory refrigeration/AC technician licensing scheme is administered by the Australian Refrigeration Council Ltd, (ARC)—an industry board appointed in June 2005 by the Australian Government. The four licenses listed in Exhibit I-7 are issued by ARC subject to presentation of the relevant trade qualification. Obtaining the trade qualification includes completion of an endorsed training course (of up to 900 hours), which includes formal and on-the-job training, specific to the license applied for. ARC conducts compliance audits at the company level. Currently, there are approximately 60,000 licensed individuals and service companies, including roughly 35,000 full licensed technicians and 7,000 transitional licensed technicians.

In addition to licensing for technicians, the Act and its attendant regulations require contractors wanting to buy refrigerant to obtain a trading authorization. As part of the authorization, individuals must:

- Have business premises equipped and operating so as to be able to handle and prevent avoidable emissions of refrigerant;
- Ensure only licensed people handle refrigerants;
- Keep up-to-date records showing the amounts of refrigerant bought, sold and recovered during each quarter;
- Have working leak detectors, vacuum pumps, and recovery units; and
- Ensure that refrigerants are handled in accordance with the Australian Standards that apply.

[15] The Australian Government provided $2 million towards a voluntary accreditation scheme for technicians, as part of the Greenhouse Gas Abatement Programme. This initiative was industry run, by the National Refrigeration and Air Conditioning Council (NRAC), and was designed to increase technician skills and reduce preventable emissions to the atmosphere. A mandatory national scheme was established in 2005, overtaking the voluntary industry scheme and the state regulatory requirements.

Similar laws apply to fire retardants, including halons. Specifically, as of July 2005, technicians must hold a license for the handling of all gaseous fire extinguishing agents. Six types of license are available, all of which are administered by the Fire Protection Association (FPA) Australia:

- Portable Fire Extinguisher Maintenance License
- Fixed System Installation and Decommissioning License
- Fixed System Testing and Maintenance License
- Recovery, Reclamation, Fill and Recycling License
- Warehouse Maintenance License
- Control Systems Installation, Commissioning and Decommissioning License

There are an estimated 2,500 licensed technicians in the fire extinguishing sector.

The 2003 amendments to the Act also reference numerous Australian and industry standards applicable to the handling of refrigeration, air conditioning and fire extinguishing equipment. These include codes of practice applicable to residential, automotive, and commercial air conditioning/refrigeration systems.[16]

Finally, a regulatory ban was placed on the import of disposable refrigerant recharge canisters through customs regulations. This effectively requires the use of re-usable and returnable cylinders for refrigerant transport and storage.

3. ODS-Containing Appliances

3.1 Background

Australian legislation provides for a ban on the intentional release of ODS and SGG refrigerant from all sources, including household refrigerated appliances. But apart from the prohibition on venting, no nationwide programs or processes govern the collection, handling, or treatment of refrigerated appliances at the end of life (EOL). No regulatory requirements are in place to mandate the recovery and destruction of ODS foam blowing agents from domestic refrigerators/freezers.

3.2 Description of Process/Program

Municipalities, retailers, and scrap yards are most apt to collect EOL appliances. The procedures and practices used by these entities in collecting and disposing of household appliances are highly variable and not well understood. Typically, the durable components of appliances are sold on recycling markets, but the extent to which refrigerant is recovered is unknown. Based on anecdotal information, refrigerant recovery is not commonly practiced on small equipment at EOL.

In theory, an industry-run product stewardship scheme provides a financial incentive (AU$5.00/kg) for the return of recovered refrigerant for destruction (as described in more detail in Section 4), which could incentivize recovery from home appliances. But in practice, this rebate is not enough to incentivize refrigerant recovery from equipment with such small charge sizes. For example, if a household refrigerator contains 150 grams of refrigerant when fully charged, and at least 20 grams of refrigerant are lost in hoses during the recovery process, technicians can only receive a maximum of AU$0.65 per unit.

[16] Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995.

Given the small amount of refrigerant recoverable from domestic refrigerators, and the relatively small financial gain that can result by collecting it for destruction (relative to the commercial sector), the practice of recovering refrigerant from such equipment is commonly viewed as non-viable.

Because there has recently been a rapid growth in the use of split system air conditioners, which have a considerably greater refrigerant charge than other AC appliances, it is believed that these units are more likely to be installed and removed by licensed technicians, and are more likely to have their refrigerant recovered at end of life.

3.3 Costs

There are no costs associated with the recycling/disposal of household refrigerated appliances in Australia, since no formal programs or processes are in place to do so. Currently, such appliances are likely to end up at scrap yards, where metals and other valuable parts are stripped and sold onto the secondary/recycling market.

3.4 Statistics on Collection

No statistics are available on the number of household appliances disposed each year, or on the quantity of refrigerant CFC/HFC recovered/destroyed from them. No foam is recovered from refrigerators/ freezers, since there is no mandate to do so.

3.5 Challenges

Without a dedicated program in place to promote the recovery of ODS from appliances, there is reason to believe that very limited recovery of refrigerant from such units is occurring at end of life. Although the product stewardship scheme applies broadly to all refrigeration/AC sectors, it inherently incentivizes the recovery of refrigerant from large systems over smaller ones, effectively leaving a void for the responsible handling of refrigerant contained in household appliances. Certainly, all ODS foams contained in appliances are being vented to the atmosphere as there is no mandate for foam recovery/destruction. This problem is recognized in Australia, but the solution needed to address it is not deemed feasible at this time from a cost/benefit perspective.

4. Bulk ODS Refrigerants

4.1 Background

As mentioned in Section 2, in 2005 it became a condition of the import license for all importers of bulk HCFC/HFC refrigerants and for importers of pre-charged refrigeration/AC equipment to demonstrate product stewardship for the products they import, by either having their own program or by participating in an established scheme. A voluntary product stewardship scheme (PSS) had already been established by industry shortly after the *Ozone Protection and Synthetic Greenhouse Gas Management Regulations (1995)* to encourage the safe disposal of waste refrigerant.

Specifically, a PSS was established in 1993 by Refrigerant Reclaim Australia (RRA), a not-for-profit organization that works nationally with the refrigeration industry to recover and destroy unwanted ODS and SGG refrigerants. Under the PSS, industry members do not have to cover all of the costs of recovery; costs incurred recovering refrigerant from systems may be legitimately charged to customers, and RRA provides rebate for the return of recovered refrigerant by authorized companies and persons.

To destroy unwanted refrigerant and decommissioned halon (per the mandatory removal of halon, discussed in more detail in Section 6), a plasma arc facility (PLASCON) was constructed in Tottenham, just outside of Melbourne. This facility is operated by DoloMatrix on a commercial basis, and is co-located with the National Halon Bank (NHB).

4.2 Description of Process/Program

Refrigerant Reclaim Australia (RRA) is the product stewardship organization for the Australian refrigeration and air conditioning industry. RRA works nationally with industry to share the responsibility for, and costs of, recovering, reclaiming and destroying surplus and unwanted refrigerants. Since the introduction of the product stewardship requirement in 2005, RRA has worked closely with importers of equipment charged with refrigerant gases to ensure they are able to meet this condition of their import license.

Structure of RRA

RRA has an eight-member Board of Directors, which is a vertical slice of the refrigeration and air conditioning industry. The structure is designed to ensure equitable industry representation and allow for broad understanding of industry needs. The Board's representatives are drawn from:

- importers of bulk refrigerant
- wholesalers of refrigerant
- contractors from the commercial sector
- contractors in the automotive sector
- importers of equipment containing refrigerant

RRA's membership includes the major industry associations. All importers and wholesalers of ODS refrigerants participate in the program.
RRA continually assesses its performance to ensure that it is meeting its objectives. RRA's funds are held in a trust and are subject to ongoing independent audits.

Under RRA's structure, industry members:

- Rent, buy or place a deposit on a recovery cylinder from a refrigeration gas wholesaler.
- Use the cylinder to recover used and contaminated (non-flammable, non-toxic) refrigerants from systems serviced.
- Drop off full cylinders to the refrigeration wholesaler, who weighs recovered refrigerant.
- Take back emptied or new cylinders from wholesaler.
- Collect credit for each kilogram of recovered refrigerants.

A-Gas' System for Refrigerant Collection

One of the largest bulk refrigerant importers in Australia, A-Gas, has bar-coded over 12,000 reclaim cylinders using a system that tracks the movement of each cylinder. To optimize system efficiency, A-Gas would like to see each cylinder returned with recovered refrigerant three times per year; but currently, cylinders make it back to A-Gas only once or twice per year. A-Gas handles about 10-14

More specifically, the major bulk ODS importers distribute refrigerant in reusable and returnable cylinders.[17] "Reclaim" cylinders are used by technicians to recover unwanted (i.e., contaminated or mixed) refrigerant, which are then returned at 150 refrigerant collection points across the country, available through the industry's existing wholesaling branch network. Upon return, a bounty of AU$5/kg (US$4.30/kg) is paid to contractors. Wholesaler branch networks are required to conduct tests on each cylinder to verify that it does not contain flammables, water or ammonia (the cheapest commonly available substances, which could be used to cheat the system).[18] Once tested, refrigerant is decanted into bulk storage and transported to RRA's secure bank in Tottenham, where it is destroyed

[17] A regulatory ban was placed on the import of disposable refrigerant containers through customs regulations, which effectively requires the use of re-usable and returnable cylinders for refrigerant transport and storage.

[18] The pressure required to charge a detectable mass of nitrogen or carbon dioxide into a refrigerant recovery cylinder would exceed the safety valve setting of about 42 bar; the vapor pressure of R-22 is about 12 bar.

using the Australian-developed plasma-arc process. Prior to destruction, RRA assays every batch of waste ODS received from the wholesalers. To date, contamination has not posed a problem for the destruction facility and there has been no evidence of tampering (e.g., boosting refrigerant content with nitrogen or propane to take advantage of rebate system in place).

The PLASCON High Temperature Destruction Process

The PLASCON destruction facility uses an electrical discharge in argon gas to create a high temperature plasma stream into which waste refrigerants and halon are injected as vapor. The injected waste is completely ionised into its constituent atoms and the resulting gases are neutralized and quenched with caustic soda and water to form a sodium

The PLASCON destruction facility uses a high temperature plasma stream to destroy the refrigerant. It is capable of destroying up to 50 metric tons/month of refrigerant gases or halon. There is currently no reclamation facility in operation in Australia, although some capacity exists.[19]

Local government and landfill operators also collect gas cylinders and other waste chemicals before they enter the landfill. Arrangements are in place for any cylinders containing ODS identified at landfills to be collected and sent to RRA for disposal.

Exhibit I-8. A-Gas' Laboratory for Testing Recovered Refrigerant

[19] Solvents Australia owns distillation columns designed for reclamation but the facility has been moth-balled since the 1990s, when the decision was made by RRA to destroy all unwanted refrigerant. This decision was based on economics; reclamation (estimated at AU$2-4/kg) was simply not viable given the low price of virgin HCFC and HFC refrigerants; however, in future, as the supply of R-22 decreases as a result of the HCFC phaseout, the economics may change.

Exhibit I-9. Refrigerant Decanting into Bulk Storage at A-Gas, Prior to Transport to RRA for Destruction

4.3 Costs

RRA was initially funded by a $1.00/kg levy on the bulk import and sale of ODS refrigerants (i.e., CFCs and HCFCs). In 2004 the levy was extended to SGG refrigerants (i.e., HFCs and PFCs); it was also extended to refrigerants imported in pre-charged equipment and sold in Australia. During this period there was substantial growth in the volume of refrigerant being imported in pre-charged equipment. The levy was increased to $1.50 in 2007 and, in December 2007, RRA filed an application with the Australian Competition and Consumer Commission to raise the levy from $1.50/kg to $2.00/kg (Commonwealth of Australia 2007).

In 2004, Refrigerants Australia agreed to a levy on all HCFC/HFC refrigerant imports in order to fund the PSS on a cost recovery basis.[20] The Australian Government endorses the PSS approach at the Australian Competition and Consumer Commission reviews. Levy costs are ultimately passed on to consumers. In addition, costs incurred recovering refrigerant from systems may be legitimately charged to customers.

Given the diversity of volumes and companies importing refrigerant, a two tiered fee structure was devised for refrigerants. Companies that import less than 100 kilograms a year (of which there are about 450) pay a flat annual fee of $100, while companies importing greater than that amount pay a levy per kilogram each quarter. These fees are in addition to the levies paid to the government (as shown in Exhibit I-6).[21]

[20] The current bulk price of HCFC-22 is approximately AU$16/kg, so the levy represents less than 10% of the product value.

[21] Small companies are responsible for roughly 20% of pre-charged equipment imports, but only 1-2% of total ODS imports.

RRA determines the rebate paid to wholesalers for the recovery of waste ODS and sets the minimum rebate amount for contractors/technicians (currently at $5/kg). Wholesalers can offer higher rebates to their customers if they wish.

The PLASCON costs around AU$1.6 million (including installation and training). The current fee for destruction is around AU$7/kg inclusive of chemical inputs (Argon and NaOH) and electricity. The equipment can also destroy PCB liquid, with minor modification.

It is also important to consider the costs of Australia's refrigeration/AC technician licensing scheme, which is a critical component to ensuring refrigerant recovery/destruction. Initially, the Australian Government provided funding to establish a voluntary national accreditation system. Further funding was provided to establish the mandatory licensing scheme. Today, ARC's outreach, enforcement, and administrative operations are funded on a cost recovery basis from licensing fees paid to the Australian Government (AU$100/license every 2 years).

4.4 Statistics on Collection

RRA has recovered about 1,595 metric tons of refrigerant between the start of the program in 1993 through the end of June 2006. About another 500 metric tons of refrigerant have been collected from June 2006 through October 2007. The majority of refrigerant recovered is HCFC-22 (see Exhibit I-10). In the 1990s, some refrigerant recovered by RRA was reclaimed to new specification, or reprocessed as feedstock by the manufacturer. Since then, however, all refrigerant collected by RRA has been destroyed.

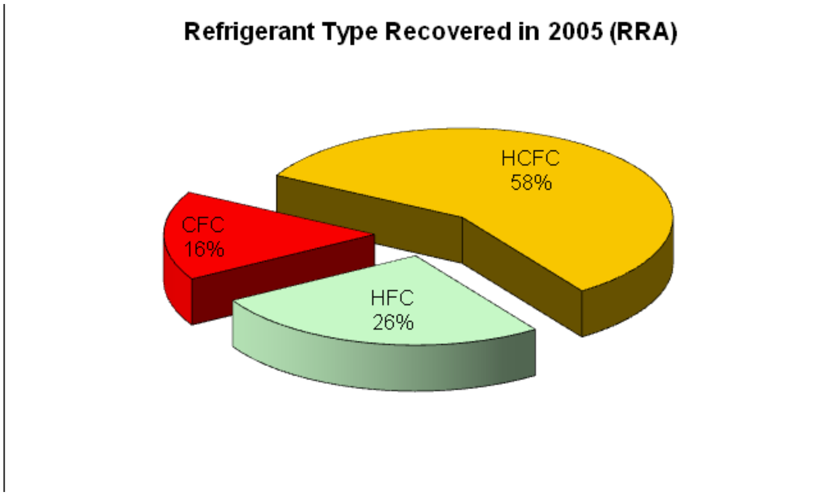

Exhibit I-10: Refrigerant Type Recovered in 2005 (RRA 2007)

Exhibit I-11 presents the monthly mass of refrigerant recovered between 2001 and 2006. In the last reported year, 2005-2006, 298 metric tons of refrigerant were collected. The volume of recovered refrigerant doubled from 2002/2003 to 2005/2006, further growth of 20% is expected in the year ending June 2007.

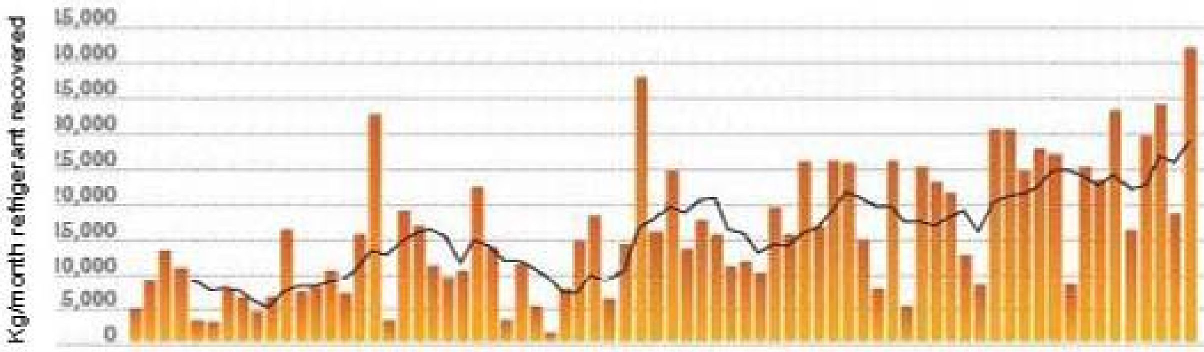

Exhibit I-11: Monthly Kilograms of Refrigerant Collected by RRA, 2001-2006

The amount of refrigerant recovered and returned to RRA is expected to continue to grow between 2006 and 2009, as an increasing number of HFC systems—namely split system AC systems—reach retirement. Indeed, beginning in 2009/2010, a growth of 50 metric tons per annum is forecast by RRA to allow for the return of refrigerant from decommissioned domestic split systems, which have recently and rapidly penetrated the Australian market (see Exhibit I-12). These systems are only just reaching the end of their useful lives and are poised to become a major source of recovered refrigerant in future.

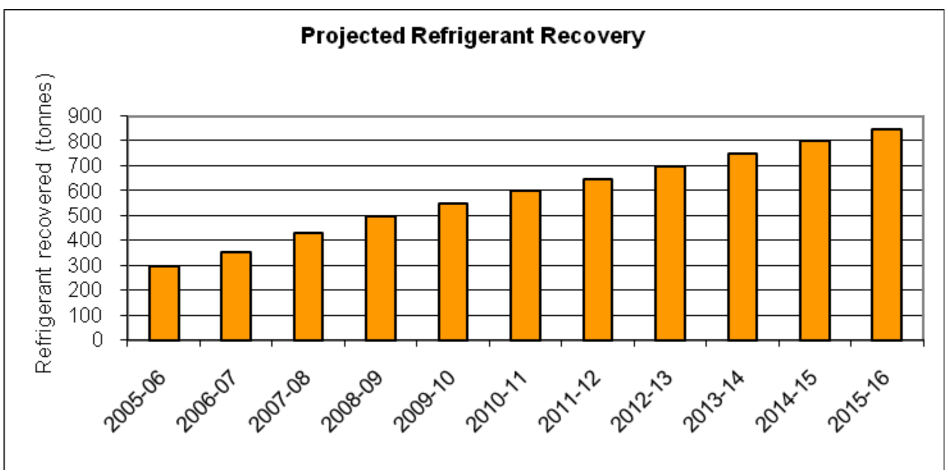

Exhibit I-12: Projected Refrigerant Recovery to 2016 (RRA 2007)

4.5 Challenges

The product stewardship scheme implemented by RRA has been very successful and internationally acclaimed. Indeed, in May 2006, RRA was awarded a prestigious Climate Protection Award from the United States Environment Protection Agency recognizing "leadership, personal dedication and technical achievements in protecting the earth's climate." However, RRA reports a number of ongoing challenges:

- Managing the increasing number of collection points in a cost effective manner as the program expands;
- Better understanding and managing the different collection processes and their effect on our return rate and costs;

- Maintaining good relationships with the contractors to encourage continued active participation in the program;
- Better understanding the nature of the market for recovery, reuse, and return and the potential volume available;
- Improving internal systems and the customer interface to achieve improved customer service and lower costs; and
- Securing long-term cost competitive services to match the projected growth in the volume of used and contaminated refrigerant being recovered.

In addition, the universal destruction of refrigerant collected by RRA threatens to bring future scarcity issues. In particular, if all recovered R-22 continues to be destroyed and not reclaimed, Australia may face undue abandonment of equipment as the HCFC phaseout advances and the import quota is reduced to zero. If/when the demand for R-22 becomes much greater than available supply, RRA may need to incorporate a reclamation component into its existing scheme. One idea could be to offer a higher rebate on the return of used, unmixed R-22 refrigerant.

4.6 Lessons Learned

Australia has achieved great success in implementing a product stewardship scheme for the recovery of unwanted refrigerant that pays for itself without overburdening industry or consumers. Australia's strong, highly organized industry has been pivotal in this success, developing infrastructure early on to minimize ODS emissions and actively shape future regulations that affect them. The result is a system that works well for the environment and for industry.

The most fundamental keys to success have been the combination of government regulation, industry education, and financial incentives. In particular:

Government Regulation

- A regulatory framework is needed to set a level playing field. In Australia, national regulations require all players—from the technicians to retailers and bulk importers—to contribute and share in the burden.

Industry Education

- Incentives: offering a rebate on recovered refrigerant incentivizes technicians and wholesalers to do the right thing. Regulations alone are not enough because enforcement cannot effectively monitor the compliance of such a large and diffuse sector. At a minimum, the economic burden associated with refrigerant destruction must be lifted from technicians/contractors.
- Technician certification has provided the necessary backdrop to the PSS incentive structure. It educates contractors about the need to recover refrigerant while also benefiting consumers by ensuring minimum trade competencies.

Financial Incentives

- By funding the PSS through a levy system, a manageable economic burden is imposed on consumers. It is important that the levy be set appropriately, so that it sufficiently funds the PSS without creating perverse incentives. For example, if the levy were to be increased from $1.50/kg to $30/kg, there would be a sharp decline in the import/sale of virgin refrigerant (which would negatively affect the inflow of PSS funds) and a sharp increase in the reuse of refrigerant—including contaminated or mixed refrigerant.

- An economically viable system for collecting unwanted refrigerant has been established by transporting recovered refrigerant through the same distribution channels as new product.
- RRA operates efficiently through one coordinated scheme, saving industry members time, money and effort.

Industry stakeholders in Australia made clear that the successes achieved in Australia cannot be replicated in other countries without considering the style of national industry elsewhere. For example, important considerations include:

- Are disposable refrigerant cylinders banned? (Recovery of refrigerant will be difficult if not, given there will be no built-in mechanism for returning unwanted refrigerant.)
- Is there a viable reclamation market? (Reclamation in lieu of universal destruction will complicate the system.)
- How many industry players are involved? (The more players, the more complex the administrative procedures and the more difficult the decision-making process.)

5. Mobile Air Conditioning

5.1 Historical Perspective

Automotive technicians dealing with repair of mobile air conditioners are required to hold refrigerant handling licenses. The same product stewardship scheme and rebates apply to the recovery of ODS and SGG as described in section 4.

5.2 Description of Process/Program

Generally, MAC refrigerant recovered during service events is reused. While no nationwide program or process is in place to recover refrigerant remaining at vehicle end of life, technicians are required to recover refrigerants during servicing and to return unwanted refrigerant for disposal.. Further, it is mandatory for importers of equipment and bulk refrigerant to participate in a Product Stewardship Scheme – all have elected to join RRA.

One company operates a refrigerant recovery program from end of life vehicles. Fluoroclaim, a small Sydney-based company that specializes in the repair of refrigerant recovery equipment while operating a refrigerant recovery service from motor auction salvage yards as a supplementary business. Fluoroclaim estimates that over 80% of end-of-life motor vehicles pass through salvage yards in New South Wales, which translates to about 150,000 vehicles/year. Fluoroclaim collected refrigerant from 11,500 vehicles that reached end-of-life in 5 auction yards around NSW over a 9-month period in 2007. Fluoroclaim recovers MAC refrigerant from six vehicles simultaneously using recovery-only devices mounted on the back of a truck. The recovery process takes about 10 minutes for the six vehicles (see Exhibit I-13).

Approximately 8% of the MACs recovered by Fluoroclaim during the first nine months of 2007 contained CFC refrigerant. On average, the recovered charge was about 0.5 kg/vehicle (roughly 70% of original charge, on average). Fluoroclaim typically sends 500 kg of unwanted refrigerant to RRA for destruction each month.

Exhibit I-13: Fluoroclaim's Mobile MAC Recovery System (2007)

5.3 Costs

As a wholesaler, Fluoroclaim receives $15/kg from RRA's product stewardship program; of this amount, the subcontractor that performs the recovery for Fluoroclaim receives $5/kg. As described above, RRA's PSS is funded through a levy on the import of refrigerant.

5.4 Challenges

Due to the small size of MACs and the average amount of refrigerant recoverable at ELV (i.e., 500 grams), it is not economically viable to operate an MAC recovery operation as a primary business. Fluoroclaim has been able to make a business out of MAC recovery, but only as a supplemental business operation but largely because it is located in Sydney, the nation's largest population center, where 300 vehicles are brought to salvage yards each week. In other parts of the country, no companies are known to conduct similar operations.

6. Halon Banking

6.1 Background

Under the Montreal Protocol the production and consumption of halons were banned in non-Article 5 countries from 1 January 1994 except for essential uses. Under the Ozone Protection Act 1989 Australia ceased importation of halons from 31 December 1992. Continued use of halons in non-essential equipment was banned in most jurisdictions from 31 December 1995. Today, there are fewer than 40 Australian-flagged vessels that still carry halon.

6.2 Description of Process/Program

The Government owned and operated National Halon Bank (NHB) was established in 1993 as a result of the December 1992 Prime Minister's Environment Statement. In the Statement, the Prime Minister noted that the decommissioning of halon fire fighting systems and portable equipment in accordance with Australia's phase out of halon was resulting in the rapid accumulation of halon stocks. A halon bank was needed to collect and store halon under controlled conditions to prevent accidental release.

Thus, the NHB was established to arrange the collection and recycling or disposal of decommissioned halon. Specifically, fire brigades and other industry specialists collect halon free of charge from individuals and small businesses and send it to the NHB. The NHB reclaims good quality halon to 99.6% purity and stores it for future use by the domestic and international aviation and reasonable maritime uses. The Australian Defence Forces maintain a separate stock to meet operational requirements. Any suspect or mixed batches of halon are destroyed by the NHB at the PLASCON facility.

While most of the country's halon has been decommissioned already, the NHB continues to receive about 10 metric tons/year of waste halon for disposal or reclamation.

6.3 Costs

The NHB is fully funded by the Australian Government. The main cost is destruction at around AU$7/kg, followed by transport and administration.

A service charge, sufficient to fund the collection, storage and disposal of the halon was levied on deposits of halon 1211 and some deposits of halon 1301. Private individuals and small businesses were able to surrender their halon at no cost.

6.4 Statistics on Collection

Only very small quantities of halon are now being collected for disposal - less than 10 metric tons per annum. Annual amounts collected since inception are shown in Exhibit I-14.

Table 1: National Halon Bank Collection

Year	Metric Tons Collected	
	Halon 1211	Halon 1301
1992/93	7.30	-
1993/94	101.48	28.36
1994/95	365.36	228.87
1995/96	444.74	110.43
1996/97	251.55	134.55
1997/98	63.88	35.80
1998/99	31.63	21.83
1999/00	32.69	20.42
2000/01	37.20	5.53
2001/02	39.65	20.12
2002/03	13.52	3.71
2003/4	14.76	6.46
2004/5	8.94	1.69
2005/6	8.08	1.11
2006/7	6.06	1.44
2007/8 estimated	1.58	1.58
Total	1,421	622
Destruction	1,300	172
Banked for Re-Use	121	450

II. Canada

1. Introduction

1.1 Country Information

Canada, a federation with ten provinces and three territories, covers a total land area of 9,093,507 sq km. It has a population of 33.1 million people, comprising over 13.6 million households. Today, nearly 80% of Canadians live in urban areas, with Toronto, Vancouver and Montreal being the most populous. Since 1931, Canada has experienced a steady rise in urbanization, with a current urbanization rate of about 81%.

Exhibit II-1: Provinces of Canada Source: Wikimedia Commons (2008a).

1.2 ODS Market Characterization

As one of the early signatories to the Montreal Protocol, Canada has made significant progress in reducing the emissions of ODS through: strong control measures implemented by federal, provincial and territorial governments; voluntary actions by industry; and changes in technology. Estimates of the size of existing CFC banks in Canada vary widely. Environment Canada has estimated that there are approximately 7,000 metric tons of CFCs remaining in Canada's stationary refrigeration sector; while the Heating, Refrigerant, and Air Conditioning Institute of Canada has estimated only 2,000 MT of CFCs remaining. As for HCFCs, the current volume of the HCFC bank is unknown, although the majority of ODS that continue to be used is HCFC-22 in refrigeration and air-conditioning equipment.

2. Relevant Legislation and Regulations

In Canada, the federal and provincial/territorial governments share regulatory responsibility for ozone layer protection. Environment Canada implements the provisions of the Montreal Protocol on behalf of the Canadian federal government through the Ozone-Depleting Substances Regulations, 1998 (ODSR 1998) and the Federal Halocarbon Regulations, 2003 (FHR 2003), both under the Canadian Environmental Protection Act, 1999 (CEPA 1999). Where ODSR 1998 establish control measures on the supply side (i.e., production, importation, and exportation of specific ODS), provincial/territorial regulations apply control measures on use through recovering, recycling, and reclaiming requirements in their respective jurisdictions (Environment Canada 2002).

Specifically, provinces are responsible for restricting emissions of CFCs and halons, while mandating recovery. It is prohibited to vent refrigerants in all Canadian jurisdictions. Some provinces have also banned the refilling of automotive air-conditioning systems or implemented other controls to further reduce ODS emissions. For example, the British Columbian Ministry of Environment (formerly the

Ministry of Water, Land and Air Protection) has passed the *Ozone-Depleting Substances and Other Halocarbons Regulation (1993)*, which prohibits the venting of ODS and requires that leaks be repaired as soon as they are detected. ODS must be recovered as efficiently as possible (during repair work or before an ODS-based product is discarded), and either recycled or held for destruction.

To ensure the success of Canada's ozone layer protection program, Canada has developed and implemented a *National Action Plan (NAP) for the Environmental Control of Ozone-Depleting Substances and their Halocarbon Alternatives*. The NAP identifies tasks necessary to ensure that consistent, progressive actions take place to control all aspects of pollution prevention and all industry sectors using ozone-depleting substances and their halocarbon alternatives (HFCs and PFCs). In 2001, the NAP was updated and approved to reflect the status of previous tasks and identify new tasks for the implementation of the Phase-Out Strategy.

The Canadian Council of Environment Minister's (CCME's) *Strategy to Accelerate the Phase-Out of CFC and Halon Uses and to Dispose of the Surplus Stocks (Phase-Out Strategy)* (2001) consists of specific approaches to phase-out uses of CFCs and Halons and to dispose of the surplus substances. This phase-out strategy applies federal "no-venting" regulations to federal (government) buildings and operations, and specifies two broader components. The first provides the "infrastructure" needed to achieve the objectives of the Strategy, and includes the extension of producer responsibility programs, consideration of market force instruments and communication of stakeholder information. The second component of the Phase-Out Strategy consists of specific phase-out approaches for individual industry sectors. In 2001, the NAP was updated and approved to reflect the status of previous tasks and identify new tasks for the implementation of the Phase-Out Strategy. The NAP is the tool used to implement the Phase-out Strategy, and as a document from the CCME, is applicable to all federal, provincial, and territorial jurisdictions in Canada.

Forming a part of the Extended Producer Responsibility initiative, Refrigerant Management Canada (RMC) is a voluntary, industry-led program that manages the environmentally responsible disposal of Canada's stocks of surplus ODS refrigerants for the Canadian refrigeration and air conditioning industries, serving as a model for other industry sectors. The RMC program is a key element of the Phase-Out Strategy and the National Action Plan. The Federal Government agency supports Extended Producer Responsibility as a policy option that is capable of achieving pollution prevention; toxics use reduction; waste minimization; and increasing the efficiency of resource use throughout the life cycle of products.

The phase-out approaches will become regulatory requirements once the federal, provincial and territorial governments adopt regulations to implement the tasks identified in the National Action Plan. The approaches are as follows:

- Encourage industry to develop Extended Producer Responsibility programs and participate in their development;
- Develop and implement control measures needed to support the extended producer responsibility programs;
- Develop awareness programs to inform stakeholders of the Phase-Out Strategy;
- Ensure that control measures developed to implement the Phase-Out Strategy form a clear and comprehensive backdrop among jurisdictions; and
- Implement the sector specific control measures and other activities identified in the Phase-Out Strategy.

Phase-Out Strategy for the refrigeration/AC sector is summarized in Exhibit II-2.

Exhibit II-2: Phase-Out Strategy for the Air Conditioning & Refrigeration Sector

Sector	Approach
Mobile Air Conditioning	Prohibit refill with CFCs as soon as possible.
Mobile Refrigeration	Prohibit refill with CFCs effective 2003.
Household Appliances	Enhance implementation of existing recovery programs. If necessary, add a ban on converting equipment to use CFCs.
Commercial Refrigeration & Air Conditioning	Staged CFC refill ban effective by year: 2004: Equipment < 5 HP 2005: Equipment 5-30 HP 2006: Equipment > 30 HP
Chillers	Limit releases from low pressure purges to less than 0.1 kg/k air effective 2003. Require conversion or replacement of CFC-containing chillers at next major overhaul. Compliance dates vary by province. The federal government and most provinces have adopted a refill ban on CFC Chillers by January 1, 2015.

Source: CCME 2001.

In addition, most provincial and territorial jurisdictions require technician training/certification for the purchase of halocarbon refrigerants. Since 1992, the Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI) has been responsible for the development, maintenance and certification process for Canada's refrigerant handlers' training program. The ODS training course, developed in partnership with Environment Canada, represents the environmental benchmark for the refrigeration and air conditioning industries. To date, over 150,000 technicians have obtained certification and are included in the national certification database, housed and managed by HRAI.

The remainder of the case study describes Canada's programs for the recovery of ODS from appliances, for management of ODS in bulk, and for halon banking.

3. ODS-Containing Appliances

3.1 Background

No national standards or programs are in place to address the collection/disposal of appliances. Rather, it is the responsibility of all provinces and territories to implement regulations or guidelines to control the management of halocarbons in domestic appliances. In general, appliance disposal programs are provided by municipalities through contractors, so vary on a case-by-case basis.

3.2 Description of Process/Program

To satisfy the agreements in the National Action Plan, all provinces and territories have implemented, or have agreed to implement, regulations or guidelines to control the management of halocarbons in domestic appliances. With respect to the disposal of domestic appliances, the main points in the provincial/territorial regulations and guidelines are:

- Most provincial and territorial regulations explicitly state that refrigerants must be removed prior to the disposal of domestic appliances. All provinces and territories prohibit the release of halocarbons into the atmosphere.

- Most provinces and territories require that all work done on refrigeration and air-conditioning systems comply with Environment Canada's "Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems" and that the work be performed by certified technicians (i.e., technicians that have received environmental awareness training).
- Some provinces and territories have technical requirements concerning the recovery equipment that must be used for recovering refrigerants from domestic appliances. These technical requirements are based on the capability of the recovery equipment to obtain a level of vacuum sufficient to extract all refrigerant from a domestic appliance.

Environment Canada has prepared a *Guide for the Implementation of a Halocarbon Recovery Program for Domestic Appliances*, which is intended primarily for municipalities that are responsible for the disposal of out-of-service domestic appliances containing halocarbons. The goal of the Guide is to help municipalities set up a recovery program for halocarbons contained in domestic appliances. The Guide pertains to halocarbons used as refrigerants in domestic appliances, which include residential refrigerators, freezers, window-mounted air-conditioners, dehumidifiers and heat pumps. The Guide is available at the following link: www.ec.gc.ca/ozone/DOCs/SandS/RAC/mbrGuide04/EN/intro.cfm.

In practice, there are three types of programs in place for the collection/disposal of appliances in Canada:

***Type 1:* Transportation by citizen and halocarbon recovery at transfer centre**

- The citizen brings the domestic appliance to the transfer centre using his/her own means. The municipality may charge a service fee for depositing the domestic appliance at the transfer centre.
- The halocarbon is recovered from the domestic appliance at the transfer centre by a municipal employee or a contractor.
- The domestic appliance, emptied of its refrigerant, is sent to a scrap metal recycler.

***Type 2:* Specialized transportation and halocarbon recovery at transfer centre**

- The citizen leaves the domestic appliance at the curb.
- Municipal employees or contractors pick up and transport the domestic appliance to the transfer centre.
- The halocarbon is received from the domestic appliances at the transfer centre.
- The domestic appliance, emptied of its refrigerant, is sent to a scrap metal recycler.

***Type 3:* Halocarbon recovery from dwellings or at curb side**

- The citizen notifies the municipality that he/she wants to dispose of a domestic appliance. The domestic appliance is kept inside the dwelling or is brought to the curb.
- Municipal employees or contractors recover halocarbons inside the citizen's dwelling or at curb side.
- Municipal employees or contractors send the domestic appliance, now emptied of halocarbon, to the transfer centre.

While not part of federal program, at least one electric utility—Hydro Quebec—is implementing an appliance disposal program aimed at reducing energy consumption as part of demand-side management measures. Specifically, Hydro Quebec signed a three-year contract with JACO Environmental, Inc., to responsibly dispose of 250,000 refrigerators/freezers, with the options to extending the contract to five years and/or increasing the volumes to 350,000 units over the first three-year phase. Under this program, JACO will recover all refrigerant and CFC foam from appliances. All appliances collected under this program from across the province of Quebec will be processed at JACO's recycling facility located in Montreal. JACO uses the SEG system to recover and destroy all CFCs, including CFC-11 foam.

3.3 Costs

No information is available on the costs of appliance collection/disposal in Canada.

3.4 Statistics on Collection

Statistics on the number of appliances collected for disposal in Canada are only available for one municipality: Halifax Regional Municipality. This municipality, which offers program type 3—refrigerant recovery from dwellings or at curb side—collected approximately 4,800 refrigerated appliances[22] for disposal in 2006. If this municipality, which has a population of 372,858 (Statistics Canada 2007), is representative of the rest of the country, an estimated 430,000 refrigerated appliances are disposed of each year in Canada.

3.5 Challenges

Because appliance disposal programs vary from municipality to municipality, and refrigerant recovery practices are likely to vary from contractor to contractor, the success of current procedures in place is unknown. Similarly, because municipalities do not collect data on the quantities of ODS refrigerant recovered from appliances, it is impossible to know the extent of compliance with refrigerant recovery requirements or the challenges involved. Certainly, under current practices, an opportunity is being missed to recover ODS foam from refrigerators/freezers.

3.6 Lessons Learned

Lessons learned regarding appliance disposal are likely to vary by municipality, based on their specific programs and experiences. At the federal level, the need to dismantle knowledge and awareness barriers for appliance owners has been recognized; consumers must be educated about what to do with their refrigerated appliances when it is time to dispose of them. Consumers are made aware of the appliance retirement programs through a variety of channels in Canada, including: truck ads, news ads, email announcements, radio ads and interviews, television stories, program launch events and campaigns, displays at local conferences and trade shows, displays at public events, refrigerator magnets, and flyers.

4. Bulk ODS Refrigerants

4.1 Background

In 1998, the Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI) was approached by the Canadian Council of Ministers of Environment (CCME) to find an industry-led solution to the environmental problem of disposing of ODS refrigerants. CCME made it clear that if industry was unable to roll-out an effective solution, governments were prepared to mandate that industries take direct responsibility for the environmental damage associated with ODS refrigerants.

[22] Refrigerated appliances include refrigerators, freezers, dehumidifiers, and AC units.

In 2001, Refrigerant Management Canada (RMC), a "virtual" not-for-profit corporation, was established by HRAI to develop an industry-led solution to the environmental problem of disposing ozone depleting refrigerants (Environment Canada 2007). Representing an *extended producer responsibility program*, RMC is an industry-led partnership involving manufacturers, importers, reclaimers, contractors and wholesalers. With funding from a voluntary levy, RMC administers the collection and disposal of all surplus ODS refrigerants from commercial stationary refrigeration/AC equipment in Canada. RMC began collecting CFCs in 2002 and was expanded to include HCFCs two years later. With program membership representing over 95% of the Canadian marketplace, RMC is the only program of its kind in North America.

While Canada does not currently have any laws assigning responsibility for the disposal of bulk ODS, RMC's voluntary program has a supporting framework in the Montreal Protocol and Canada's NAP, approved by the CCME in 2001. In some provincial jurisdictions, RMC is supported by regulation; British Columbia, Alberta, Quebec, Prince Edward Island (PEI), Saskatchewan, Manitoba, Ontario and Newfoundland have adopted CFC refill bans and seller take back regulations. In addition, all Canadian provinces now require CFCs and HCFCs to be reclaimed and recycled to the maximum extent possible. CFCs and HCFCs are sent either to a reclamation facility in the Atlantic Region, or to one in the Ontario Region of Canada. Some refrigerant is also exported to the U.S. for reclamation.

4.2 Description of Process/Program

The goal of the RMC program is to meet CCME's objective to "minimize and avoid the release of ozone depleting refrigerants into the environment, and ensure that any surplus ozone depleting refrigerants are managed in the most environmentally responsible manner to minimize the depletion of the ozone" (Environment Canada 2007). To this end, RMC has developed a formal process for the collection, transportation, storage and disposal of bulk ODS refrigerants; a model that has been built on the industry's current reclamation system.

In terms of designated products, RMC accepts CFC and HCFC refrigerants from commercial and residential stationary refrigeration and AC equipment. The program does not accept these substances from mobile equipment or domestic appliances. The program also does not accept halons or HFCs, although RMC's administration is currently looking for ways in which to incorporate HFCs into the program.

RMC has built its program using the existing infrastructure in place in Canada. Specifically, bulk ODS refrigerants are collected from equipment owners by licensed contractors. Refrigerant is then collected from the contractor by the wholesaler (distributor), who records the refrigerant information, stores it, and coordinates transportation to one of three RMC approved Collection Service Provider (CSP). The CSPs are located in: Mississauga, Ontario (Fielding Chemical Technologies), Aurora, Ontario (Linde Canada Inc.), and Dartmouth, Nova Scotia (Refrigerant Service, Inc.).

CSPs are responsible for performing content and containment tests before bulking and storing the ODS. Once a sufficient volume is collected, the CSP arranges to transport the refrigerant to an RMC-approved disposal partner. ODS refrigerants are shipped using ISO tanks. Tanks used under this program are classed as IMO 5 tanks, which are manufactured specifically to hold pressured gases, up to an approximate capacity of 13,600 kilograms of refrigerant gas each. RMC has a fleet of 12 ISO tanks.

Because all refrigerant that is placed into RMC is unusable or unwanted, the RMC sends all ODS refrigerant for destruction. RMC has contracts in place with three disposal facilities that use high temperature incineration:

- Earth Tech (Swan Hills, Alberta, Canada)

- Veolia Environmental Services (Texas, USA)
- Veolia Environmental Services (Illinois, USA)

All three facilities use rotary kilns to destroy ODS. The Swan Hills Treatment Centre has signed a 10-year contract with the Government of Alberta to operate the facility on its behalf. In 2005, to facilitate bulk ODS management and processing, RMC committed to providing Earth Tech with a continuous stream of shipments, which allows Earth Tech to plan the scheduling of the kiln and determine what waste streams to feed with the waste refrigerants. This has lead to improved feed rates and faster processing times. (Swan Hills Treatment Centre 2005, Conservation Bureau 2006) The text box (right) provides additional information on the technology used at the Swan Hills Treatment Center.

> **ODS Destruction at the Swan Hills Treatment Center**
>
> The Swan Hills incinerator destroys bulk ODS at temperatures up to 1200° Celsius. Acid gases and particulate matter are scrubbed from the resulting flue gases in a multi-stage process; bottom ash and fly-ash are stabilized and placed in secure on-site landfill cells. For the best results and maximum removal, incinerator temperatures must remain high, residence time must be adequate (1-2 seconds), excess oxygen and good mixing be achieved. As part of the FB&D proprietary pollution control system, activated carbon is injected during the gas scrubbing stage, in order to remove trace dioxins and furans that formed during the post-combustion cooling.

On average, refrigerant in storage must be transported to destruction facilities over 3,000 km away; some must travel nearly 5,500 km in distance. On average, refrigerant is stored 90 days prior to being transported for destruction. Upon disposal, the disposal service provider issues a certificate of destruction.

The transportation and destruction of ODS refrigerants is funded through an environmental levy on the sale of virgin and reclaimed HCFCs sold in bulk into the stationary refrigeration/AC industry. This levy is collected by RMC's Administrative Oversight Body, which is also responsible for informing industry, government, and the public of the implementation and progress of the program.

A summary of RMC stakeholder responsibilities is provided in Exhibit II-3.

Exhibit II-3: RMC Stakeholder Responsibility Chart

Stakeholder	Responsibility	Role
Manufacturers & Importers	Economic	Refrigerant manufacturers, importers and reclaimers remit a voluntary levy on the sales of virgin and reclaimed HCFC refrigerants.
Wholesalers	Physical, Economic	Wholesalers collect refrigerants from equipment service contractors or qualified refrigeration and air conditioning service contractors. Wholesalers record information on the RMC tag and store the refrigerant until a sufficient quantity is collected for shipment to an RMC CSP. The wholesaler also provides contractors with information on the program.
Collection Services Providers (CSP)	Physical	CSPs accept the refrigerant from the wholesaler. The CSP performs a variety of services for RMC, such as: perform purity and contaminate tests; bulk and store refrigerant; and prepare the refrigerant for shipment to an RMC approved disposal facility. In tracking all program refrigerants, CSPs are required to provide monthly activity reports to RMC. CSPs are subject to annual quality audits to ensure that their operations meet RMC's environmental standards.
Administrative Oversight Body	Physical, Economic, Informative	RMC, a non profit industry group, collects an environmental levy from the sales of virgin and reclaimed HCFCs and informs industry, the government and the public of the implementation and progress of the program.
Consumers	Physical	Consumers, in this case, are building owners and homeowners. When they hire qualified equipment service contractors or refrigeration and air conditioning service contractors to service their refrigeration equipment, the used ODS are

Exhibit II-3: RMC Stakeholder Responsibility Chart

Stakeholder	Responsibility	Role
		managed for proper disposal through the program.
Federal Government	N/A	Canada's Federal Government has no direct responsibility for the operation of this program. Environment Canada has assisted industry by establishing a baseline of stockpiled CFCs. Environment Canada also participates in the board meetings.
Provincial and Territorial Governments	N/A	Provincial and Territorial Governments do not have any roles or responsibilities for this program.
Local Government	N/A	Local Governments do not have any roles or responsibilities for this program.

Source: Environment Canada 2007.

RMC works to remain fully transparent and accountable to its stakeholders and the public. RMC tracks data on refrigerant disposal by requiring the CSPs to submit monthly reports. The tracking database provides statistical data to RMC, which allow for the development of more accurate forecasts for budgeting and operational needs. In addition, the RMC Board opted to extend auditing requirements beyond CSP operations to also include the activities of Disposal Service Providers and participants in 2005-2006. All parties are now audited to ensure they meet the program requirements and performance standards outlined in the RMC Guidelines. To ensure this, RMC funds are being handled in a transparent manner, and financial audits and environmental audits are conducted regularly. In 2006, Jacques Whitford, an environmental consulting firm, was commissioned by RMC to develop the environmental audit protocol for the Canadian and American ODS disposal facilities. The new Canadian protocol, launched in 2007, was used to audit the Swan Hills destruction facility. The overarching goal of the audits is to ensure that destruction providers meet both the high environmental standards required by the RMC program and the jurisdictions in which they operate (RMC 2006).

4.3 Costs

As mentioned, all aspects of the RMC program, including collection, transportation, storage and destruction, are funded through a voluntary environmental levy placed on the sale of virgin and reclaimed HCFC refrigerants to the Canadian stationary refrigeration/AC industry. Those remitting the levy on sales to the industry include Canadian refrigerant manufacturers and HCFC importers/reclaimers. All funds generated through the levy are used to manage and administer the collection and environmentally sound destruction of both CFCs and HCFCs.

The environmental levy was initially retained at C$1.00 per kilogram. But between 2004 and 2006, the volume of waste refrigerant entering the RMC program had increased significantly. To ensure program funding going forward, the RMC Board therefore elected to increase the levy from C$1.00 to $1.50 per kilogram on the sale of new and reclaimed HCFCs and HCFC blends. As stated in RMC's annual report, the decision to increase the levy "was not taken lightly… Both the RMC Board and Levy Task Team had reviewed and researched the issue for approximately three years, prior to making the decision." In January 2006, the levy was adjusted to C$1.50 kilogram. The formula used to establish the program's levy amount is shown below:

$$\text{Formula for RMC's Levy Amount} = \frac{\text{Cost of collection/destruction process per unit} * \text{Estimated number of units}}{\text{Product volume for levy}}$$

In 2005, total revenue for the RMC program was C$2,721,005. The environmental levies totaled $2,420,635 in revenue, with remaining revenue from investment income. The total expenses were $3,524,362, with $251,390 of this being administration and $3,272,972 operational expenses. As of 2007, the average program cost to dispose one kilogram of ozone depleting refrigerant is C$11.50.

4.4 Statistics on Collection

Since 2001, the RMC program has enabled the collection of over 1,000,000 kg of unwanted ODS refrigerant, of which 880,000 kg has already been destroyed. Since its inception, the initiative has reduced Canadian ODS emissions by approximately 554,000 ODP-weighted kg. The types and amounts of ODS refrigerant collected from 2003-2007, and those projected to be collected from 2008-2010 are shown below.

Exhibit II-4: Amount of Bulk ODS Collected by Year

ODS Type	Kilograms Collected (Non-ODP Weighted)				
	2003	2004	2005	2006	2007
CFC-11 and CFC-12	74,246	162,975	225,659	212,160	214,400
HCFC-22	N/A	92,385	100,612	99,840	105,600

Exhibit II-5: Anticipated Amount of Bulk ODS to be Collected

ODS Type	Kilograms Collected (Non-ODP Weighted)		
	2008	2009	2010
Both CFCs and HCFCs	352,000	333,000	322,000

The program's success is measured by volume of ODS refrigerant destroyed. To help measure the success of the program, refrigerant quantities are reconciled against the quantities destroyed by the disposal facilities. As noted above, Collection and Disposal Service Providers are subject to annual audits to ensure that their operations meet RMC's environmental standards.

4.5 Challenges

With only one ODS destruction facility in Canada, there is not adequate capacity to destroy all refrigerant collected by RMC within the country. As such, Canada must source destruction facilities in the United States; this poses a challenge because obtaining the necessary export/import permits is a time-consuming and difficult process, which typically takes about 40 days. The delays caused by this process have created significant storage and backlog issues. In addition, RMC experiences supply problems for recovery cylinders. To overcome these challenges, RMC has had to purchase additional storage containers and lease large ISO containers.

A disconnect between wholesalers and contractors has been another challenge faced by RMC. RMC has asked wholesalers to promote the program, but some remain inactive and apathetic due to awareness barriers, lack of incentives, cumbersome processes, and/or lack of general interest. To address this issue, RMC plans to develop an online training program for wholesalers, which is divided into three modules/tests: (1) RMC Guidelines; (2) ODS regulation in jurisdiction(s) where the branch is located; and (3) issues/solutions to marketing and awareness raising. On each test, wholesalers will be required to achieve 75% or higher to retain status as a designated wholesaler. In light of the continual changes to criteria and regulations, wholesalers will be required to take tests every 2-3 years. The online program is currently undergoing beta tests, and the pilot program has been distributed to a handful of wholesalers. The online module is expected to be ready in early 2008.

Another challenge has been stakeholder outreach. Though RMC was developed in 2000, it was still experiencing difficulties in conveying its goals, mandate, and operations to industry participants in 2006. To better reach industry participants, RMC's has made the establishment its corporate identity its main focus by increasing its marketing efforts to stakeholders and clearly communicating the organization's purpose. The RMC logo and tagline were also redeveloped and improved to create an updated look and message to be incorporated into various types of media.

Finally, there have been minor challenges associated with "free riders"; about 5% of the industry has not voluntarily joined the program. In fact, one importer has declined to join the program unless legislated to do so.

4.6 Lessons Learned

A number of lessons have been learned from RMC's experience in Canada. First, it is critical to establish an appropriate means for funding the ODS destruction program, and one that removes any financial barriers that may otherwise prevent those handling refrigerant—i.e., technicians and contractors—from properly disposing of unwanted refrigerant. The levy structure was determined to be the least complex process for collecting funds. By placing the levy on the "start" of the supply chain (manufacturer/distributor) rather than the "end" of the supply chain (retail), the system provides companies with greater flexibility in dealing with the costs. In addition, from a cost perspective, given that RMC is voluntary, it was necessary to determine the critical mass of industry players to make the program viable. With 95% of industry involved in the program voluntarily, the RMC program has been able to fully fund itself through the levy on the sale of virgin HCFCs, HCFC blends, and reclaimed HCFCs.

Further, the levy price is important to continually monitor and assess, so ongoing analysis and review is essential. The RMC Board's decision to increase the levy from C$1.00 to $1.50 per kilogram in 2006 was based on careful review and research conducted over a three-year period. Care was given to properly balance the levy cost against the cost of the product being levied, and project the volume of product to be recovered from the field. By gradually building the RMC fund over time, the RMC Board worked to limit the levy's impact on the marketplace, while taking time to gather accurate market information and data to help RMC determine the longer term "direction" of the levy. Industry's response to this incremental approach has been positive, with key stakeholders supporting the levy increase to ensure the continuation of the program's benefits.

The RMC program has also learned that guidelines must be established for all processes of the program—handling, collection, destruction—and audits are needed to ensure compliance with those guidelines. For example, emission standards are established and monitored, and environmental audits of operational standards for service providers are conducted. Audit confirmation letters are also included in RMC's annual reports, which are publicly available.

Based on RMC's experience, it is important to "over-communicate" and beware of "communications complacency" after initial start-up hype. It is necessary to ensure that stakeholders and industry participants clearly understand the goals and objectives of the program. To do this, RMC has had to recommit to awareness-raising efforts at regular intervals.

Overall, RMC has demonstrated that a viable refrigerant collection/destruction program can be built using existing infrastructure, with low overhead costs and no fixed assets or human resource obligations.

5. Mobile Air Conditioning

Apart from the provincial regulations that prohibit the venting of refrigerants, no nationwide programs are in place to deal with the recovery, reuse, and destruction of ODS from MACS. Thus far, the RMC program has not been successful in bringing the automotive sector into its program. According to RMC, a strong regulatory framework would be needed in order to do so.

6. Halon Banking

Having never been produced in Canada, the importation of halons began in 1965 .Canada has no physical halon bank where users can deposit or withdraw halons. Canada's virtual Halon Bank is a clearinghouse service administered by the Underwriters' Laboratories of Canada (ULC).The Halon Bank matches clients with appropriate companies - halon owners with halon buyers and vice-versa – and provides up-to-date news and information relating to the conservation and use of halons. To date, the Underwriters' Laboratories has published two standards that specifically address halon recycling: (i) the servicing of halon extinguishing systems; and (ii) halon recovery and reconditioning equipment.

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III. Czech Republic

1. Introduction

1.1 Country Information

The Czech Republic is an industrialized country of 10.3 million people (Czech Statistical Office 2007), comprising over 4.2 million households. Seventy-four percent of the country lives in urban areas (United Nations Statistical Division 2001), with Prague, Brno, Ostrava, and Plzeň being the most populous cities. The Czech Republic covers approximately 78,900 square kilometers. The Czech Republic joined the European Union on May 1, 2004, along with nine other countries.

Exhibit III-1: The Czech Republic Source: Applied Language 2008a.

1.2 ODS Market Characterization

Historically, ODS has been used in refrigeration, air conditioning, insulation, and fire protection sectors in the Czech Republic. Through various projects funded by the GEF, much of the consumption has been successfully phased out. There are minor uses remaining in military applications. The majority of ODS that exists in the Czech Republic today is installed in equipment. Much of this ODS is already or will become obsolete in the relatively near term or is being collected, recovered, recycled, reclaimed, and stored for future critical use. Unwanted ODS, recovered from equipment through various programs or that is identified in bulk, is sent for destruction.

For example, there are numerous sectors in the Czech Republic in which unwanted ODS are potentially stocked. Refrigerators are common and comprise a large wastestream, as do other refrigerated appliances, such as small packaged air conditioning units. Approximately 350,000 refrigerated appliances are disposed of annually in the Czech Republic. These appliances may contain ODS in both refrigerant and in insulating foam. Large industrial and commercial chillers may also contain CFC refrigerant. Older fire protection systems in a variety of applications often contain halons, including nuclear power and military facilities that have used ODS, and may continue to have some critical applications, but which also may have unwanted ODS stocks.

2. Relevant Legislation and Regulations

The Czech Republic has enacted extensive legislation to regulate the handling and disposal of unwanted ODS; indeed, there are ninety-three regulations covering ODS. Act 86/2002 is the primary legislation regarding unwanted ODS. The Act mandates, for the appliance sector, that all ODS must be recovered by technicians during the servicing of equipment. For the disposal of ODS-containing appliances, Act 185/2001 requires appliance manufacturers to take back end-of-life appliances and institute programs to collect them. According to Act 86/2002, the ODS must be recovered from the compressor circuit, as well as from insulating foam, when these appliances are disassembled. Collected CFCs must be destroyed; HCFCs may be destroyed, reclaimed, or re-used until 2015. An import tax of approximately US$21 is placed on every kilogram of ODS imported and placed on the Czech market.

These Czech policies are the national level implementation of European Union policy. EC 2037/2000 is the European Parliament's and Council's regulation on ODS (UK Department of Trade and Industry 2000). EC 2037/2000 requires the recovery of ODS when servicing or disposing of appliances and the destruction of all recovered CFCs. Recovered HCFCs must be recycled or destroyed. Any existing stocks of CFCs may not be used to recharge any equipment. HCFCs can be used for recharging until 2015. As for foams, the directive requires that ODS in foams be recovered "if practicable." Both ODS solvents and halons are banned from use, except for critical applications, and both must be recovered and destroyed if a piece of equipment containing them undergoes servicing.

Czech national policy further details the requirements on the collection of end-of-life appliances. Requirements are codified under the Czech Waste Act, No. 185/2001, which implements Directive 2003/108/EC on Waste Electric and Electronic Equipment (WEEE), and which requires that all producers take back private home appliances at their own expense, providing the financing for all collection, treatments, recovery, and disposal (Parliament of the Czech Republic 2001). Furthermore, the collection locations for appliance drop-off must be as accessible to consumers as are the points of purchase. The producers must compile reports on their take-back programs annually. Ten categories of waste electric and electronic equipment are detailed under WEEE and the Czech Waste Act, including large and small refrigerated appliances, which correspond to Categories 1 and 2 of the Act No. 185/2001.

Additionally, Czech Decree Number 117/2005 implements requirements for proper handling and disposal of refrigerants, implementing what is termed "legally binding technology" (Parliament of the Czech Republic 2005). Transportation and any temporary storage of refrigeration units must be conducted in a way that minimizes the risk of damage to the units. During disassembly of units, ODS refrigerants must be removed and stored in containers, with each gas separated from others. Furthermore, ODS-containing foam must be treated by mechanical crushing, effectively requiring the crushing of the whole unit, and all the ODS must be captured. Further requirements on the dismantling of electronic equipment with hazardous substances are detailed in Decree Number 325/2005.

Large industrial and commercial equipment that uses ODS is not regulated in terms of disposal at end-of-life. As a result, there are no specific collection systems or arrangements for the ODS from these units, but it should be noted that large amounts of refrigerant can be recovered from these systems.

The Czech Republic has also set up a State Environmental Fund that supports pollution reduction projects, including ODS disposal projects. Environmental import taxes and polluter fines are paid into the Fund, and the monies are then used to support new projects (Quasnitzova 2007). For ODS disposal work, projects involving transportation, equipment disposal, and processing can receive assistance from the Fund. The applicant projects are selected based on the amount of ODS to be destroyed and the amount of equipment that would be safely disposed of.

Czech authorities have also partnered with industry to operate a national halon bank. Halons are collected from storage tanks and fire extinguishing equipment. They are then purified and either reused in critical applications or stored safely at the Bank.

The following sections of the case study review the Czech programs for appliance collection and recycling, including the costs and challenges of these programs, followed by a review of bulk ODS disposal in the Czech Republic, and finally, a discussion of halon banking.

3. ODS-Containing Appliances

3.1 Background

As a result of Czech Act 185/2001, the Czech Republic's major appliance producers formed a collaborative association for the collection of end-of-life appliances in order to comply with the Act's requirements on manufacturer take-back (Elektrowin 2006). The association, Elektrowin a.s., was founded in May 2005 as a non-profit organization. A total of twelve producers have joined the association, with all members having both equal ownership and equal obligation. In March 2006, Elektrowin's collection network started operations, providing collection points for Czech citizens around the country. Elektrowin collects appliances in three of the ten waste equipment categories: large household appliances (Category 1), small household appliances (Category 2), and electrical and electronic tools (Category 6). Only Categories 1 and 2 are likely to be comprised of equipment containing ODS.

3.2 Description of Process/Program

Under the Elektrowin system, consumers can drop off used appliances at designated collection points, free of charge. Many of these take-back locations are operated with contractual cooperation from municipality governments (Elektrowin 2006); as of July 2007, Elektrowin worked with 465 municipal collection yards (Masek 2007). In addition, many retail stores also provide Elektrowin collection services, taking back old appliances for free, upon delivery of a new one; as of July 2007, there were an estimated 1,350 such participating retail establishments. Areas without collection locations are served by mobile collection operators providing transportation of appliances; as of November 2007, there were 2,100 such mobile operators partnered with Elektrowin. In all, the Elektrowin network provides take-back coverage for about 2,500 cities, towns, and villages, reaching people all over the Czech Republic.

Elektrowin then transports the used appliances and equipment to one of the four refrigerated appliance demanufacturers located throughout the Czech Republic. (There are a total of 73 demanufacturers for all types of appliances.) Some units may be placed in temporary storage prior to delivery to a demanufacturer. At the demanufacturing plants, the ODS is recovered and stored. The appliances are taken apart into metal, plastic, and foam. Foams are degassed and the captured ODS is stored. The ODS is then sent for destruction, either by rotary kiln at the SPOVO facility in Spovo or by gas conversion at Solvay Fluor in Frankfurt, Germany.

Exhibit III-2: Praktik Liberec s.r.o. and storage yard (right)

Approximately 90% of refrigerator demanufacturing in the Czech Republic is handled by Praktik Liberec s.r.o., located in Stráž pod Ralskem (see Exhibit III-3). The three other demanufacturing facilities are operated by SEG-Rumpold and are smaller facilities that account for a small share of the decommissioning operations throughput. A visit was conducted to Praktik during the course of this study.

Praktik began handling ODS-containing equipment in 1995, and began work with appliance manufacturers in 2003. The company also built a new facility in 2004.

Praktik begins by removing the refrigerant and oil mixture from the units, measuring and documenting the amount from each (Praktik System). After the refrigerant is extracted from the mixture, the residual amount of refrigerant left in the oil does not exceed 0.1% by weight. The unit is then dismantled (see Exhibit III-3), and the foam is crushed and ground inside a vacuum chamber, with the CFCs being condensed out of the waste stream. The residual CFC left in the foam does not exceed 0.2% by weight. Extracted CFCs are pumped into pressure tanks. The recovered ODS from the refrigerants and foams are sent to be destroyed by gas conversion.

Exhibit III-3: The Praktik demanufacturing facility, with two segments of the disassembly line shown

Ekotez Ltd. is a manufacturer of refrigerator servicing equipment, a key component in ODS recovery, and it was also visited for the study. As ODS recovery is mandated for all equipment servicing, technicians need portable recovery equipment to collect used ODS. Ekotez, located in Prague, manufactures lightweight recovery units (see Exhibit III-4). The smallest, the Mini-R, is capable of recovering vapor at 7 kg an hour or liquid at 200 kg an hour (Ekotez 2005). The collected ODS is then sent for destruction or, in the case of some HCFCs, for reuse. Ekotez also provides extensive training and seminars to refrigerator technicians, and produces non-ODS based equipment, including dehumidifiers containing hydrocarbon

Exhibit III-4: The inner workings of a recovery unit manufactured by Ekotez refrigerant, as well as refrigerant line flushing systems. This diversity of business helps to ensure a good business base and other sustainable sources of income.

3.3 Costs

Producers of appliances are required to pay a fee into the Elektrowin system for each of their used units that is collected and disposed. The value of the fee is added to the sale price of new appliances and is labeled as the "visible fee" in order to transparently present the cost of collection, recovery, and disposal. The fees are shown below. Much of the equipment being retired today was manufactured before the implementation of the fee system, of course, and so today's fees must subsidize the cost of properly recycling old units. Thus, it is stipulated that the fees are higher than the actual cost of disposal, and fees may be reduced in a few years.

Exhibit III-5: Visible Fees for 2007 for the Disposal of Equipment

Category	Fee in $US, including tax
Refrigeration	16.50
Large Appliances	5.00
Medium-Sized Appliances	1.10
Small Appliances	0.33
Tools and Instruments	0.38

Source: Elektrowin 2006)

Praktik reports that the initial investment in the refrigerator recycling technology paid back in five to six years of operation. The handling of waste appliances is now a profitable business for Praktik. The cost of setting up a stationary recycling unit is estimated at $4.4 million. It should be noted that, in a nationwide recycling system, the establishment of multiple facilities also reduces the cost of appliance transportation.

3.4 Statistics on Collection

On the collection side, Elektrowin's first two years of operation consisted of successful work on several fronts. The first phase of the program was the implementation of a take-back network. Agreements with hundreds of municipalities and retailers were made in order to provide the convenient take-back network mandated by Czech law. Second, the association launched a series of educational events to promote proper disposal of equipment. Information on the Elektrowin system and ODS regulations was distributed to Czech citizens. A magazine was started as well to provide information on the industry.

Elektrowin has compiled statistics on waste equipment treated; of course, the vast majority of electronic and electric equipment are not ODS-based appliances. In its first year of operation, 2006, Elektrowin treated "50% of all electric and electronic equipment waste collected" (Elektrowin 2006). It should be noted that its 2006 fees (as charged to producers) were higher than the 2007 rates, by anywhere from 40% to 75%. The fees listed above were adopted as of 2007. As for foam treatment, the Czech Ministry of the Environment estimates that 30% of disposed appliances were subject to ODS recovery from foam.

Exhibit III-6: Sales of Electric and Electronic Equipment in 2006 (Source: Elektrowin 2006)

Type of Equipment	Percent of 2006 Sales
Large Household Appliances	32.45%
Small Household Appliances	6.24%
Electric and Electronic Tools	2.50%
Other Appliances	58.81%

Four hundred seventeen producers signed contractual agreements with Elektrowin. It was calculated that the producers together sold more than 82,000 metric tons of electric and electronic equipment on the Czech market over the course of one year. The breakdown of 2006 sales is presented below.

Elektrowin collected a total of 10,720 MT of electrical and electronic equipment in 2006. Of this amount, 67% was collected in waste yards, 18% from end retailers, and 15% by mobile collection services. The breakdown by equipment sector is presented below. By weight, refrigerators comprised 93% of all equipment collected.

It is estimated that 43,461 kg of ODS were collected from refrigerated appliances in 2006. For refrigerators, an average of 0.04 kg of ODS refrigerant and 0.215 kg of foam ODS were recovered from each unit (Elektrowin 2006). Indeed, Praktik reports that 90% of its recovered CFCs came from foams and 10% from refrigerant recovery.

Exhibit III-7: Collection of Disposed Waste Electric and Electronic Equipment in 2006 (Source: Elektrowin 2006)

Type of Equipment	Percent of 2006 Elektrowin Collection
Large Household Appliances	48.36%
Small Household Appliances	1%
Electric and Electronic Tools	0.06%
Other Appliances	50.58%

3.5 Challenges

The Czech collection program and destruction actions are in their early years. In 2006, only 10,720 MT of appliances were collected in contrast to the 82,000 MT sold. Approximately 14,500 MT were collected in 2007. However, Elektrowin was successful in launching a very large collection network.

It is clear that there is still a strong trend among consumers towards improper disposal. The pirating of compressors and other refrigerator parts is one factor that reduces proper recycling. Effective enforcement is needed, according the Czech Ministry of the Environment. Additionally, the Ministry estimates indicate that the recovery rate for ODS foam is even lower than ODS refrigerant. Clearly, foam recovery is a more arduous process, and, for producers, this drives up costs.

The Ministry also notes that there is no regulatory requirement for the recycling of building air conditioning units and large industrial units. There is also no available data on voluntary recycling that may exist in this sector, if any.

3.6 Lessons Learned

Progress so far in the collection and destruction system can be attributed to several key factors. First, a coalition of companies in the refrigeration and appliance industry allows for a nationwide, seamless system. The burden of setting up a system is also shared as a result. Furthermore, the fees for disposal, paid by each company and ultimately the consumer, allow for a fair distribution of disposal costs.

Additionally, the impressive scale of the collection network enables appliance collection to be largely practicable. With over 2,500 communities covered by the network, few Czechs remain out of reach of convenient appliance disposal.

The mechanism by which this was done is notable. Partnerships with hundreds of municipal governments allowed collection at existing waste yards, and retailers were included as part of the collection structure. This eases the process for Czechs to dispose of their appliances properly.

It is important that waste management is done by a knowledgeable company or association of companies that understands the appliance market. For example, it is vital to know which disposal technologies need to be invested in given the share of different appliances on the market. Elektrowin representatives also note that a business partnership with destruction facility operators are vital to smooth operation.

Most significant of all, however, is that the consumer faces no fees for disposal at the end of the appliance's life. Any fee charged at time of disposal would clearly be a disincentive. The cost of disposal is passed on to the consumer at the time of purchase, eliminating any financial burden at time of disposal.

Additionally, Czech regulation on waste equipment does not impose any paperwork burden on consumers or waste recyclers, allowing for easy disposal.

Consumer awareness is also notable and a critical part of success. Homeowners in the Czech Republic are largely aware of the proper disposal methods, the ODS regulations, and the Elektrowin collective, owing in great part to Elektrowin's education efforts.

However, stronger enforcement is needed, as the Czech Ministry notes. The sale of salvaged refrigerator parts and scrap metal creates a market for illegal dumping of appliances; stronger enforcement would curb this issue, as would fees for recovered refrigerant. A rebate program for refrigerant return, however, would require large scale funding.

Effective controls on the import of ODS are also needed to prevent illegal ODS use and disposal. This includes thorough training for customs officers for the interception of illegal shipments.

The Ministry notes, in addition, that a proper disposal program is needed for building foams and commercial refrigeration and air conditioning equipment. No program currently exists for these sectors.

4. Bulk ODS Destruction

4.1 Background

The ODS that is recovered from refrigerated appliances, as well as any bulk ODS that may be recovered from industrial processes, is generally sent for destruction in the Czech Republic. All CFCs are entirely destroyed, as dictated by law (Czech Act 86/2002 and EC 2037/2000), and most HCFCs are destroyed as well. ODS is either sent to the SPOVO Ostrava facility, in Spovo, Czech Republic, or to RCN, in Goch, Germany. SPOVO destroys ODS by means of high-temperature incineration. RCN purifies the ODS it receives and ships it to Solvay Fluor, in Frankfurt, where it is destroyed by means of conversion into fluorinated products.

4.2 Description of Process/Program

ODS is shipped directly from refrigerated appliance demanufacturers to either SPOVO Ostrava (officially SPOVO, s.r.o) in the Czech Republic or to RCN (officially RCN Chemie GmbH), in Goch, Germany. Notably, Praktik sends all its recovered CFCs to RCN; the Czech Halon Bank, on the other hand, sends waste ODS to SPOVO.

At SPOVO, the ODS is destroyed using a rotary kiln. First, the shipped cylinders of ODS are pumped into a main tank until it is full. The ODS is then pumped out at 3 to 5 kg/hr, passing through heated pipes into an expansion tank where it is evaporated. The pipes are heated to a temperature of 80°C, and the evaporation tank is heated to 90°C. The main tank is flushed with nitrogen if the pressure falls below 0.5 MPa in order to leave no trace ODS. Once evaporated in the expansion tank, the ODS is then pumped into the rotary kiln. The kiln itself consists of a main furnace and a secondary afterburning chamber and it destroys the ODS at a temperature of 1150°C.

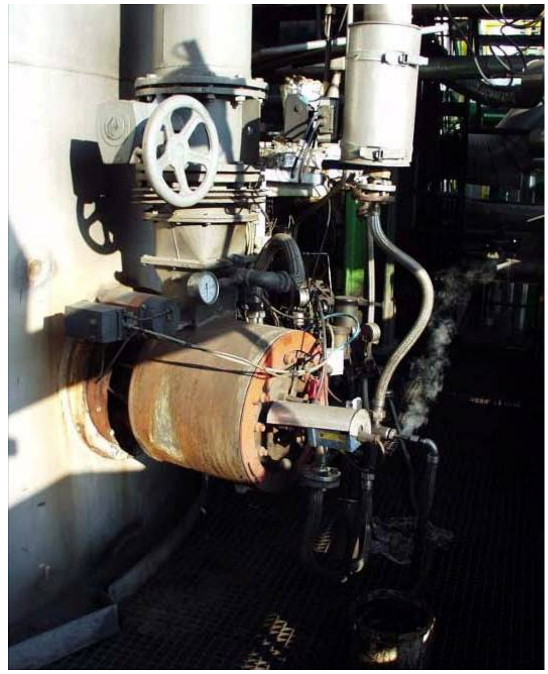

Exhibit III-8: The expansion unit (left) and combustion jet (right) at SPOVO Ostrava destruction facility

The SPOVO facility is capable of destroying all ODS and even PCBs. Exhaust gas from the process is scrubbed through two-stage scrubbing, catalytic processes, and dioxin filtering. Waste heat from the process is supplied, via steam, to a chemical company located adjacent to SPOVO's plant. A turbine generator is also used to recover some waste heat to produce electricity. The facility has a hazardous waste destruction capacity of 18,500 metric tons per year (Indaver 2007), or 1.95 metric tons per hour. As ODS must be mixed in, SPOVO's ODS capacity is rated at 40 metric tons per year, or 5 kilograms per hour (SITA CZ 2007). It is the largest facility of its kind in the Czech Republic. SPOVO, s.r.o, is a member company of the Indaver Group, a waste management provider with facilities across the EU.

RCN, the other recipient of unwanted ODS, purifies the ODS and ships it for gas conversion to Solvay Fluor. A site visit was conducted to RCN at their facility in Goch, Germany, to study the purification process. The Case Study for Germany (presented in Case Study IV) provides a description of Solvay/RCN process and the gas conversion technologies involved.

4.3 Costs

It is estimated that the destruction of one kilogram of ODS costs approximately $US 15. However, the processing of refrigerators and the destruction of the recovered ODS is conducted by private contract, and thus more accurate data is not publicly available.

4.4 Statistics on Collection

It is estimated that 43,461 kg (about 43.5 metric tons) of ODS were collected from refrigerated appliances in 2006 in the Czech Republic. SPOVO Ostrava reports that it destroyed 10 metric tons of regulated substances in 2007. The RCN-Solvay partnership currently receives 33.5 metric tons of ODS from the Czech Republic each year; in total, it receives 500 metric tons of ODS annually from its German and Czech sources combined.

Finally, the recovery of ODS from large industrial units is not required. Thus, there is little data on any voluntary recovery and/or destruction in this sector that may be occurring.

5. Halon Banking

5.1 Background

The use of halons is banned in the EU as of 2003, apart from approved critical uses, and recovery from any end-of-life equipment that contains halons is mandatory. The vast majority of halon stocks are found in old firefighting equipment, both hand held and total flooding systems. The Czech government has set up a National Halon Bank for the collection of recovered halons (see Exhibit III-9). The Bank also handles methyl bromide, ethyl bromide, and carbon tetrachloride. The Bank aims to collect, reclaim, and safely store these substances, either for critical use or eventual destruction. The Bank's facility opened in January 2007.

Exhibit III-9: Display of historical halon cylinders at National Halon Bank

5.2 Description of Process/ Program

The National Halon Bank is located in the city of Cheb and is operated by the contractor Esto Cheb Ltd., a fire safety company. The Bank was visited during the course of this study.

Halons are sent to the Bank either in pure or contaminated condition. Esto Cheb reports that 99% of the organizations sending halon are sending it after an approved critical use. The halons are then reclaimed, with the reclamation machine processing 40 kg per hour. The machine is able to process all halons and fluorinated gases. Halon purity is then checked by a national university laboratory (see Exhibit III-10). The gas is stored in cylinders, using the international standard ISO 7021. The cylinders are stored onsite; approximately 50% is thereafter used for critical use, and the other 50% is sent to be destroyed. Cylinders in storage are pressure-tested and checked regularly for leaks, and they are tagged and catalogued for tracking.

All critical uses are approved and monitored by the Czech Ministry of the Environment, in order to track their handling (Czech Ministry of Environment). The largest single critical use in the Czech Republic is the nuclear power plant in Dukovany.

In addition, the Bank also offers many related services to users, including training, ODS transportation, consulting, refilling of equipment, installation of new equipment, and retrofits of existing equipment. The training for ODS technicians is thorough, covering 21 modules and providing certification to attendees. Consulting and training were initially provided free of charge, but are now paid services.

Exhibit III-10: Halon cylinder being checked for purity at the National Halon Bank (left); halon cylinder storage (right)

Initially, the Bank was co-financed by the State Environmental Fund, which is the recipient of polluter fines and environmental import taxes. This money was needed as the Bank was running at a 10% loss from 1997 to 2004. The Bank was also co-funded by the sale of halon to critical use operators, such as nuclear power plants; the price as of September 2006 was €10 per kilogram (Koeppen 2006). For the initial establishment of its operations, the Bank also received startup funds from the Global Environment Facility, as an ozone phase-out project. Additional startup monies came from the EU's Phare program (a system helping EU applicant countries).

In 2007, state funding for most of the Bank's day-to-day operations was brought to an end; the sale of halons to critical, approved uses continues, helping make the Bank largely independent. The State Environmental Fund pays for the support services that the Bank provides to municipalities, and the Fund also provides for part of the cost of halon destruction. Halon users now pay a fee for the destruction of used halon, as well, in order to generate income for the Bank's activities. The changing of consulting and training programs from free service to paid service is also part of realigning the Bank's revenue strategy (Koeppen 2006).

Today, the Bank has 15 employees. A future partnership with Ekotez is being considered. Ekotez would be able to provide technical expertise on the transfer of ODS.

The capacity of the Bank is projected at 100 metric tons per year, a level that exceeds the domestic demand of the Czech Republic (Czech Ministry of Environment). Quality control testing for the Bank is provided by the Czech Army.

5.3 Statistics on Collection

The Halon Bank reports that 93% of the halon it receives is Halon-1301. Seven percent is Halon-1211, and the remaining 3% is Halon-2402. Halon 2402, Halon 1011, methyl bromide, and certain other non-critical fire suppression agents are sent for destruction after recovery. Halon 1301 and 1211 are recovered, reclaimed, and stored. Approximately 9,000 kg collected in the Halon Bank and are available or have been distributed for critical use.

IV. Germany

1. Introduction

1.1 Country Information

Germany has a population of 82.3 million people, comprising 38 million households (Cogen Europe 2005). With 88% of Germans living in urban areas, the population is largely urbanized (Ohio University 2007a). Major cities in Germany include Berlin, Frankfurt, Hamburg, Munich, Cologne, and Stuttgart. Germany has a land area 357,021 square kilometers. The country is comprised of 16 states, with legislative power divided between federal and state government. Germany is a founding member of the European Union.

Exhibit IV-1: Germany Source: Applied Language 2008b.

1.2 ODS Market Characterization

There are approximately 200 domestic appliance manufacturers and appliance importers operating in Germany. All new refrigerators manufactured in Germany use hydrocarbons (HCs). However, there are an estimated 36 million refrigerators in Germany that contain CFCs (RAL 2007). Each year, approximately 3 million CFC-based refrigerators enter the waste stream. The risks posed by the improper disposal of these units make the need for a strong appliance recycling program clear.

2. Relevant Legislation and Regulations

Germany, as a member of the European Union, is subject to Regulation (EC) No 2037/2000, a European Council act regulating ODS. Under EC 2037/2000, all ODS must be recovered during equipment servicing and disposal. Recovered CFCs must be destroyed, since their continued use is prohibited. HCFCs can be destroyed or re-used until 2015. For ODS-containing foams, the Directive requires that the ODS be recovered from foams "if practicable." All ODS solvents are banned from reuse. Halons are banned from reuse as well, except for a small number of critical applications, mostly in the military. Both ODS solvents and halons must be recovered and destroyed if any piece of equipment containing them undergoes servicing. Furthermore, Directive 2002/96/EC on Waste Electrical and Electronic Equipment requires EU appliance producers to be responsible for disposing of end-of-life residential units. Finally, the European Commission also sets limits each year on the volumes of CFCs, halons, and several other ODS that can be sold on the market. Importation limits are also set for each chemical manufacturer that seeks to import ODS.

Germany has enacted several legislative measures to meet and often exceed these EU regulations. In particular, Germany has enacted legislation to prohibit the export of CFCs contained in bulk or in pre-charged equipment. Exports of equipment containing HCFC-22 are also banned, while equipment containing other types of HCFCs may be exported until 2010. Only CFC equipment manufactured prior to the CFC use ban may be imported. ODS may also be imported in bulk for destruction or reclamation purposes. All imports are monitored and regulated by Stiftung Elektro-Altregäte Register, the Fürth-based regulatory office established by appliance manufacturers. Bulk ODS imports must also be registered with the European Commission.

Further, in 2006, Germany passed the Electrical and Electronic Equipment Act to regulate the disposal of appliances, including those containing ODS. This act, generally known as ElektroG, holds German importers and manufacturers of electrical and electronic equipment responsible for the disposal of such waste equipment. For any appliances containing ODS, this includes the recovery and disposal of ODS. Under the ElektroG definition, “large appliances” include refrigerators, freezers, air conditioners, and other large cooling appliances. Penalties in Germany for illegal disposal of appliances range in the hundreds of Euros. ElektroG has also required the phase-out of HCFC-22 use in Germany in 2000, two years before it was required by the EC regulation. Additionally, ElektroG sets more stringent requirements than the EC for the leak inspection of ODS-containing equipment.

The facilities in Germany that demanufacture ODS-containing equipment are regulated by Section 5.4.8.10.3 of TA Luft. First, it requires appliance recyclers to perform “complete” removal of CFCs from units, specifying that the ODS remaining in the oil mixture after degassing cannot exceed 2 g per kg of mix. Additionally, as an annual plant check, the sum of CFC coolant collected over the year must be at least 90% of the sum as listed on all the refrigeration units processed; in other words, an average of 90% recovery or more of stated CFC is required over the course of the year. (The regulation does not take into consideration that many refrigerators and AC units may not contain a full charge due to damage and leakage.) Furthermore, any foams containing CFC must be degassed in an airtight chamber, with the exhaust gas being fed into a waste gas treatment facility. Degassed foam cannot exceed 0.2% ODS by weight; if more ODS is remaining, the foam must be sent for incineration. The exhaust gas from the facility cannot contain more than 10 g CFCs per hour or, more than 20 mg per cubic meter in concentration; for old plants, the limits are 25 grams CFCs per hour and 50 mg per cubic meter. The exhaust stream must also be continuously monitored for reporting. An annual emissions test is conducted by German state authorities.

While the exhaust gas standards for plants in Germany are strictly enforced, the regulatory requirement of an average 90% refrigerant recovery rate is largely not enforced. To address the issue of refrigerant recovery rates in practice, UBA has suggested guidelines and German RAL GZ-728[23] has proposed specifications for state-of-the-art processing, which should achieve a recovery rate of more than 90% of the *remaining charge* at time of disposal. UBA is considering mandating such guidelines in order to require recyclers to maintain records of the quantities of ODS they recover and the number of appliances they process. It is expected that such a mandate would result in improved ODS recovery beyond what is currently being achieved under the standards on exhaust gas and annual average recovery rates.

In Germany, environmental policies are developed and implemented by the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, headquartered in Bonn. Enforcement of these policies is the duty of Umweltbundesamt (the Federal Environmental Agency), also known as UBA.

[23] The RAL Quality Assurance Association for the Demanufacture of Refrigeration Equipment Containing CFCs was created to guarantee quality in the refrigerated appliance recycling process and to ensure compliance with existing environmental standards. The RAL GZ-728 quality assurance and test specifications contain the standards to be met for the collection, storage, preparation and treatment of waste refrigeration equipment.

3. ODS-Containing Appliances

3.1 Background

German appliance manufacturers and importers are held financially responsible by law for the proper disposal of their products. The German companies in this industry, numbering approximately 200, have formed an association to work together for efficient disposal of appliances. The association works with municipal waste authorities to collect disposed units. To coordinate disposal, the association has a registry office, Stiftung Elektro-Altregäte Register. Waste appliances are collected, demanufactured, and recycled, with ODS recovered and destroyed.

3.2 Description of Process/Program

Consumers in Germany can drop off their end-of-life appliances at municipal waste centers free of charge. These centers, numbering approximately 1,500 nationwide, are known as “Communal Handover Offices.” On average, each center serves an area of 50-100 km^2. Some municipalities also offer curbside pickup service to their residents. As an additional means of collection, many retailers offer take-back services, handing off returned units to Communal Handover Offices. Municipal authorities then store all waste electric and electronic equipment in a container at the waste center until the container is filled.

As directed by the Federal Environmental Agency (UBA), appliance manufacturers must pay for the pick up and transport of containers to recycling facilities. These assignments are distributed such that a company’s annual responsibility is proportional to the company’s market share in the appliance sector. Coordination is provided by the industry association’s registry office, Stiftung Elektro-Altgeräte Register.

Appliance manufacturers must have containers removed within four days of arrival, at risk of receiving fines for nonperformance. To prevent misuse of the service, appliance manufacturers can file complaints with federal authorities, for example, if other waste has been mixed into the container.

There are approximately 20 appliance recyclers in Germany. Generally, a transportation contractor is hired to take the containers from waste centers to recyclers, although some recycling plants provide pick-up services of their own.

Recyclers then dismantle refrigerators and AC units (and other appliances), and both ODS refrigerant and ODS from foams are recovered in the process. The remaining scrap metal and plastic is sorted and sold. Foams are put through shredders inside a sealed chamber. The resulting polyurethane flakes are heated to release additional ODS. The ODS is removed from the exhaust gas and stored for destruction.

At one refrigerator recycling facility in Grevenbroich, EGN, refrigerators are placed on tilt tables, and vacuum pumps are used to remove the refrigerant-oil mixture from each unit, with the operation conducted in a nitrogen-blanketed environment. The mixture is then distilled to separate the refrigerant from the oil, and the refrigerant is stored to await shipment by truck. Foams from the refrigerators are shredded and degassed. The waste gas from the shredder is treated onsite, with the ODS recovered and stored for shipment. The resulting foam powder is either sent to an incineration operator or is sold to Sali, a company that uses the material for construction. EGN is considering construction of an on-site combustion cogeneration system that would generate electricity from burning the degassed foam.

Appliance recycling plants such as EGN are subject to extensive annual performance checks that include a measurement of the concentration of ODS remaining in exhaust gases, as specified in TA Luft. The shredding chambers are also checked for leaks. A plant that fails two consecutive tests must be shut down. New plants are inspected upon their opening.

The ODS recovered by refrigerated appliance recyclers is either (a) sent directly to thermal destruction facilities; (b) sent to a reclamation facility to be reclaimed for reuse; or (c) sent to a reclamation facility for purification prior to destruction. The latter is occasionally performed since some operators of high-temperature incinerators require purified ODS rather than ODS mixtures for accurate process control and consistent flow rate.

3.3 Costs

The demanufacturing of residential appliances is organized under private contracts between appliance manufacturers and recyclers. A manufacturer will contract a recycler for €200 (US$294) per metric ton of refrigerator charge, and the recycler is then responsible for the costs of destruction, which is about €30 (US$44) per metric ton. All payments are coordinated by the national Stiftung Elektro-Altgeräte Register.

As for the consumer, the recycling costs are included in the price of the new appliance, as part of the WEEE system.

Proklima[24] estimates that the cost of refrigerator recycling/recovery is between €6 and €12 per unit (~US$9 -$18/unit). Proklima also estimates that average costs of recovering a metric ton of CFC are between €2,000 and €4,000 (~US$2,900 -$5,850).

3.4 Statistics on Collection

German authorities do not require recyclers to report on the number of appliances processed or the amounts of ODS recovered, therefore, data on the collection and treatment of refrigerated appliances in Germany is not readily available. However, based on state-level data collected by an advocacy group, Deutsche Umwelthilfen, an estimated 2.4 million refrigerated appliances were processed by recyclers in 2005. According to Proklima, 3.3 million refrigerators are recycled each year, over 95% of which are collected through the national recycling program. The discrepancy between these two estimates can be explained by different assumptions regarding the weight of refrigerators, since both estimates are based on raw data on the tonnage of refrigerators collected. Proklima estimates that 5% are landfilled or otherwise illegally disposed of. Of the appliances collected through the national recycling program, Proklima estimates that ODS refrigerant and foam is properly recovered from over 80%.

While ODS recovery rates are not reported or generally verified during the licensing and inspection of recyclers (only the exhaust gas emissions are checked), UBA estimates that a total of 500 g of CFC are contained in each refrigerator. This estimate corresponds with figures from Deutsche Umwelthilfen, which estimates that each unit contains an average of 127 g of CFC-12 refrigerant and 312 g of CFC-11 foam.

Based on data from one recycling company, EGN, 89% of the incoming refrigerators are CFC-based. On average, EGN recovered 98.5% of the ODS contained in the units at time of disposal. After the degassing process, the foam flakes consisted of less than 0.5% CFC by weight. EGN recycles 92.7% of refrigerated appliances by weight.

In-depth studies of refrigerator recycling have been conducted by RAL Quality Assurance Association for the Demanufacture of Refrigeration Equipment Containing CFCs. RAL has undertaken a comprehensive study of the transportation and demanufacturing of collected refrigerators, assessing the precautions taken

[24] Proklima is a division of GTZ, the sustainable development enterprise owned by the German government.

to avoid damage during transport, proper record-keeping, thoroughness of demanufacture, proper recovery of ODS, and fugitive emissions. In the course of the study, RAL conducted checks at recyclers around Germany and found that many recyclers calculated ODS recovery values of 90% or more; however, ODS recovery rates actually averaged only 63%.

3.5 Challenges

One challenge associated with the proper recovery of ODS from appliances in Germany is the assurance of high recovery rates. German authorities require testing of the exhaust gas at recycling plants, but rarely require verification of ODS recovery per unit. The 2008 EU conference on ODS may revise regulations to include recovery standards, which is what RAL recommends. The proposed standard would require that 100 units be measured for ODS content and then put through the recycling process. The amount of ODS recovered would be measured and averaged out. A contracted tester would operate the plant during this test.

It is important that ODS recovery checks not only be conducted, but that they be conducted properly. RAL noted that the required air emissions performance test conducted in Germany are performed by contractors hired by the recyclers, creating potential conflicts of interest—despite the fact that testers are highly screened by government authorities. RAL notes that the plants are also notified before a test, which allows a recycler to prepare just in time for a check. Further, the German Quality Assurance Institute reports that some refrigerator recycling facilities schedule their annual facility maintenance directly before their air emissions performance test to “brush up” their performance in advance of the test. RAL recommends that tests not be scheduled in advance and that they be conducted by randomly assigned testers who rotate facility assignments annually.

Another challenge in Germany is enforcement. Different states in Germany enforce regulations with varying degrees of effort. RAL reports that, while most Germans properly dispose of their appliances, enforcement is incomplete and the number of refrigerators actually being recycled is unknown.

Furthermore, concern has been raised by the Federal Environmental Agency and the German Quality Assurance Institute that copper parts and compressors are being pirated from refrigerators, allowing ODS to escape. Specifically, municipal collection sites are generally unlocked and are not tightly secured. This has allowed thieves to enter the facilities and strip refrigerators of their compressors and tubing, in order to sell the copper for a profit. However, according to Deutsche Umwelthilfen, ODS losses associated with metal pirating are not significant; they maintain that the low rate of ODS refrigerant recovery from German refrigerator recycling facilities is attributed to the fact that many units (an estimated 20%) arrive at facilities with no refrigerant charge as a result of lifetime leakage or damage. Nonetheless, RAL has proposed that all municipal collection sites be locked up and/or manned.

In the future, refrigerators and other cooling units will mostly be HC-based in Germany. Under current law, these can be destroyed by simple shredding, without recovery. Unless regulations are changed to require that HC units be demanufactured, many appliance demanufacturers could be put out of business. If recovery is required, however, existing destruction facilities will be able to expand their business to handle HCs. One reclamation facility, RCN, is anticipating regulations that require, or at least encourage, recovery of HCs and is in the process of obtaining a permit to construct a solvent reclamation unit designed to recover HCs. RCN’s current solvent units can process CFC and HCFCs, but not HCs (e.g., cyclopentane). There is a discussion among regulators in Germany and at the EC level as to whether recovery of the HC should be required by either country-specific or EC-wide regulations.

Deutsche Umwelthilfen also reports that, in some German states, household refrigerators containing HFC-134a are being illegally processed in automobile shredder facilities along with HC refrigerators. It is unlikely that auto shredders are recovering the R-134a contained in disposed units, as required by law.

3.6 Lessons Learned

Proklima notes that Germany's comprehensive collection and recycling procedures coordinated by Stiftung Elektro-Altregäte Register are cost-efficient and have largely been supported by manufacturers. In addition, cross-border harmonization of WEEE regulations has effectively prevented illegal waste disposal in the EU.

However, without any enforcement of ODS recovery rates, recyclers do not typically collect data on refrigerant recovery; therefore, actual plant performance and efficiency is unknown, with the exception of those committing to RAL. Regulations specifying a minimum recovery rate per unit and recordkeeping requirements would allow Germany to assess plant efficiency and implement improvement measures if needed. Similarly, under the current procedures for annual air emission testing, recycling plant operators may not necessarily pay attention to how plants are operating between scheduled performance tests.

4. Bulk ODS Destruction

4.1 Background

German regulations require the destruction of any recovered CFCs, and the destruction or reclamation of recovered HCFCs. However, there is no nationally organized collection program for waste ODS contained in commercial and industrial equipment, and building foams are typically landfilled.

4.2 Description of Process/Program

There is no organized producer-driven program in Germany for commercial and industrial equipment as there is for domestic appliances. However, according to law, it is the responsibility of the owner of the equipment to ensure that ODS refrigerant collected from commercial and industrial equipment is either recovered for storage, destruction—or in the case of HCFCs—recycling or reclamation.

In Germany, there are hazardous waste incinerators located throughout the country that destroy bulk ODS. Six were operating as of 2002, and more have been built since. Some of the recovered ODS is shipped directly to one of these hazardous waste incinerators, typically the one closest to the recycler. (Some is shipped to France for destruction.) These incineration facilities are often partly state-owned.

> **ODS Reclamation for Gas Conversion**
>
> The RCN reclamation facility in Goch operates multiple ODS distillation units for chlorinated solvents, non-chlorinated solvents, and refrigerants. At the Goch facility, CFC/HCFC and oil mixture is passed through filtration, and the resulting mix is then passed into a compression unit to remove the oil. The ODS is cooled and passed through a series of filters before being stored for purity checks. The facility has full exhaust air treatment and wastewater treatment. RCN ships the purified ODS to Solvay according to Solvay specifications, using two 200 m^3 tanks and tube trailers. Under one specification, Solvay accepts ODS with no more than 5% cyclopentane, in order to reduce the risk of explosion.
>
> Once received at Solvay's facility in Frankfurt's Hoechst industrial park, reclaimed ODS is evaporated and then cracked with hydrogen and oxygen at approximately 1,800 ºC, producing hydrofluoric acid and hydrochloric acid. Both the hydrofluoric acid and hydrochloric acid resulting from the cracking are passed through absorption. The hydrofluoric acid is used for the production of polymers such as Teflon, generally at another Solvay site. The hydrochloric acid is piped out and sold to other companies in the Hoescht industrial park. The exhaust gases at Solvay are washed with sodium sulfite, resulting in sodium sulfate, carbon dioxide, water, and trace NO_x emissions. Effectively, no fugitive ODS emissions result from the conversion process.
>
> To perform the conversion, Solvay receives refrigerant from multiple sources, including HCFCs from its own plants in Bad Wimpfen and Tarragona, Spain. ODS comprises only 20% or less of fluorine input for Solvay's conversion process (with fluorspar, mined in Namibia, representing the majority).

There are also two ODS reclamation facilities in Germany, neither of which reclaims ODS for reuse; one reclamation facility sends the purified products for destruction, and the other sends the products for gas conversion.

Specifically, some incineration operators refuse to accept mixed or contaminated stocks of ODS as it hampers process control. Indeed, incinerators may not be able to meet emissions standards as a result of processing mixed ODS. Therefore, some stocks of recovered ODS are sent to KSR GmbH & Co. for reclamation before incineration. KSR GmbH & Co. KSR separates mixed ODS into pure compounds; these ODS compounds are then sent to thermal destruction facilities. This allows the operators of high-temperature incinerators to readily accept the ODS, as they can destroy it with accurate process control.

Finally, some ODS is sent for reclamation followed by gas conversion. These stocks are sent to RCN Chemie GmbH. RCN separates mixed ODS into pure compounds; the ODS compounds are then used for gas conversion by Solvay Fluor GmbH, a chemical company that specializes in the manufacturing of fluorinated products. Specifically, Solvay converts the ODS it receives into hydrofluoric acid and hydrochloric acid to ultimately produce polymers such as Teflon. Effectively, no fugitive ODS emissions result from the conversion process (see text box, above). Solvay promotes the conversion process, developed in 1981, as the most ecologically friendly solution to ODS disposal. Solvay is the only operator of an ODS gas conversion facility in Germany, and its plant boasts the highest capacity of ODS conversion plant in the world—capable of 200 kg/hr or 1600 MT/year. Solvay developed the conversion process in 1981 and integrated the process into their production system at the Frankfurt facility in 1983.

4.3 Costs

As the destruction of ODS is conducted under private contract, cost information is not available. It should be noted that the Solvay-RCN partnership charges a fee for receiving and processing ODS; this fee must be paid by the appliance manufacturers and, for commercial equipment, the owners of the commercial equipment. The partnership has higher operating costs than do the regional waste incineration operators, but it accepts mixed ODS, unlike many of the incineration operators. However, if Solvay could obtain additional ODS throughput, the cost per kilogram of ODS would be lower.

4.4 Statistics on Destruction

Since German regulations list all refrigerants under one waste code, separate recording of ODS disposal is not federally required, so the quantity of bulk ODS destroyed is unknown. Likewise, foam that is directly incinerated in municipal incinerators is not reported as destruction of ODS.

However, based on data from Solvay obtained for this study, Solvay receives approximately 500 metric tons (MT) of ODS per year from RCN. To date, it has converted 800 MT of ODS. However, Solvay had anticipated a volume of ODS of 800 MT/year from RCN and, as a result of receiving significantly less ODS than projected, is looking for additional business partnerships with companies, including possibly KSR. Solvay was recently granted permission to receive ODS shipments directly from a Berlin refrigerator recycler.

4.5 Challenges

Without a national program to govern the collection, reclamation, and disposal of ODS from commercial/industrial equipment in Germany, there is concern that such equipment may not be disposed of responsibly at end of life. According to the German Quality Assurance Institute, installation contractors often leave disposed commercial equipment outside facilities/buildings which are commonly collected by ordinary scrap metal recycling facilities or equipment refurbishment facilities that may not be recovering the refrigerant.

Incineration is not always an ecologically sound means of disposal. Generally, it is easiest for recyclers and the manufacturers that are paying for the recycling to ship ODS to the nearest incinerator. The incinerators, however, lack destruction standards, and fugitive emissions often result. Solvay/RCN markets its services to the appliance industry as providing the most ecologically responsible ODS disposal option, and the company is pushing to have their process legally recognized as environmentally preferable to incineration. The partnership is also working for the adoption of more stringent disposal regulations.

But Solvay is facing challenges in securing new sources of ODS. While partnerships with additional reclamation facilities are being explored, there is a regulatory preference for ODS to be destroyed instead of converted, as well as preference to ship ODS to local plants, not across the country. If additional ODS input material was available, Solvay could build additional reactors for conversion at the Frankfurt site (and in fact has permission to do so).

One final challenge in Germany is that ODS-containing foams from construction and demolition are not regularly recycled. These foams, most often found in commercial cold rooms, are commonly landfilled. Some foams may be incinerated at low-temperature municipal solid waste incinerators. The German Quality Assurance Institute reported that the combustion of CFC-containing foam in standard domestic municipal solid waste incinerators does not guarantee the destruction of the CFCs. The polyurethane foam must be combusted in a high-temperature incineration facility, at temperatures of at least 1,200 °C, in order to destroy CFCs.

5. Mobile Air Conditioning

There are no German-specific regulations concerning the recovery of ODS from mobile air conditioning units. Germany has, of course, implemented the EC regulations concerning the recovery of ODS from vehicles. However, there is no organized collection system in place for mobile air conditioning units, as there is for household refrigerators. UBA notes that the owner of a mobile air conditioning unit must pay the cost of disposing the CFC. Solvay receives ODS from motor vehicle recovery and uses it for gas conversion as well.

6. Halon Banking

6.1 Background

Today, only a very limited number of halon systems are installed in Germany, mostly in military applications. Most halon was phased out by 2003, when halon was permitted only for critical use applications. UBA reports that most of the halons that were decommissioned in response to the phaseout were vented to the atmosphere by users, instead of being collected for disposal. While halon was prohibited from being exported, there is the possibility that some of the halon was collected and transferred to in-country critical uses, but any such transfers were not documented.

RCN reports that they occasionally receive shipments of wastes containing halons. As RCN does not process halon-containing wastes, on account of the bromine content, any materials that contain halon – which are rarely received, in general – are sent to a subcontractor for destruction.

6.2 Lessons Learned

Given that halon was prohibited for reuse and export, which effectively required users to pay for destruction, there was a strong economic incentive for users to illegally vent halon. A national program to subsidize halon collection and reclamation/destruction would have been needed to prevent illegal venting within this regulatory framework. In phasing out ODS, it is critical to consider the economic incentives in place and ensure that the regulatory program is sufficiently designed to prevent venting. Providing commercial property insurers with financial incentives for early halon phaseout may be an effective approach worth exploring.

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V. Japan

1. Introduction

1.1 Country Information

Japan consists of four major islands, Honshu (the main island), Hokkaido, Shikoku, and Kyushu, with more than 4,000 smaller islands surrounding these four. In total, Japan's land comprises an area of 377,873 square kilometers. Japan is a rapidly expanding country, with 127.4 million people (CIA World Fact Book 2007) and over 49 million households (SBSRTI 2007). The capital of Japan, Tokyo, is home to nearly 10% of the national population, with approximately 12,059,000 people. Other major population centers include Yokohama (3,426,000 people), Osaka (2,598,000 people), Nagoya (2,171,000 people), Sapporo (1,822,000 people), Kobe (1,493,000 people), Fukuoka (1,290,000 people), and Sendai (1,008,000 people). The average population density of Japan is 343 people per square kilometer, although the population density of Tokyo is about 17 times this average, with 5,751 persons per square kilometer (SBSRTI 2007).

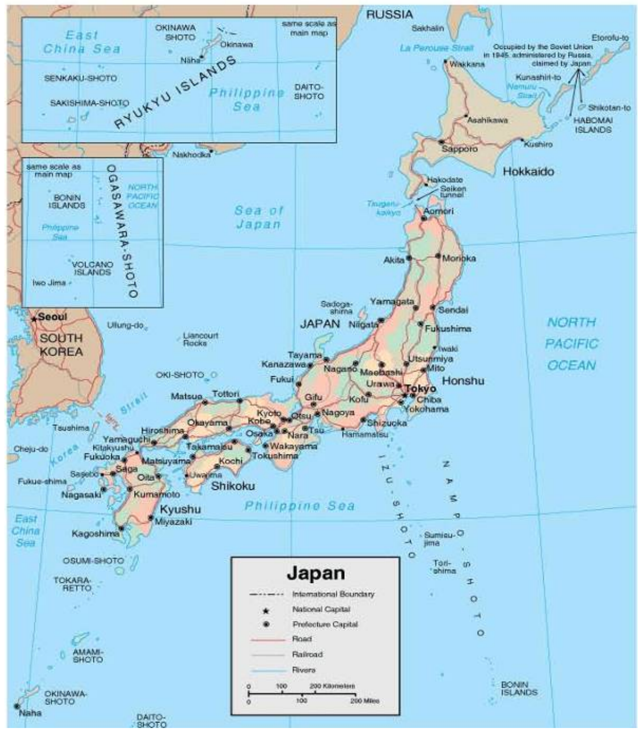


Exhibit V-1: Japan Source: Map-of-Japan.org

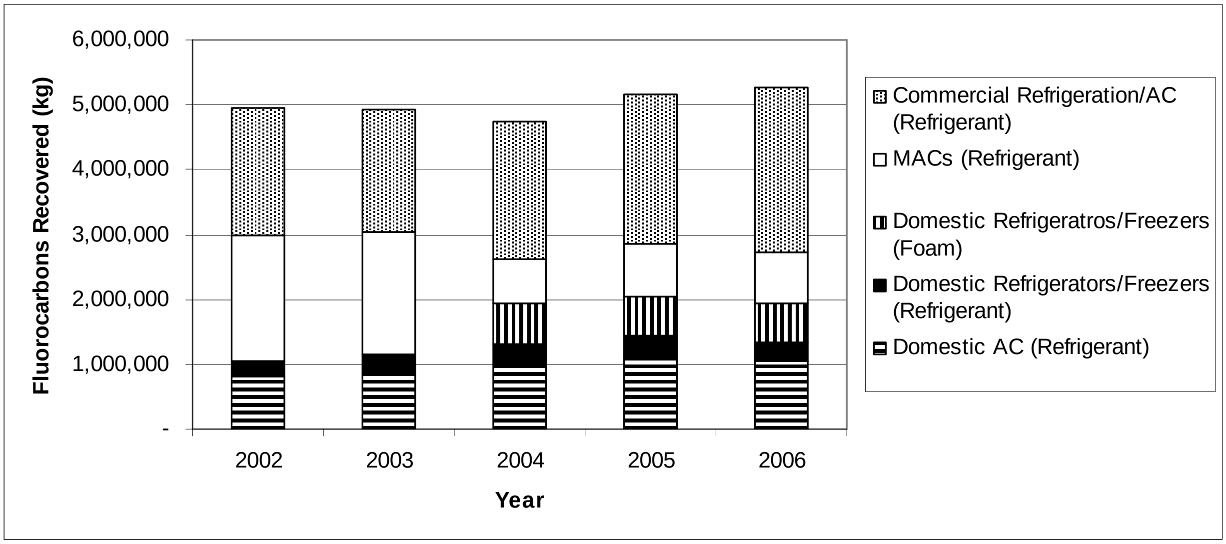
Japan has a strong economy, ranking third after the US and China (CIA World Fact Book 2007). Japan domestically ships and exports refrigeration and air conditioning equipment. From October 2005 to September 2006 4,984,230 MACs, 153,339 residential AC units, and 270,066 commercial AC units were exported; in the same year, 4,689,077 MACs, 7,527,251 residential AC units, and 798,128 commercial AC units were shipped domestically (JRAIA 2007).

1.2 ODS Market Characterization

Japan is a major producer of domestic refrigerators/freezers and air-conditioners, as well as automobiles. In addition, Japan produces HCFCs and HFCs, and in 2006, shipped roughly 50,000 metric tons of fluorocarbons. The majority of these fluorocarbons were refrigerants, but some were also intended for foam, solvent, and aerosol applications.

Over the last several years, Japan has implemented stringent fluorocarbon recovery laws and established sophisticated infrastructure to achieve high recovery levels for refrigerant from the commercial, domestic, and motor vehicle sectors alike (see Exhibit V-2). Significant amounts of foam blowing agent from domestic refrigerators/freezers have also been recovered starting in 2004 (although some foam recovery began on a test-basis as early as 2001). In 2006, the commercial sector accounted for 48% of total fluorocarbon recovery in Japan, while the residential sector accounted for 37%, and the MAC sector accounted for 15%.

Exhibit V-2: Fluorocarbons Recovered by Sector, 2001-2006



As a result of decades of outreach and education, Japanese citizens, including elementary students, are aware of the health hazards associated with ODS and the dangers posed by the release of refrigerants. Japan's refrigeration/AC industry is also highly organized, with numerous associations across the country and strong networks with other industry segments (e.g., building dismantlers, construction companies) that allows for the effective training and education of stakeholders.

2. Relevant Legislation and Regulations

The Japanese Government has enacted several laws mandating the recovery of fluorocarbons for destruction if not for reuse/reclamation. Specifically, these laws include:

- Home Appliance Recycling Law (promulgated in 1998, enacted in 2001)
- Fluorocarbons Recovery and Destruction Law (promulgated in 2001, enacted in 2002)
- End-of-Life Vehicle Recycling Law (promulgated in 2002, enacted in 2005)

The *Home Appliance Recycling Law* establishes procedures for the recycling of home refrigerators, air-conditioners (including split systems), televisions, and washing machines (Japanese Ministry of the Environment 2007a). These four appliance types were selected because they are delivered and installed by retailers, who can serve as channels for appliance return. The law mandates the recovery of fluorocarbon refrigerants and foams,[25] and also sets minimum recycling rates for the durable components of these appliances (of 50%-60%).[26] The law also requires that appliances be collected by retailers and

[25] Manufacturers/importers began testing the feasibility of foam recovery/destruction in 2001; by 2004, it was proven to be feasible, and the recovery and destruction of foam from domestic refrigerators/freezers became legally required in 2004.

[26] National standards for recycling ratios are defined based on commercial value of recyclable materials. If materials are reused but no commercial value is assigned for that use (e.g., if plastics are used as fuel but no payment is received for it), Japanese law does not consider this to be "recycled." If commercial value were not considered in the definition of "recycling," current Japanese recycling rates for appliances would be over 90%.

recycled by manufacturers or importers. Fees for the collection, transport, and recycling are paid by consumers at the time of disposal.

The *Fluorocarbons Recovery and Destruction Law* aims to guarantee the recovery and destruction of fluorocarbons from commercial refrigerators/air-conditioners (AC) (Japanese Ministry of the Environment 2007a). The law requires the recovery of fluorocarbon refrigerants (i.e., CFCs, HCFCs, HFCs) from commercial equipment during service and disposal events. The law also requires that refrigerant recovery be performed by recovery operators/firms registered with prefecture government. Fluorocarbon recovery operators must report annually to prefecture governors on the amount of fluorocarbons recovered from commercial AC and refrigerators in the previous year. In addition, the law requires that any refrigerant destruction must be performed by permitted facilities using sound environmental technologies. Destruction facility permits are granted by the national government (the Ministry of the Environment [MOE] and the Ministry of Economy, Trade and Industry [METI]). The law also mandates that the fee for fluorocarbon recovery and destruction be paid by end-users.

In June 2006, this law was amended to improve refrigerant recovery levels from commercial equipment, which was estimated to be about 30%. Among other things, the amendments require increased reporting and recordkeeping for commercial equipment owners to increase responsibility and accountability. The amendments also added responsibility for building dismantlers to check for and properly dispose of any commercial refrigeration/AC equipment containing fluorocarbons. In addition, the amendments strengthened the authority of local governments so that they can give guidance, advice, recommendations and orders to the equipment owners, and to those receiving the equipment to guarantee recovery operators recover the fluorocarbons installed. Previously, the authority of local governments had been limited to the issuance of guidance to recovery operators. The amendments entered into force in October 2007.

The *End-of-Life Vehicle Recycling Law* was adopted in 2002 to address the recycling of end-of-life vehicles and the recovery of fluorocarbon refrigerants during the recycling process (Japanese Ministry of the Environment 2007a). Previously, the recovery and destruction of refrigerants from MACs had been covered under the *Fluorocarbons Recovery and Destruction Law*. Under the current legal framework, disposed vehicles must be collected by registered collection operators (i.e., registered car dealers and auto repair shops), transferred to registered recovery operators to remove refrigerant, and then transferred to permitted dismantling and shredding operators (Japanese Ministry of the Environment 2007a). Fees for the recovery, transport, and destruction are paid by consumers. In addition, consumers must also pay fees for the recycling of air-bags and shredder-residues.

3. ODS-Containing Appliances

3.1 Background

Historically, retailers and municipalities in Japan landfilled appliances whole or following shredding (Ministry of Economy, Trade, and Industry). Such practices resulted in the waste of natural resources—such as metals, plastics, and glass—as well as the release of harmful ODS refrigerants and foams. To reduce waste and reuse natural resources, the *Home Appliance Recycling Law*, which entered into force in 2001, established a new recycling framework. The law introduced new concepts of sharing the responsibilities among consumers, retailers, and suppliers, as well as charging consumers directly for disposal (Ministry of Economy, Trade, and Industry).

3.2 Description of Process/Program

The *Home Appliance Recycling Law* obligates all retailers of refrigerators/freezers, AC units, televisions, and washing machines to take-back old units they have sold, as well as old units disposed of at the time a new unit is purchased. Retailers also charge the consumer for associated transport and recycling costs. The law also places responsibility on the manufacturers and importers of these appliances to recycle. The illegal dumping of waste home appliances is punishable under the Waste Management & Public Cleansing Law; up to 5 years imprisonment and/or a fine of up to ¥10,000,000 (roughly US$90,000).

End-users are obligated to return old home appliances to a retailer selling those products, to municipal offices,[27] or directly to designated appliance collection sites. Municipalities generally deal with appliance collection only in cases where local retailers are small and inadequate for transporting old appliances to designated collection sites. Appliance owners who take appliances directly to designated appliance collection sites must complete a *Home Appliances Recycling Coupon* (manifest), available at post offices around the country. According to a recent national survey, over 90% of disposed appliances are estimated to be handled through retailer channels. There are nearly 74,000 retail stores that accept old home appliances.

Upon handing over old appliances to retailers, end-users are responsible for paying the costs of collection, transport, and recycling. (If the retailer charges a fee to the consumer, the retailer is prohibited from re-selling the old unit; he must dispose of it through proper channels.) For the collection, transport, and recycling of refrigerators/freezers, consumers must pay approximately ¥4,600 (roughly US$40); for AC units, consumers must pay approximately ¥3,000 (roughly US$25).

Retailers are obligated by law to collect old appliances and transport them to one of 380 designated appliance collection sites. Upon pick-up, retailers are required to issue a *Home Appliances Recycling Coupon,*[28] or recycling ticket, which serves as a manifest to monitor the end-of-life management of appliances and also allows consumers to track the location and fate of their old units. Specifically, the coupon is placed on the appliance, and copies of the coupon are given to the consumer and kept by the retailer for recordkeeping purposes. Retailers are required to maintain slips for three years. The location and status of each unit is tracked electronically and reported online.

Once at the designated collection points, it is the responsibility of manufacturers/importers to recycle their respective appliances. Because it is not cost-effective for each company to establish separate recycling facilities, the major manufacturers and importers created two groups, *Group A* and *Group B.*[29] Both Group A and Group B collectively established facilities to recycle their respective appliances, with the operating costs distributed among manufacturers based on their share of originally produced equipment that is processed by the facilities. These two Groups were established to ensure competition and efficiency of recycling operations. Of the 380 designated appliance collection sites, 190 are run by Group A, the other 190 by Group B. Each Group has a contractor—Ecology Net for Group A and R-Station for

[27] Municipal offices that receive home appliances from end-users are assigned the task of either transferring appliances to manufacturers or "Designated Agent" or recycling these appliances themselves (Ministry of International Trade and Industry 1998). Municipalities that collect appliances must follow the same procedures for issuing *Home Appliances Recycling Coupons* as retailers.

[28] Recycling tickets assign each unit with a unique identification number and indicate the equipment type, manufacturer, end-user, recycling fee, transportation fee, consumption tax (5%), and the date of pick-up.

[29] Group A recycling plants were established by Matsushita and Toshiba; Group B recycling plants were established by Sanyo, Sharp, Sony, Hitachi, Fujitsu, and Mitsubishi. Other appliance manufacturers also participate in Group B (although they did not pay to establish facilities).

Group B—that manages the transport and recycling of appliances once they reach the designated collection sites. Group B separates appliances by original manufacturer and, once enough equipment is collected, sends them to one of 48 government-certified recycling plants owned by Groups A and B, in accordance with original manufacturer/importer (Ministry of Economy, Trade, and Industry; Ministry of International Trade and Industry 1998). Group A does not separate appliances by manufacturer, but determines cost sharing responsibilities based on the *Home Appliances Recycling Coupons* (which state original manufacturer).

Of these 48 appliance recycling plants, Group A operates 30, Group B operates 16, and 2 are shared by both groups. Not all plants are equipped to deal with all appliance types; 24 are designed to recycle refrigerators/freezers, and 37 are designed to recycle AC units.[30] Disposed appliances from the smaller islands are shipped by boat to the main island for recycling.

If the manufacturer or importer of a specific appliance is unknown or no longer in business, then they must be transferred to a "Designated Agent," which is run by the Association for Electric Home Appliances (AEHA) (Ministry of International Trade and Industry 1998).[31] As a *Designated Agent,* AEHA is obligated by law to perform the following three main duties: (1) recycle appliances when the manufacturer or importer is unknown; (2) recycle appliances when small and medium-sized manufacturers or importers entrust them to do so; and (3) collect appliances that municipal offices or residents find difficult to transfer to manufacturers or importers (Ministry of International Trade and Industry 1998). Appliances from unknown or small/medium manufacturers/importers are sent to Group B facilities for recycling. Those units collected by municipal offices or residents are sent to Group A or B, in accordance with the manufacturer/importer of the specific equipment. The activities of AEHA are funded by consumer fees.

After the groups of manufacturers/ importers and *Designated Agent* acquire appliances at the designated in-take points, they must recycle them following standards set by the government. During recycling, manufacturers and importers remove parts and materials for reuse, and recover fluorocarbon refrigerants and foams from appliances. Group A and Group B have set their own standards for the recovery of refrigerant, based on the level of pressure or the amount of refrigerant per unit. Three different technologies are used in Japan for the recovery and destruction of fluorocarbon foam:

- *Activated carbon*: After the foam is shredded and separated using a pneumatic separator, the fluorocarbons that are released from the foam are adsorbed onto activated carbon and liquefied (by cooling) for recovery and destruction.
- *Direct decomposition*: After the foam is shredded, the fluorocarbons that are released from the foam are injected into an adjacent incinerator and decomposed.
- *Low-temperature condensation recovery*: After the foam is shredded, the fluorocarbons that are released from the foam are liquefied by liquid nitrogen and recovered.

Most commonly, fluorocarbons are sent to the nearest destruction facility. R-22 is sometimes reclaimed or used by Teflon manufacturers.

[30] Group A operates 11 refrigerator recycling plants and 22 AC recycling plants; Group B operates 12 refrigerator recycling plants and 13 AC recycling plants. In addition, one refrigerator recycling plant and two AC recycling plants are jointly operated by Groups A and B.

[31] Apart from servicing as a Designated Corporation for managing the recycling of "non-designated" appliances, AEHA also issues recycling tickets to retailers, and compiles reports based on statistics provided by Groups A and B.

Exhibit V-3. Kanto Eco Recycle (KAREC) Home Appliance Recycling Plant. *Domestic appliances are stored at Kanto Eco Recycle prior to processing. Appliances are transported and stored in specially-designed crates to maximize efficiency. Located on the outskirts of Tokyo, this facility recycles all four types of household appliances.*

Under the *Home Appliance Recycling Law*, the Ministries of the Environment and Economy, Trade and Industry are authorized to inspect retailers, manufacturers, and importers to ensure they are in compliance with the law. Since Japan's appliance recycling laws came into effect six years ago, ongoing efforts have been made not only to ensure compliance, but also to improve recycling plant efficiency. For example, R-Station provides guidance to their recycling plants on good practices to increase recovery and recycling rates. As a result of instruction and training, as well as technological improvements in equipment, R-Station has increased the quantity of recovered materials from refrigerators/freezers by a factor of 1.6, and the quantity recovered from AC systems by a factor of two. Effort has also been spent to increase transportation efficiency, by creating different containers to move and store different appliance types (see Exhibit V-3). In addition, R-Station publishes a bi-monthly newsletter that lists the recovery rates of each recycling plant to highlight those achieving the best results and stimulate others to improve. At the end of the year, awards are given to the best plants, and those award-winning plants help educate others on their methods for success.

The appliance recycling infrastructure in Japan has given rise to environmental benefits that go beyond those achieved at equipment end of life. Appliance manufacturers have worked with appliance recyclers to improve product design and enhance the recyclability of components. In this way, the product stewardship scheme in Japan has led to green design and improved product lifecycles.

3.3 Costs

As described above, consumers must pay a fee for the collection, transport and recycling of their disposed appliances. Approximate fees for recycling charged to consumer are presented in Exhibit V-4, but may vary by manufacturer/importer. Additional fees for the collection and transport vary by retailer. Average fees for collection and transportation of an old unit when a new unit is purchased is ¥644 to ¥688 (~US$6-7) for large retailers, and ¥2,026 to ¥2,632 (~US$19-25) for small (local) retailers. Retailers charge higher fees for the collection/transport of old units when the return is not accompanied by a new appliance purchase; large retailers charge between ¥2,319 and ¥2,458 (~US$22-23), and small retailers charge between ¥2,451 and ¥3,086 (~US$23-29). However, as governed by law, recycling fees must not be above the appropriate costs for efficient recycling, and should be set at a reasonable level, as not to dissuade consumers from properly disposing of appliances. To be sure manufacturers, importers, and retailers are charging appropriate fees, they must publicize their collection/recycling fees. If the government deems the fees unsuitable, it has the authority to order a fee correction (Ministry of International Trade and Industry 1998).

Exhibit V-4: Approximate Recycling Fees Charged to Consumers[a]

Appliance	Fee (Yen)	Fee (Approximate US Dollars)
Air-conditioner	¥3,000	$26.50
TV (CRT Types)	¥2,700	$24.30
Refrigerator/Freezer	¥4,600	$41.40
Washing Machine	¥2,400	$21.60

[a] Actual recycling fees may vary by manufacturer. Additional fees are charged by retailers for collection and transport.

The capital cost associated with each of the recycling facilities is estimated at ¥2-3 billion (US$20-25 million). The recycling plants are highly sophisticated, with the smaller ones employing roughly 50 staff, and larger ones employing 150 personnel. One facility built and operated by Hitachi has an area of 17,700 m^2 and recycles 1.1 million appliances per year (see Exhibit V-3 through Exhibit V-6).

Additional costs are associated with the administration/operations of the recycling plants conducted by contractors R-Station and Ecology Net. (The recycling fees paid by consumers cover these administration costs.) R-Station, which manages the recycling of 60% of all appliances, employs 24 staff.

Exhibit V-5. Kanto Eco Recycle (KAREC) Home Appliance Recycling Plant. *Refrigerant is recovered from refrigerators at the Kanto Eco Recycling plant. The facility includes two crushers, one for refrigerators/freezers, and another for AC systems and washing machines. Prior to crushing, refrigerant and plastic/glass components must be removed.*

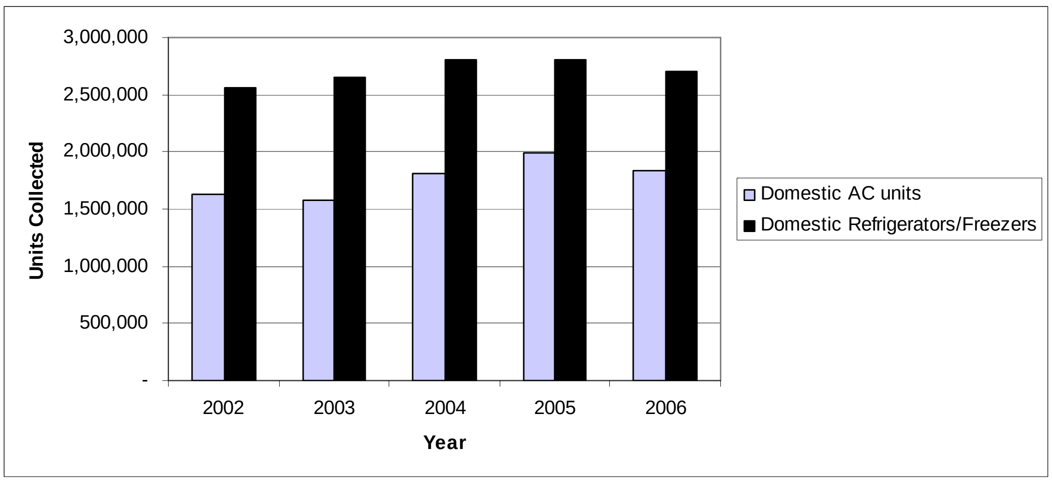
Exhibit V-6. Kanto Eco Recycle (KAREC) Home Appliance Recycling Plant. *Refrigerators are placed on a conveyor belt prior to crushing at the Kanto Eco Recycling plant. The plant processes appliances from 22 different designated collection sites in eight prefectures.*

Refrigerant and foam recovered from appliances are typically sent to the nearest destruction facility, with consideration given to cost. ODS destruction costs can range between US$3-10/kg, with a rotary kiln facility charging ¥450/kg (~ US$4/kg), and a plasma arc facility charging ¥1,000/kg (~ US$9/kg). The Kanto Recycling facility sends HCFC-22 to a Teflon manufacturer that charges only ¥200/kg (<US$2/kg).

3.4 Statistics on Collection

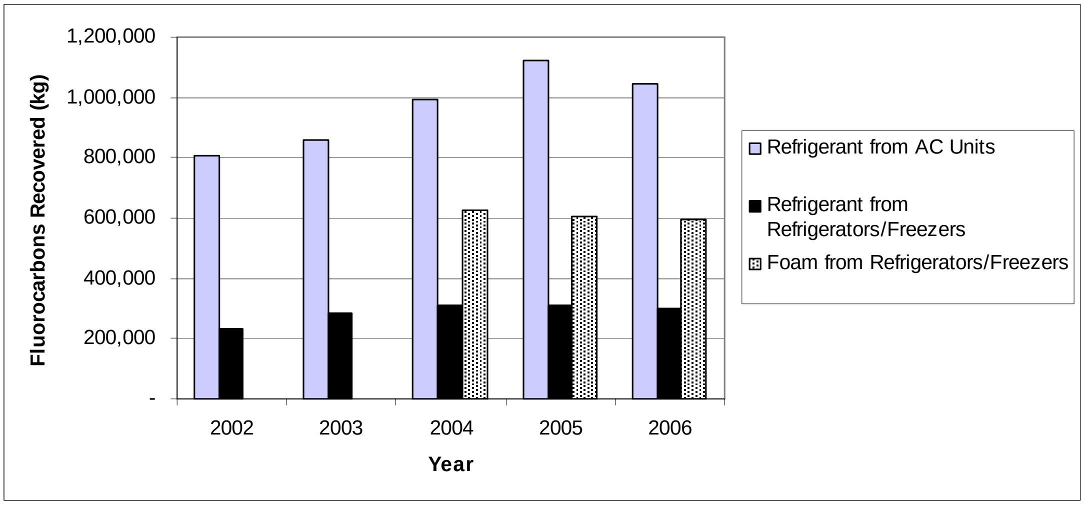
An estimated 22-23 million refrigerators/freezers, AC units, televisions, and washing machines are disposed in Japan each year (Ministry of Economy, Trade, and Industry). From 2001 to 2004, the number of household refrigerators/freezers and domestic AC units collected for recycling has steadily increased and has since leveled off (see Exhibit V-7). Roughly 1.8 million AC units and 2.7 million refrigerators/freezers were collected in 2006.

Exhibit V-7: Number of Household Refrigerators/Freezers and AC Units Collected for Recycling, 2002-2006



According to the Kanto Recycling facility, refrigerators/freezers reaching their facility contain an average of 125 grams of refrigerant per unit, while AC units contain an average of 730 grams per unit. Roughly 20% of AC units arrive empty of refrigerant charge, but very few refrigerators/freezers arrive in this condition. On average, 275 grams of foam are recovered from each refrigerator/freezer, which is approximately half of the original amount contained in units at the time of manufacture. In 2006, over 1,000 metric tons of refrigerant were collected from AC units, while roughly 300 metric tons were collected from refrigerators/freezers. A further 600 metric tons of fluorocarbons was recovered from foams contained in refrigerators/freezers—excluding amounts recovered using the direct decomposition method, for which no data are available. Thus, in total, nearly 2,000 metric tons of fluorocarbons were recovered from domestic appliances in 2006 (see Exhibit V-8).

Exhibit V-8: Fluorocarbons Collected from Household Appliances, 2002-2006[a]



[a] Actual quantities of recovered foam are greater as these data exclude amounts recovered using the direct decomposition method.

3.5 Challenges

Of the roughly 22 million home appliances disposed in Japan each year, only 11-12 million are currently being collected through legal channels. (Of those collected through legal channels, 1.8 million are AC units and 2.7 million are refrigerators/freezers.) Thus, overall, nearly 50% of appliances are illegally resold or dumped. Part of this "invisible flow" is believed to be small companies that offer free appliance collection to consumers, and often sell old equipment to Article 5 countries for reuse or (component) recycling. Likewise, retailers do not always deliver appliances to the designated collection sites as required, and may also be reselling units or dumping them illegally. For example, in 2005, a large number of disposed appliances were found illegally dumped in a pond, and the collection operator responsible for the units was fined. Consumers may also illegally dump their unwanted appliances to avoid paying recycling fees.

To increase compliance with appliance recycling laws, Japan is exploring various options. These options include:

- Establishing criteria for reselling units;[32]
- Increasing retailer reporting requirements to the national government (MOE/METI); and
- Requiring advance payment from consumers for recycling fees.

With regards to the latter issue, Japan recognizes that the disposal fees collected at time of appliance disposal may lead to illegal dumping despite the country's strict legal framework and strong environmental awareness among consumers to prevent such behavior. The difficulty, however, with

[32] Criteria under consideration would require that appliances be operational, in good physical condition, and less than six years old. According to a demonstration project being run by one large retailer, only 1.3% of appliances being disposed in Japan would qualify for resale based on these criteria.

charging recycling fees at the time of appliance purchase instead of disposal, is that it would create the need for an innovative mechanism to fund the disposal of appliances already in use..

3.6 Lessons Learned

While efforts are needed to increase compliance in Japan, great success has been realized in recycling appliances and recovering large amounts of fluorocarbon refrigerant and foam from domestic refrigerators/freezers and AC units—an estimated 2,000 tons/year. Moreover, the success in Japan goes well beyond fluorocarbon recovery; nearly all equipment components are now recycled and more sustainable (recyclable) products have been developed. Much of the efficiency has been achieved through competition that has been built into the system—by having companies collaborate yet compete (Group A vs. Group B) and by developing innovative ways to constantly improve efficiency (e.g., newsletters, awards, trainings, etc.).

Based on input from Japanese stakeholders, such success could not have been realized if not for industry's strength, organization, and leadership. With so many large appliance manufacturers in Japan, it is possible to make them responsible for the recycling of their own products. Moreover, by mandating producer responsibility at the national level, there are no "free riders," so all industry players share the same burden. Further, there is a willingness on the part of consumers to pay the recycling fee, thanks in large part to their environmental education and awareness.

4. Bulk ODS Refrigerants

4.1 Background

The *Fluorocarbon Recovery and Destruction Law* entered into force in 2001 to ensure fluorocarbons from commercial refrigerators/air-conditioners are properly recovered and destroyed (Japanese Ministry of the Environment 2007a). Refrigerant recovery operators must send unwanted refrigerant to one of 82 destruction facilities registered to destroy ODS in Japan. Of these 82 facilities, 80 were in operation as of April 2007. The number of ODS destruction facilities in operation is subject to change as fluorocarbons destruction operator permits are now being renewed. These facilities use the following destruction technologies:

- Cement Kilns/Lime Rotary Kilns (7)
- Nitrogen Plasma Arc (8)
- Rotary Kiln Incineration/Municipal Solid Waste Incinerators (24)
- Liquid Injection Incineration (7)
- Microwave Plasma (5)
- Inductively Coupled Radio Frequency Plasma (1)
- Gas-Phase Catalytic Dehalogenation (1)
- Superheated Steam Reactors (25)
- Solid-Phase Alkaline Reactor (1)
- Electric Furnace (1)

Currently, Japanese regulations do not allow for the import of ODS waste for the purpose of destruction. It is expected that most of the destruction facilities in Japan would be operating at or near full ODS destruction capacity in the coming years, if no new capacity is established.

4.2 Description of Process/Program

Under the *Fluorocarbon Recovery and Destruction Law* end-users are charged a fee at the time of disposal for recovery, transportation, and destruction of commercial refrigerators/air-conditioners. The law requires recovery operators to recover fluorocarbons in commercial refrigerators/air-conditioners in servicing and prior to disposal. After recovering the fluorocarbons, the recovery operators deliver the fluorocarbons to destruction or reclamation operators, and pay a fee (Japanese Ministry of the Environment 2007a). Recovery operators must follow standards for the recovery and transportation of fluorocarbons (e.g., fluorocarbons should be recovered to the extent where the pressure value goes below the standard value, and re-charge of recovered fluorocarbons into a different cylinder is discouraged)[33] and must submit an annual report to local governments accounting for the fluorocarbons recovered. Such reporting allows the government to keep track of how many units of commercial equipment are being disposed of each year, as well as the amount of fluorocarbons recovered from the units. Over 1,000 on-site inspections for fluorocarbons recovery operators are conducted every year.

Once fluorocarbons are delivered by recovery operators, destruction operators destroy fluorocarbons into harmless materials according to standards provided. Destruction operators must generate an annual report detailing their activities to give to competent ministers. In addition, competent ministers receive annual reports from local governments detailing the progress of the program (Japanese Ministry of the Environment 2007a). Destruction operators must follow set standards for the destruction of fluorocarbons and must follow detailed reporting to help track progress in reducing the amount of unwanted ODS in the country. Over 10 on-site inspections for fluorocarbons destruction operators are conducted every year.

Starting in October 2007, in accordance with the amendment, end-users must issue a commitment confirmation to the commissioned company, who then passes the confirmation document on to the recovery operators. Recovery operators issue fluorocarbons receipt certifications to end users who must maintain them for record-keeping purposes, and operators are required to retain copies for record-keeping purposes as well (Japanese Ministry of the Environment 2007a).

Under the new amendment, companies providing maintenance for commercial refrigerators/air-conditioners are required to register with the local government if they recover fluorocarbons or to transfer them to registered recovery operators (Japanese Ministry of the Environment 2007a). In addition, the new amendment requires building dismantlers to check for any commercial refrigerators/air-conditioners containing fluorocarbons and to explain the results of their inspection in a report (Japanese Ministry of the Environment 2007a).

> Registering Recovery Operators and Businesses
>
> Operators and firms must be registered with prefectural governments of the place(s) where the business of the operators and firms is/are carried out. To be registered, prefectural governments often request applicants to provide certification related to refrigerant recovery. As such, the Refrigerants Recycling Promotion and Technology Center (RRC) certification can be accepted. RRC training includes a seminar and evaluation. The RRC curriculum educates technicians on the importance of preventing the release of ODS and GHG refrigerants; the safe handling of high-pressure refrigerants; the prevention of cross-contamination of refrigerants; use of recovery/recycling equipment; and the use of recovered refrigerant. RRC certification is valid for three years. For operators to successfully be registered with prefectural governments they must own a refrigerant recovery or recovery/recycling device or prove the availability of such device for their use. Registration must be renewed every five years.
> As of April 2007, approximately 27,000 recovery operators were registered with prefectural governments. (RRC 2007)

[33] Recharge of recovered fluorocarbons into a different cylinder can be performed only by operators registered as a second class High Pressure Gas producer under the “High Pressure Gas Control Law.”

There are five reclamation facilities in Japan that have been accredited by the Refrigerants Recycling Promotion and Technology Center (RRC): Create (Saitama), Abe Kagaku (Shizuoka), Kankyo Soken (Saitama), Kankyo Soken (Chubu), and Hyogo Sanso (Hyogo). These facilities follow strict reclamation standard, set by the RRC, which are in place for CFC-12, R-502, HCFC-22, and HFC-134a. However, due to the relatively low price of new refrigerants and in light of laws and regulations in Japan, currently HCFC-22 accounts for the majority of refrigerant reclaimed. According to the standard, HCFC-22 with a purity level of 99.3% or more is reclaimable. As the scarcity of R-22 increases as the phaseout matures, reclamation of R-22 is expected to increase. Moreover, private companies concerned about their public image often choose destruction over reclamation, since it is perceived as being the more environmentally friendly option.

Exhibit V-9. Kankyo Soken's Refrigerant Reclamation Technology and Catalytic Fluorocarbon Decomposition Plant

Left: Distillation technology is used to reclaim refrigerant at the Kankyo Soken facility. The capacity of the distillation tank is 100 L, and its maximum evaporation capacity is 50 kg/hour.

Right: The catalytic fluorocarbon decomposition plan, currently under construction at Kankyo Soken, has an initial cost of roughly ¥36 million (US$330,000). This technology has a maximum processing ability of 6 kg/hr, with an annual throughout of 36,000 kg. It has a decomposition rate of 99.99% or greater.

4.3 Costs

It is the responsibility of registered recovery operators to identify destruction operators and pay for fluorocarbon destruction, although they can pass these costs on to consumers. The fee charged to end-users covers the recovery, transportation, and destruction of fluorocarbons from commercial equipment.

Surveys show that destruction/reclamation of unwanted ODS is between \$3-\$10/Kg. Destruction costs vary by company and technology, but generally range from \$3-\$10/kg. The following destruction prices from selected facilities were obtained:

- Rotary kiln: ¥450/kg (~ US$4/kg)
- Superheated vapor/steam: ¥600/kg (~ US$5.30/kg)
- Plasma arc: ¥1,000/kg (~ US$9/kg)

Reclamation costs are on the order of ¥450/kg (approximately US$4/kg).

4.4 Statistics on Collection

According to reports submitted by recovery operators in FY2006 (April 2006-March 2007), approximately 2,500 tons of fluorocarbons were recovered from approximately 900,000 commercial refrigerators and AC units (see Exhibit V-10). Of the fluorocarbons recovered in FY2006, 78% was HCFC, 14% was CFC, and 8% was HFC. (MOE 2007a)

Exhibit V-10: Fluorocarbons Recovered from the Commercial Refrigeration/Air-Conditioning Sector (FY2006)

Source: Japanese Ministry of the Environment (2007a)

	CFC	HCFC	HFC	Total
Number of collected appliances (units)	115,157	597,874	165,399	878,430
Quantity recovered (kg)	348,273	1,986,577	206,307	2,541,157

Exhibit V-11 presents the number of units collected from 2002 through 2006 that contained ODS refrigerants. The quantities of ODS refrigerants recovered from those units are shown in Exhibit V-12. Although small quantities of ODS are reclaimed, the majority (>90%) are destroyed.

Exhibit V-11. Number of Commercial Refrigeration/AC Units Containing ODS Collected for Disposal, 2002-2006

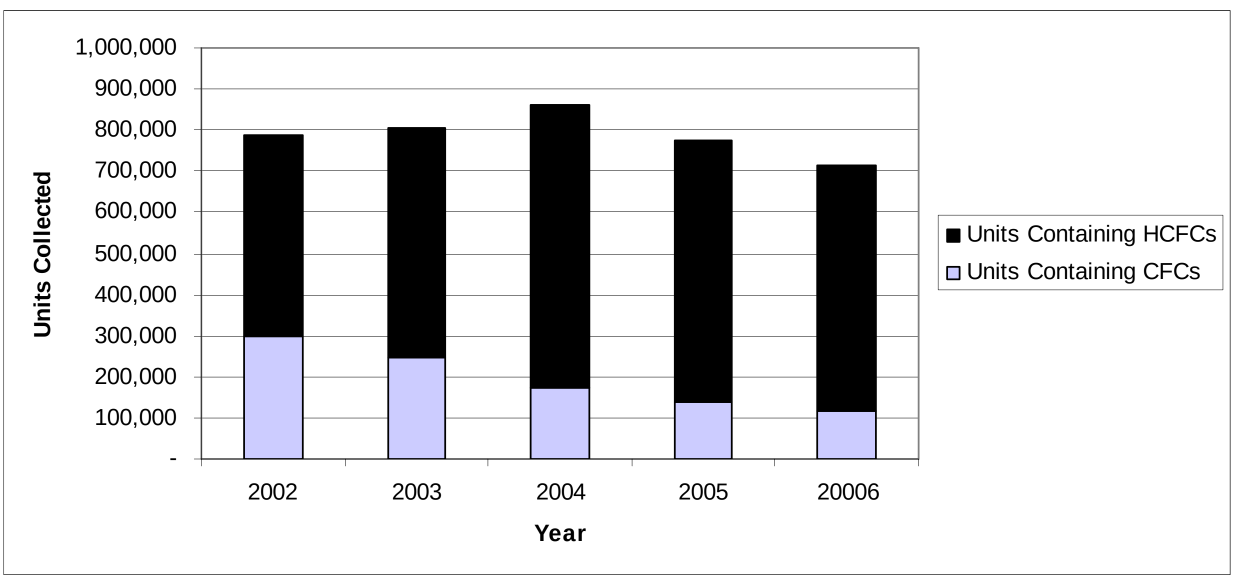
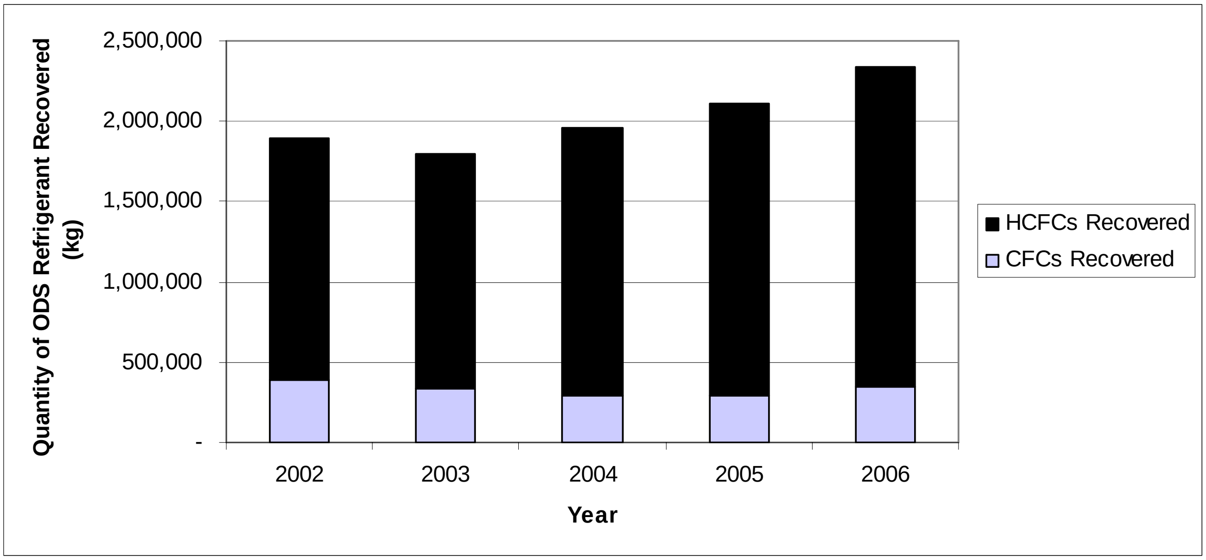


Exhibit V-12. Quantity of ODS Refrigerant Recovered from Commercial Equipment, 2002-2006



As the amendments to the *Fluorocarbons Recovery and Destruction Law* took effect in October 2007, it is expected that the recovery rate of fluorocarbons will double in the coming years.

4.5 Challenges

Prior to the regulatory amendments that took effect in October 2007, the fluorocarbon recovery rate from commercial refrigeration/AC equipment was estimated to be 30% (Japanese Ministry of the Environment 2007a). The Japanese government is expecting that the amendments—which increase accountability for commercial equipment owners through reporting/recordkeeping and place new responsibility on building dismantlers to recover refrigerant from commercial systems prior to demolition—will cause recovery rates to double. The new amendments are requiring additional training and reporting on the part of building owners and demolition contractors, but RRC has focused on satisfying this need by conducting seminars and providing workshops throughout the country. RRC is also conducting outreach campaigns to educate people of their new responsibilities.

4.6 Lessons Learned

It was clear from the low levels of refrigerant recovery within the commercial sector that more was needed to ensure that refrigerant is recovered from commercial equipment. Japan has approached the problem by increasing the accountability for commercial equipment owners through reporting/recordkeeping and by placing new responsibilities on building dismantlers. Japan has achieved its current level of success through extensive and comprehensive training (through RRC and other organizations), a high rate of compliance inspections, and heavy reporting requirements to ensure accountability on the part of recovery and destruction operators. The reporting requirements also allow the Government to track progress on fluorocarbon recovery and amend regulations as needed to achieve national goals.

5. Mobile Air Conditioning

5.1 Historical Perspective

The *End-of-Life Vehicle Recycling Law,* enacted in 2002, requires the recovery and destruction of fluorocarbons from MACs, as well as the recycling of vehicle parts (Japanese Ministry of the Environment 2007a). The Japan Auto Recycling Partnership (JARP), a limited liability intermediate corporation, was established by industry to ensure vehicles and fluorocarbons from MACs are disposed of in an environmentally safe and economical manner (JARP 2007). JARP was established in January 2004 by 12 Japanese auto manufacturers and the Japan Automobile Importers Association (JAIA); these 13 bodies are the shareholders of JARP.

5.2 Description of Process/Program

Vehicle owners are responsible for returning cars to end-of-life (EOL) handling firms, which are car dealers and auto repair shops registered with local governments (Japanese Ministry of the Environment 2007a). EOL handling firms transfer vehicles to registered recovery operators, of which there are approximately 24,000 nationwide, to remove CFC/HFC refrigerant. Recovery operators must keep records of the quantities and types of fluorocarbons recovered, and submit annual reports to local governments (Japanese Ministry of the Environment 2007a).

Recovery operators are paid based on the number of MACs and quantity of refrigerant recovered; if operators recover 270 grams or more per MAC, they will receive payment, usually on the order of ¥1,550 (approximately USD$14).[34] Recovery operators must send cylinders of recovered refrigerant to one of eight designated collection facilities where the refrigerant is destroyed. Recovered refrigerant may be reclaimed, but due to the low economic value of CFC-12 and HFC-134a in Japan, nearly 98% is destroyed.

Once refrigerant is recovered, recovery operators transfer the disposed vehicles to auto dismantlers, of which there are approximately 6,500 nationwide (Japanese Ministry of the Environment 2007a). Dismantling operators must recover airbags and deliver them to auto manufacturers or importers, who are charged a collection fee for the airbags. Other parts of the vehicles are salvaged and sold or recycled. Dismantled vehicles are then sent to authorized shredding agents who shred the vehicles, sell the metals on recycling markets, and send the shredder residue to one of two "teams" of auto manufacturers/importers for recycling and disposal (Japanese Ministry of the Environment 2007a). These two "teams"— TH and ART—represent an even number of auto Japanese manufacturers/importers, and are designed to increase competition and efficiency among recycling operations (similar to Groups A and Group B, described earlier).

The costs of MAC refrigerant collection and vehicle recycling are borne by vehicle owners at the time of vehicle purchase. In addition, for vehicles purchased prior to the enactment of the law in 2005—of which there were an estimated 70 million—vehicle recycling fees must be paid prior to periodic vehicle inspection/re-registration, or at the time of vehicle disposal—whichever occurs first. By charging recycling fees at the time of periodic vehicle inspections/re-registration, adequate program funds were collected in a timely manner, and the number of payments required at time of disposal (which are more likely to lead to illegal dumping) were minimized.

[34] Payment varies by manufacturer; ¥1,550/MAC is an approximate average.

JARP provides direct instructions to refrigerant recovery firms on the need to prevent overfilling, the need for thorough recovery, leak prevention, and other best practices. For example, JARP identifies recovery operators that consistently recover significantly less refrigerant to provide them with direct instruction and inspect their recovery equipment through individual visits.

5.3 Costs

At the time of vehicle purchase, consumers are charged a vehicle recycling fee, which typically ranges between ¥7,000 and ¥18,000 per vehicle (roughly US$60- $160). This fee can also vary based on the manufacturer and vehicle type. Of this recycling fee, approximately ¥2,000 (roughly US$18) goes towards fluorocarbon removal and destruction.

Vehicle recycling fees are managed by the Japan Automobile Recycling Promoting Center (JARC) Management Institution, which disburses funds to service entities accordingly. The funds reimbursed from JARC to auto manufacturers and importers are passed on to fluorocarbons recovery operators, fluorocarbons destruction agents/facilities, auto dismantlers and airbag destruction agents/facilities through JARP. Specifically, information is managed through the JARC Information Management Center, and the collection/disbursement of funds is managed by the JARC Management Institution. The JARC Information Management Center tracks the fate of all vehicle components on-line by assigning each vehicle a unique identification number. When service providers enter information regarding the fate of vehicle components into the tracking system, the JARC Management Institution disburses funds to the relevant service providers. JARC cross-checks the data reported by refrigerant recovery operators against that reported by destruction facilities, to make sure all data align. For example, each gas cylinder filled by refrigerant recovery operators is given an identification number and tracked electronically; each cylinder is weighed by the destruction facility; so the amount destroyed is used to cross-check the reported amount recovered. In addition, JARC also conducts annual audits to ensure that all entities are following proper procedures and requirements.

Refrigerant recovery operators are paid based on the number of MACs and quantity of refrigerant recovered. If operators recover 270 grams or more per MAC, they will receive payment, usually on the order of ¥1,550 (approximately USD$14).[35] In this way, if no refrigerant is recovered, no payment is disbursed.

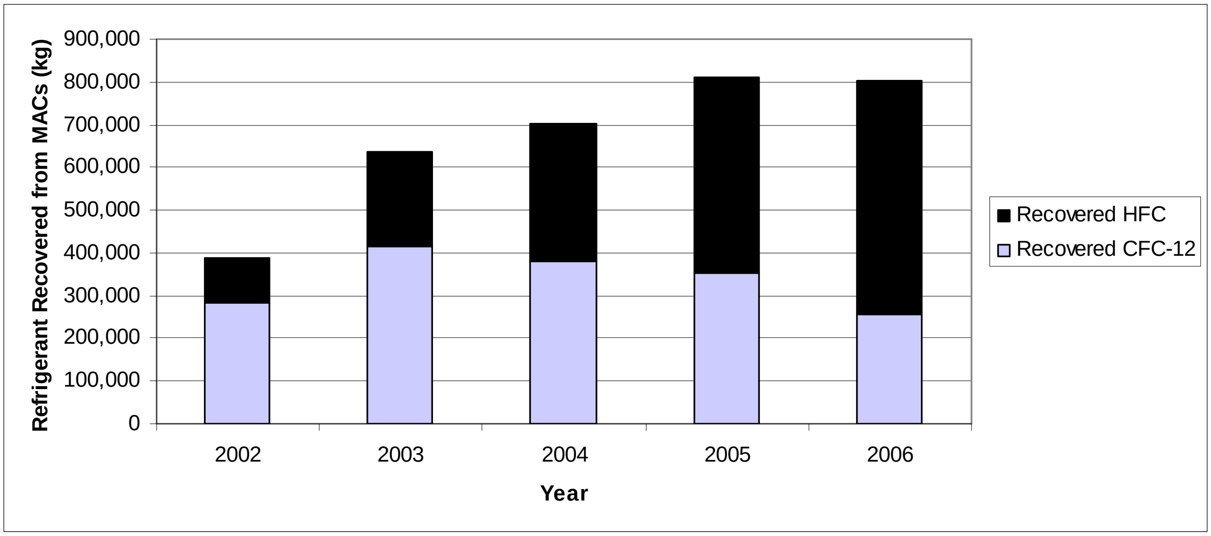
JARP has estimated that the capital cost of Japan's vehicle recycling/MAC recovery system was ¥14.5 billion (nearly US$130 million). This capital cost was covered by auto manufacturers and importers. In addition, the scheme relies on the full-time employment of approximately 160 staff. While the end-user recycling fees fully cover the destruction and recovery of refrigerant, the operating costs of the entire system are shared equally by manufacturers and end-users.

5.4 Statistics on Collection

The number of MACs recovered in Japan has been increasing since the *End of Life Recycling Law* took effect. In 2006, nearly 2.6 million vehicles were collected for recycling. As the aging vehicle fleet is retired, an increasing share of the vehicles reaching disposal contain HFC-134a compared to CFC-12; in 2006, 68% of MACs contained HFC, compared to just 46% in 2004, and 27% in 2002. In 2006, an average of 300 grams of refrigerant was recovered from MACs at EOL.

[35] Payment varies by manufacturer; ¥1,550/MAC is an approximate average.

Exhibit V-13: Quantity of Refrigerant Recovered from MACs in Japan, 2002-2006



5.5 Challenges

Prior to 2005, when the *End-of-Life Vehicle Recycling Law* came into effect, the national government estimated that 220,000 vehicles had been dumped illegally; in March 2007, the number of illegally dumped vehicles was estimated at only 35,000. While this demonstrates that illegal dumping is still a problem, it also indicates that the law has been effective at significantly reducing such activity. Over time, the rate of illegal dumping is expected to continue to fall, as the older vehicles that require payment for recycling at time of disposal (versus time of vehicle registration or purchase) are retired.

5.6 Lessons Learned

Significant funding is needed to set up the type of MAC recovery/vehicle recycling program that is successfully in operation in Japan. In Japan, such costs were borne by the nation's powerful auto manufacturers and importers. Without strong business, government (taxpayers) would need to bear these costs, which may not be feasible in all countries. As in the appliance sector, the proactive, highly organized nature of Japan's automotive manufacturing/import sector has allowed the development and implementation of an innovative system, while the national mandate for producer responsibility has created a level-playing field for all industry players to share the burden.

A willingness on the part of consumers to pay the recycling fee has also been critical. But unlike the appliance sector, recycling fees can largely be paid on vehicles *in advance* of disposal (thereby increase the likelihood of compliance) without creating a funding problem for units already in use; this is thanks to industry's innovative idea of obtaining consumer payment at the time of vehicle re-registration.

6. Halon Banking

6.1 Background

Since January 1, 1992, the production of halons has been controlled under the *Law on Ozone Layer Protection through Control of Certain Substances*. Manufacturers of fire extinguishing equipment and other concerned organizations established the Halon Recycling and Banking Support Committee in 1993 to collect and reuse halons, and prevent the accidental discharge of halons to the atmosphere. The Halon Recycling and Banking Support Committee is responsible for the appropriate management of halons, including their collection and reuse. Production of halons was discontinued after January 1, 1994. In July 2000, the National Halon Management Strategy was submitted to the Ozone Secretariat of UNEP (National Halon Management Strategy 2000). This strategy was developed to determine basic policies concerning emission control and other activities regarding halons in Japan.

6.2 Description of Process/Program

The Halon Recycling and Banking Support Committee began activities on March 1, 1994. The Committee created a database to track halon use in buildings and facilities. Specifically, the database tracks the place of installation, type of halon installed, and amount of halon used.

Operators of buildings and facilities that require halons must send a request to the Committee, which then grants approval for the supply of halons for critical uses. Critical uses of halon are determined by the Halon Recycling and Banking Support Committee. Halons are approved if they are necessary to ensure safety in the event of a fire, and if no suitable alternative is available. The details of halon installations must be communicated to the Committee for recordkeeping purposes. A report detailing the state of the installation is also delivered to all concerned fire fighting organizations to ensure the location and type of halons is known in the event of a fire.

Buildings that receive halons must also communicate their projected schedule for halon disposal to both the Committee and the Fire Department. The Committee instructs specialized firms to collect halons from buildings and facilities at time of disposal. Upon completion of halon decommissioning, the specialized firms must confirm collection with the Committee. The Fire Department then conducts “on-site” inspections at the building/facility to verify that the halon has been decommissioned as stated. The results of the inspection are then shared with the Fire and Disaster Management Agency, as well as the Committee, and recorded in a tracking database.

Halons will continue to be supplied to approved buildings and facilities until 2017. Until that time, buildings and facilities with existing installments of halon equipment may continue to receive halon supplies, but, depending on changes in circumstances, the supply will be reviewed. If a suitable alternative is determined, the halons will be required to be replaced. For new installations, halon supplies may only be distributed for approved critical use purposes, until alternative fire extinguishers with comparable performance and safety characteristics are developed.

As of January 2006, there has been a change in the halon bank. A new organization, known as the Fire Protection and Environment Network (FPEN), was established to manage the halon bank from the Halon Recycling and Banking Committee and to control emissions of fire extinguishing agents during the installation, modification, operation, servicing, and disposal of fire extinguishing equipment.

In addition to the controls and monitoring set forth by FPEN, in October 2005, the Japan Fire Extinguishing Systems Manufacturers Association (JFESMA) developed a voluntary action plan for the proper management of halons. This action plan calls for JFESMA to ensure the recovery and storage of halons. It also requires JFESMA to account for future demands and supply needs. During FY 2007, a third party evaluation was conducted to determine the results of JFESMA’s progress, and it was concluded that JFESMA was satisfactorily meeting the objectives of the action plan.

Alternatives are gradually gaining acceptance, and are being installed in places where their application is comparable to that of halons. Presently, halogenide (halide) and inert gas type fire extinguishers are commonly used as halon alternatives. In May 2001, the *Committee to Examine Halon Restriction*

Measures (CEHRM)[36] defined critical use criteria for halons, and reviewed the criteria again in April 2005. Due to the development of new halon alternatives, CEHRM has been working to ensure safe and appropriate installation of fire protection equipment using alternatives and has been actively recording their locations in a database. In March 2002, CEHRM developed a standardized methodology to further ensure proper installation of halon alternative gases.

6.3 Statistics on Collection

As of March 2007, a reported 15,422 metric tons of halon is installed in Japan, shown in Exhibit V-14. Over 90% or more of this amount is used in fire extinguishing equipment in Japan for which no alternatives are currently deemed feasible.

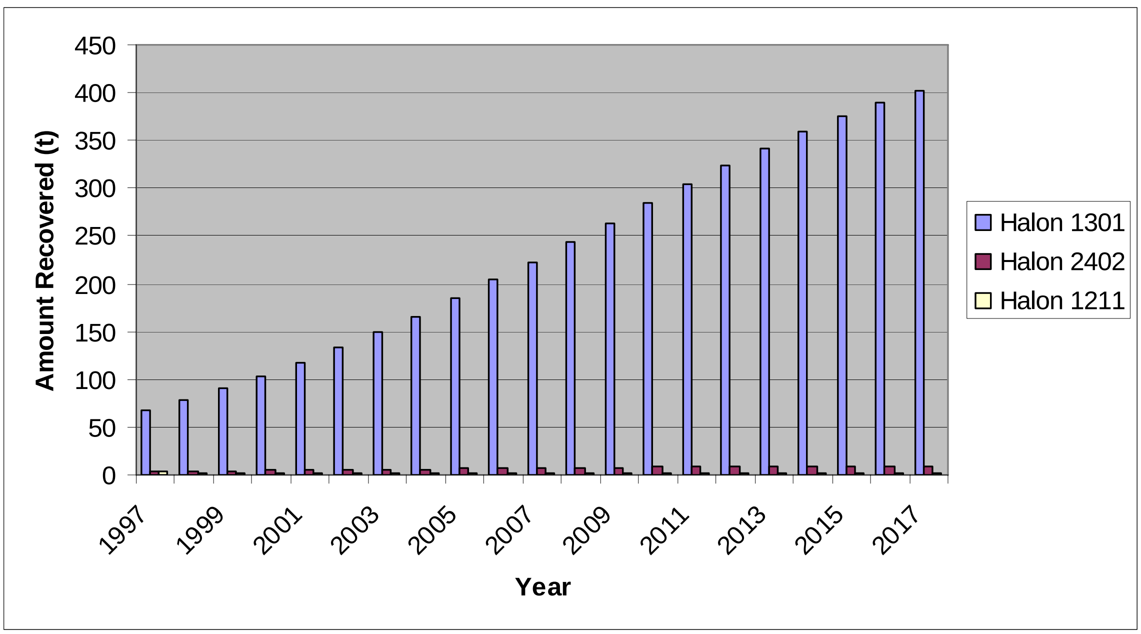
Exhibit V-14: Quantity of Halons Installed in Japan as of March 31, 2007

Type of Halon	Quantity of Halons Installed (Metric Tons)
Halon 1211	44
Halon 2402	239
Halon 1301	15,199
Total	15,481

Source: Questionnaire survey for members of JFESMA (2007).

Since halon 1301 is used in 90% of fire extinguishing equipment, it continues to account for the majority of the halons recovered in Japan (see Exhibit V-15).

Exhibit V-15: Actual and Projected Quantity of Halons Recovered in Japan (1997-2017)



[36] CEHRM was established by the Fire and Disaster Management Agency (FDMA) in 19990 to control the use of halons as fire extinguishing agents.

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VI. United Kingdom

1. Introduction

1.1 Country Information

The United Kingdom is a country of 61 million people (Office for National Statistics 2007), comprising 22 million households. Approximately 90% of British residents live in urban areas (Ohio University 2007b), with London, Birmingham, Glasgow, Liverpool, and Leeds being the most populous cities. The country has an area of approximately 244,820 square kilometers. The UK joined the European Union on January 1, 1973.

1.2 ODS Market Characterization

Millions of British households own refrigerators, and the disposal of these refrigerators creates a major waste stream. Indeed, approximately 2 million refrigerators each year are disposed of in England and Wales alone. Of these disposed units, 63% are ODS-based.

R-22 is a refrigerant that is in high demand by operators of large equipment. For the commercial and industrial sectors, there is limited information on quantities of ODS installed in equipment or used in building foams.

2. Relevant Legislation and Regulations

The United Kingdom, as a member of the European Union, is subject to Regulation (EC) No 2037/2000, a European Council act regulating ODS. Under EC 2037/2000, all ODS must be recovered during equipment servicing and disposal. Recovered CFCs must be destroyed, since their continued use is prohibited. HCFCs can be destroyed or re-used until 2015. For ODS-containing foams, the Directive requires that the ODS be recovered from foams "if practicable." All ODS solvents are banned from reuse. Halons are banned from reuse as well, except for a small number of critical applications, mostly in the military. Both ODS solvents and halons must be recovered and destroyed if any piece of equipment containing them undergoes servicing. The European Commission also sets limits each year on the volumes of CFCs, halons, and several other ODS that can be sold on the market. Importation limits are also set for each chemical manufacturer that seeks to import ODS. Furthermore, the Directive

Exhibit VI-1: The United Kingdom Source: Wikimedia Commons. (2008b).

2002/96/EC on Waste Electrical and Electronic Equipment (WEEE) requires EU appliance producers to be responsible for disposing of end-of-life residential units.

The United Kingdom's Department for Environment, Food, and Rural Affairs (DEFRA) is the policymaking department that has jurisdiction over ODS and works directly with the EU on European environmental policy. In 2002, the UK implemented the *Controls on Ozone-Depleting Substances* (Statutory Instrument 2002 No. 528). The Controls require the recovery of ODS from all disposed refrigerator and AC units during dismantling. Business owners face heavy penalties for the deliberate release of ODS to the atmosphere.

The UK implemented WEEE legislation on December 12, 2006, and the UK regulations implementing the WEEE Directive took effect January 2, 2007. Implementation of the WEEE Directive in the UK was delayed by more than two years from the initially planned schedule for implementing the Directive. The UK initially planned to introduce implementing legislation by August 13, 2004, with the UK regulations scheduled to take effect August 13, 2005. Since July 1, 2007, the UK WEEE regulations require equipment manufacturers to finance the treatment and recycling of residential waste electric and electronic equipment. Effectively, manufacturers must pay for the collection, transportation, and dismantling of the refrigerators and AC units for the destruction of ODS.

Households are legally required to dispose of their appliances, including refrigerated appliances, through the proper disposal channels. While ODS-based appliances in the UK must be sent for refrigerant recovery, ammonia- and pentane-based units can be sent to large mechanical shredders, where refrigerant is not recovered. The WEEE regulation requires the recovery of all hydrocarbons with a global warming potential of greater than 15.

For commercial equipment, disposal of the units is the duty of the end user, under the 2002 Controls. However, the manufacturer take-back system accepts commercial equipment in additional to residential units. Additionally, for appliances placed on the market since August 13, 2005 that become waste after July 1, 2007, the producer of the appliance will be responsible for financing treatment unless there is an alternate arrangement agreed upon by both the producer and the end-user. For older equipment that becomes waste after July, 1 2007, the default responsibility rests with the end-user, unless the end-user is buying a similar replacement product, in which case the producer of the replacement product will be responsible on a one-for-one basis.

In separate legislation, the UK regulates the handling of end-of-life vehicles. All ODS must be recovered from air conditioning systems in all cars and trucks. Additionally, the Transfrontier Shipment of Waste Regulations govern the import and export of ODS.

Refrigerator transporters, appliance recyclers, and ODS destruction operators are required to be licensed. Appliance demanufacturers must meet a wide range of criteria to obtain a license. Specifically, they must meet standards for appliance storage, ODS tank handling, and environmental containment during destruction. A minimum of 99% of the coolant-oil mixture must be drained out of each unit, and the mixture must be distilled such that the concentration of refrigerant remaining is no more than 0.9%. In addition, damaged refrigerators must be drained within 48 hours of arrival at the facility. For all units, destruction of the refrigerator carcass (i.e., once foam has been removed and metals have been shredded) must be done in a contained environment. The foam remaining on the shredded metal after separation should not exceed 0.5% of the weight; the foam on the plastic should not exceed 1%. After the foam is degassed, it cannot contain more than 0.5% ODS by weight. The Agency's regulations also specify the maximum amount of ODS that can be released through exhaust gases (in grams per hour), given the numbers of refrigerated appliances recycled (units per hour). There are also recordkeeping requirements as well as specifications regarding the length of time that waste can be stored on site (Environment Agency 2004).

The UK has also established minimum qualifications and license requirements for technician training in the stationary refrigeration/AC, MAC, and fire protection sectors. Additionally, educational materials on proper refrigerant recovery and servicing are distributed to technicians' associations by the UK government or, for Europe-wide associations, by the EU. The UK has also published guides to the industries and businesses that are end-users of ODS on how to safely dispose of ODS and find non-ODS alternatives.

Licensing, inspection, and enforcement pertaining to the environment are handled by the Environment Agency in England and Wales; other agencies cover Scotland, Northern Ireland, and the islands. Funding for the Agency comes in equal parts from DEFRA, licensing fees, and local governments.

The EU is currently considering revising export procedures for ODS, as well as refrigerant regulations pertaining to recovery-per-unit standards (Ecosphere 2007). Future policy may establish a specific preference for destruction; the EU is currently debating how this preference could be implemented.

3. ODS-Containing Appliances

3.1 Background

Prior to the WEEE regulation, most refrigerators and AC units in the UK were sent to car shredders for metal and plastic recycling. Some British municipalities pursued refrigerator recycling by paying contractors to properly dispose of units in their jurisdiction. However, with no national assistance to pay for such recycling programs, and without national ODS recovery standards to ensure best practices, there was concern that refrigerator recyclers were not recovering as much ODS as possible.

With the passage of the EC ODS Directive (EC 2037/2000), the UK became responsible for collecting ODS. However, the UK's DEFRA was in lengthy debate with the EU about the feasibility of recovering and destroying ODS appliance foams, and about whether or not this activity was specifically mandated by Regulation (EC) 2037/2000. EC law required that national regulations be established by January 2002; however, in December 2001, DEFRA raised questions to the EC about whether foams were in fact covered under the EC regulation. This negotiation caused the UK to delay the implementation of the law, which in turn caused practical problems related to end of life refrigerator management.

More specifically, during the two years of negotiation with the EU, no appliance recycling facilities were established in the UK to process the waste refrigerators that were being collected and stored in municipal waste yards—which resulted in enormous stockpiles. Approximately 50,000 waste refrigerators were sent to high-temperature incineration facilities during this period, and an additional 300,000 were exported each year for disposal, largely to Germany. Export was especially significant from 2002 to 2004.

These issues came to a close as the UK's first appliance recycling facilities began operation in early 2003, at which point the processing of the backlog of stockpiled refrigerators was initiated. The UK's plants have processed most of the backlog of stockpiled refrigerators, although many of the stored units were rusted and damaged, with no ODS refrigerant charge remaining. Today, the UK's producer responsibility system for ODS appliances is under full implementation, although a small volume of units continue to be exported.

3.2 Description of Process/Program

Consumers dispose of old domestic appliances either through retail or local/municipal channels. Specifically, consumers in the UK may either drop their old appliances off at local waste collection sites generally run by municipal authorities—known as Designated Collection Facilities (DCFs)—or they may have their old units collected by retail stores. There are approximately 1,400 DCFs throughout the UK, all of which accept refrigerators that contain ODS and non-ODS refrigerants. In regard to retailer collection, some appliance retailers in the UK provide waste collection, either through home pick-up service or by allowing consumers to drop off their old units at retail locations.

In 2007, to comply with the WEEE mandate, equipment manufacturers and importers formed industry associations to run waste appliance recycling programs; these programs came to be known as "compliance schemes." In order to efficiently collect appliances for recycling, the newly founded compliance schemes began working with existing networks of DCFs. Compliance schemes are licensed by the Environment Agency and must demonstrate that a three-year working plan is in place. Additionally, data on destruction must be submitted each year.

There are 37 WEEE compliance schemes in the UK, about half of which represent refrigerator and AC manufacturers. Each compliance scheme, representing a group of producers, has a disposal responsibility proportional to its members' market shares of sales of new electronic/electric equipment—i.e., each compliance scheme must dispose of a predetermined minimum number of units (Environment Agency 2008). Each manufacturer is responsible for paying into their scheme proportionally to their market share. A manufacturer can always leave a scheme if it is not to their liking, and either join another scheme or start a new one.

DCF administrators (i.e., municipal authorities) select the compliance schemes of their choice to recycle the appliances collected at their facilities. Municipal DCFs do not pay anything to the schemes (although some conduct outreach activities to promote the proper disposal of appliances). Some schemes that are not selected by enough DCFs are unable to collect enough equipment to meet their minimum requirements. If a scheme fails to collect/process the number of units for which it is responsible, it can buy "tradable notes" from schemes that have collected more than their required share of units. These tradable notes have become a highly traded commodity. For example, one scheme, Electrolink, has been successful

The Appliance Demanufacture Process at M Baker Recycling

One refrigeration demanufacturer, M Baker Recycling, processes residential and commercial refrigeration equipment from Ireland and the UK at their plant in St. Helens. For residential refrigerators, refrigerant is drained from units using a tilt table and a vacuum system, and then heated for four hours to separate the oil from the refrigerant. The refrigerant is then condensed into a one-ton tank to await shipment to a destruction facility. Waste oil, compressors, and internal mechanisms are sent for recycling, while the door and body are separated and fed into a shredder. A pentane detector is used to identify pentane-based refrigerators before shredding, since these units must not be fed into the shredder consecutively, in order to avoid explosion. Finally, the ODS from the foams is extracted from the shredder's exhaust gas, using a carbon absorption system, and is stored in a drum to await destruction. This process varies slightly for commercial equipment; waste commercial units must be disassembled by hand, as their steel frames cannot be put through shredders.

After appliances are shredded, a series of sorting machines is used to separate aluminum, ferrous metals, and plastics, with a hammer mill separating the foam from the metal. Plastics, glass, and metals are sent for recycling. The degassed foam is steam washed and compressed into bricks. After this process, the foam has less than 0.001% ODS content. The degassed foam bricks are sent to landfills; no market for the material has been found despite extensive research by M Baker. The ODS from this degassing is pumped into cylinders and stored.

Once enough ODS has been collected, it is sent to one of two high-temperature incinerators in the UK, for destruction. However, one refrigerator recycler, EnvironCon, chemically converts the ODS on-site using a catalyst process. The amount of ODS destroyed is generally recorded by destruction facilities, which charge for their services per kilogram of ODS destroyed.

in collecting more than its responsibility, enabling it to profit on the sale of tradable notes. If a scheme fails to process its required number of refrigerators, and fails to buy enough notes, its license can be revoked.

In the course of recycling WEEE, these schemes must first transport it from the DCFs. Generally, schemes contract both the transportation and recycling to private waste management companies, some of which are specifically refrigerator waste management companies. The UK also imports refrigerators from Ireland, Channel Island, the Isle of Man, and northern France for proper disposal and ODS destruction.

Some units are first taken to temporary storage, but eventually all are taken to specialized refrigeration demanufacturers. There are 11 demanufacturers of refrigerators and AC units in the UK. The first facility began operation in 2003.

At recycling plants, the ODS-oil mixture is removed and the ODS is recovered cryogenically. Coils and compressors are removed, generally manually, and sent for recycling. For refrigerators, the body of the unit is then shredded, with ODS captured from the foams. The metal, plastic, and glass that result are sent for recycling. The specific procedures used by one refrigeration demanufacturer in St. Helens, M Baker Recycling, are described in the text box (right).

It should be noted that, apart from appliance foams, other types of ODS foams (e.g., building foams) tend to be landfilled and not recovered for destruction, because it is not deemed economically feasible to do so. Unlike refrigerators and AC units, from which metals, plastics, and glass can be recycled to generate revenue, there is no means to offset costs for the destruction of building foams and other pure foams. Further, foam wall insulation (e.g., 20 foot panels used in refrigerated warehouses) is rarely processed for ODS recovery because it is generally too large for shredding by refrigerated appliance demanufacturers and is inconsistently labeled, making it difficult to identify ODS-containing ones.

3.3 Costs

Consumers are not charged a fee for the disposal of their old units through DCFs or retailers. Each municipal DCF receives £9,000 (~US$17,600) annually through municipal government taxes for operating and maintaining the facility. In order to obtain a license from the Environment Agency, new schemes must pay a fee of £12,000 (~US$23,450). However, actual data on the costs to process refrigerators and AC units is difficult to obtain, since these activities are conducted under private contract between the schemes and the recyclers. Each scheme pays recyclers based on the number of units processed. According to British authorities, the competition of different schemes results in lower prices (compared to one national-level collection system).

Unlike the system in many other EU countries, a “visible fee” or recycling charge is not imposed on the sale of new appliances. In the UK, appliance producers directly take on the cost of recycling, and each must determine how to carry this cost – either by increasing prices, reducing manufacturing costs, accepting a reduced profit, or a combination of all three.

3.4 Statistics on Collection

In 2006, a total of 391,343 kg of ODS were collected at UK refrigerator recycling plants. The average weight of a refrigerator in the UK is 45 kilograms, and each unit contains 40-95 grams of ODS refrigerant and an additional 180-230 grams of ODS in foams.

DEFRA estimates that more than 90% of end-of-life refrigerators in the UK are sent to refrigerator recyclers. The other 10% are most likely illegally exported, disassembled, or landfilled. According to

DEFRA and recyclers, nearly 40% of the refrigerators recycled are hydrocarbon-based. Retailers maintain that up to 70% of the units collected are HC-based.

3.5 Challenges

One of the challenges associated with appliance collection/recycling in the UK is that many refrigerators arrive at recycling facilities in poor condition, with no tubing, broken walls, or missing components; thus the opportunity to recover ODS at recycling facilities is diminished.

In addition, doors are often removed from refrigerators during the demanufacture process, for safety reasons. These doors may sometimes be diverted directly to scrap metal recyclers, resulting in possible ODS release from unenclosed door shredding. This release of ODS can be prevented by ensuring that the doors are sent to shredders with built-in ODS recovery mechanisms.

Another challenge is the illegal export of used refrigerators. The export of used refrigerators is legal in the UK *if* the units are in good working condition. The Environment Agency reports that exports of working refrigerators to Eastern Europe and Africa are common, but notes that exports of used refrigerators are largely unregulated. There is a concern that non-operational (i.e., waste) equipment is being falsely labeled as “working” and illegally shipped overseas. In June 2007, a court fined one London-based company £25,000 (~US$49,000) for attempting to ship waste refrigerators to China. Fortunately, given the growth of the refrigerator recycling businesses in the UK, the illegal export of waste refrigerators is not believed to be significant.

Looking forward, the appliance recycling industry may face several additional challenges. First, recovery standards for the recycling of WEEE are being considered at the EU level (with input from DEFRA). The goal would be to adopt a common standard for the percent of ODS recovered in every refrigerator and AC unit. But because the condition of refrigerators at the time of disposal vary widely, it would be critical to establish an appropriate baseline prior to any such regulation.

Finally, there is a concern that, as ODS refrigerators disappear from the market, appliance demanufacturers will not be able to stay in business, since HC appliances may be sent to direct shredding without refrigerant recovery. The EU is currently considering regulations for non-ODS refrigerators and AC units, but the costs of sending refrigerated appliances for demanufacture are higher than for shredding, and the environmental benefits are not as compelling. Moreover, there have been cases of pentane units causing explosions in demanufacturer plants.

3.6 Lessons Learned

The vast majority of refrigerators and AC units have been properly collected and recycled since 2002. Key to this success is that the public has a wide variety of disposal options available to them. At no costs, households can drop off units at their town’s DCF or, in many cases, at their local retailer. With over 1,400 DCFs, few British residents are out of reach of the collection network. Furthermore, the 37 collection schemes, each funded by a collective of manufacturers, allows for nationwide appliance recycling. The economic and geographic accessibility of the program helps to ensure that appliances will be properly disposed at end of life.

Enforcement is vital as well. Without strong enforcement, many waste refrigerated appliances would likely be illegally exported. Furthermore, the enforcement of demanufacturing standards ensures that ODS is in fact being recovered at a significant level. The monitoring of the compliance schemes also ensures that waste equipment is being properly disposed of.

Finally, there is a widespread public sentiment in the UK now that proper recycling is the correct thing to do, and this public support for the process helps maintain a high recovery rate. This is due in great part to the outreach efforts conducted by municipalities to encourage proper recycling of waste appliances.

Data collection is also important in the processing of waste refrigerators and AC units. In the UK, each scheme pays recyclers based on the number of units processed. As a result, there is a strong need for proper tracking and record-keeping.

4. Bulk ODS Refrigerants

Historically, commercial refrigeration equipment was disposed of on a voluntary basis. Today, the WEEE law places the burden of commercial equipment recycling on the end user.

Bulk ODS in the UK is sent for destruction to high-temperature incinerators. There are two such incinerators in the UK: Veolia Environmental Services in Ellesmere Port, Merseyside, and Pyros Environmental Ltd. in Southampton, Hampshire.

5. MACs

There are no UK-specific regulations concerning the recovery of ODS from mobile air conditioning units. The UK has, of course, implemented the EC regulations concerning the recovery of CFCs from vehicles; however, there is no organized collection system in place for MACs as there is for household refrigerators.

6. Halon Banking

The first halon bank in the world, the Halon Users National Consortium, was established by halon users in the UK in 1993. A non-profit, HUNC was funded by the subscribing members that recovered and used halon (DEFRA 2003).

Halon systems are banned in the UK, which has resulted in halons being decommissioned and put into storage; possibly some stocks were illegally vented to avoid costs associated with storage or destruction. A facility that seeks to store halons longer than 12 months must obtain a license. Halons are not regulated any further by the Environment Agency. Effectively, halons are waste gases in the UK.

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VII. United States

1. Introduction

1.1 Country Information

The United States of America (US) has 126,316,181 households (US Census Bureau 2007a) and a population of 303.6 million (US Census Bureau 2007b). The nation's land area comprises 9,826,630 square kilometers. The US has the largest and most technologically powerful economy in the world (CIA World Fact Book 2008). As an industrialized country with a strong economy, the US is able to domestically ship, as well as export, refrigeration and air conditioning equipment. In 2002, shipments of refrigerators and freezers totaled nearly $5.5 billion, while those for MACs totaled $6.7 billion, and those for air-conditioning, warm air heating equipment, and industrial refrigeration equipment totaled $23.9 billion (US Census Bureau 2002a).

Exhibit VII-1: The United States Source: 50states.com

1.2 ODS Market Characterization

The quantity of ODS contained in banks includes ODS in fire protection, refrigeration/AC equipment, and foams. Based on an EPA model, the ODS bank was estimated at 1.8 million MT in 2007. The bank is expected to decrease steadily through 2030. It is estimated that the amount of ODS "recoverable" from this equipment was 0.65 million metric tons in 2007. The vast majority of this bank is found in the refrigeration/AC sector.

2. Relevant Legislation and Regulations

The ratification of the Montreal Protocol led to an amendment of the U.S. Clean Air Act (CAA) in 1990. This 1990 change in the U.S. law governing clean air added "Title VI, Stratospheric Ozone Protection." Within Title VI, Section 608 entitled "The National Recycling and Emissions Reduction Program," details legislation directing U.S. Environmental Protection Agency (EPA) to create national regulations on the use, reclamation, and disposal of CFC and HCFC refrigerants and their substitutes. Section 609 of the amendments establishes standards and requirements regarding the servicing of mobile air conditioners (MACs). According to these regulations, it is illegal to knowingly vent or release any CFC or HCFC refrigerant or ODS substitute refrigerants in the course of maintaining, servicing, repairing, or disposing of equipment, although *de minimis* emissions associated with good faith attempts to contain the ODS are permissible.

To reduce use and emissions and maximize recapture and recycling of ODS and their substitutes, technicians are required to evacuate refrigeration/AC equipment containing ODS to certain vacuum levels when opening the equipment for service or disposal. In addition, regulations require certification of refrigeration technicians, certification of refrigerant recovery equipment, and certification of reclamation facilities, each of which is described briefly below:

- *Technician certification*: Technicians servicing ODS equipment in the stationary and mobile sectors are required to pass EPA-approved tests given by EPA-approved certifying organizations (of which there are currently 24) to become certified under a mandatory technician certification program. Four types of technician certification are available: (1) for servicing small appliances (Type I); (2) for servicing or disposing of high- or very high-pressure appliances, except small appliances and MACs (Type II); (3) for servicing or disposing of low-pressure appliances (Type III); and (4) for servicing all types of equipment (Universal). The sale of ODS refrigerant is restricted to certified technicians. For MAC servicing (Section 609), it is estimated that there are 642,000 technicians certified, with 75,000 new technicians certified each year. Estimates are unavailable on technicians certified for stationary equipment servicing.
- *Recovery equipment certification*: Recycling and recovery equipment intended for use with small appliances and MACs must be tested and certified (by ARI or UL) and must be able to achieve specified levels of evacuation (ranging from 80%-90%, depending on the year the recovery equipment was manufactured and whether the compressor of the unit from which refrigerant is being recovered is operational or not). All other refrigerant recovery and recycling equipment must also be tested and certified, and must achieve specified inches of mercury vacuum, based on the year in which the recovery equipment was manufactured and the type of appliance from which refrigerant is being recovered.
- *Reclamation facility certification*: EPA certified reclaimers are approved to reprocess used refrigerant to at least the purity level specified in ARI Standard 700. Reclaimers must release no more than 1.5% of the refrigerant during the reclamation process and must dispose of wastes properly.

There is also a regulatory restriction on the sales of bulk ODS refrigerants to certified technicians only, and maximum allowable leak rates are in place from refrigeration/AC equipment with an ODS charge of greater than 50 pounds (22.7 kg). Maximum allowable leak rates currently range from 15% to 35%, depending on the type of equipment. Owners of equipment found to be in violation of the maximum allowable leak rates are required to repair leaks.

Disposal Requirements for Refrigerators/ Freezers

In addition to the requirement to properly recovery ODS refrigerant prior to the disposal of refrigerators/freezers, federal requirements also specify that mercury, used oil, and PCBs must also be properly managed and stored accordingly. Individual States also may have more stringent requirements, including stipulations related to the handling of hazardous waste and/or the disposal of certain durable components in landfills.

The recovery and reclamation/destruction of

The Internal Revenue Service imposes a tax on certain Class I[37] ODS when it is first sold or used by its manufacturer or importer. The manufacturer or importer is liable for the tax, which may be paid at either the time the substance is produced/imported or when the substance is sold or used. The tax is based on ODP and varies from $1.075 per pound for methyl chloroform to $107.50 per pound for Halon-1301. Additionally, a "floor stocks tax" is imposed on the same Class I ODS if over a certain quantity is held as stocks as of January 1 of each year.

EPA requires that used ODS refrigerants that are sold to a new owner must be reclaimed by a certified reclaimer. Refrigerants that are removed from an MAC and placed into another must be either reclaimed by a certified reclaimer, or recycled by a certified technician using certified recovery equipment.

Safe disposal requirements are in place. Specifically, equipment that is typically dismantled on-site before disposal (e.g., retail food refrigeration, central residential air conditioning, chillers, and industrial process refrigeration) must have the refrigerant recovered in accordance with EPA's requirements for servicing. However, equipment that typically enters the waste stream with the charge intact (e.g., mobile air conditioners, household refrigerators and freezers, and room air conditioners) is subject to special safe disposal requirements. Under these requirements, the final person in the disposal chain (e.g., a scrap metal recycler or landfill owner) is responsible for ensuring that refrigerant is recovered from equipment before the final disposal of the equipment. Persons "upstream" may remove the refrigerant and provide documentation of its removal to the final person if this is more cost-effective. At the final step in the disposal chain, when appliances no longer hold a refrigerant charge, the accepting entity is responsible for maintaining a signed statement from whom the appliance/s is being accepted. The signed statement must include the name and address of the person who recovered the refrigerant, and the date that the refrigerant was recovered, or a copy of a contract stating that the refrigerant was removed prior to delivery.

The equipment used to recover refrigerant from appliances prior to their final disposal must meet the same performance standards as equipment used prior to servicing, but it does not need to be tested by a laboratory. For MACs and MAC-like appliances, the performance requirement is 102 mm of mercury vacuum and for small appliances, the recovery equipment performance requirements are 90 percent efficiency when the appliance compressor is operational, and 80 percent efficiency when the appliance compressor is not operational. (In other words, 90 percent and 80 percent of the refrigerant contained in the system must be recovered by the equipment).

EPA is proposing to extend the above requirements in place for CFC and HCFC refrigerants to HFC and PFC refrigerants. Specifically, EPA is proposing to extend to HFCs and PFCs requirements related to recovery practices; certification programs for recovery/recycling equipment, reclaimers, and technicians; the prohibition on the sale of refrigerant to anyone but certified technicians; maximum allowable leak rates and leak repair requirements; and safe disposal requirements. Additionally, EPA is proposing to lower the maximum allowable leak rates for equipment with an ODS charge greater than 50 lbs.

Regarding the destruction of ODS, US regulations specify that ODS must be destroyed using technologies approved by the Montreal Protocol Parties. Further, ODS must be "completely destroyed" which, according to US regulations, means that ODS must be destroyed to a 98% destruction efficiency (DE).

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[37] Class I substances comprise several groups of chemicals with an ozone-depletion potential (ODP) of 0.2 or higher, including: CFCs, halons, carbon tetrachloride, methyl chloroform, HBFCs, and methyl bromide. Class II substances include chemicals with an ODP of less than 0.2, i.e., all HCFCs.

In addition, several types of waste ODS are classified as "hazardous wastes" under the Resource Conservation and Recovery Act (RCRA). Specifically, ODS (or ODS-containing waste) may be classified as hazardous wastes if they fall under one of the following waste categories:

- Wastes from non-specific sources (Code F);
- Commercial chemical products (Code U);
- Characteristic wastes (Code D); or
- Wastes from specific sources (Code K).

Waste ODS classified as hazardous wastes must be destroyed in hazardous-waste permitted destruction facilities. Permitted hazardous waste facilities that operate hazardous waste combustors (e.g., incinerators) are also required by the standards for Maximum Achievable Control Technology (MACT) to adhere to a minimum 99.99% DRE and meet certain air emissions limits. While most waste ODS types are not classified as hazardous wastes (e.g., CFC/HCFC refrigerants, halons), research has indicated that, in practice, most ODS are destroyed in the US by hazardous waste permitted facilities, and that all ODS are destroyed to at least a 99.99% DRE when sent to such facilities.

Under the Clean Air Act Amendments, ODS destruction facilities must provide the following reports:

- A report to EPA with the names and quantities of all ODS destroyed during each calendar year;
- A one-time report to EPA stating the destruction unit's DRE, the methods used to record the volume destroyed, and the methods used to record DRE—among other things; and
- A destruction verification document to the producer/importer or user from whom the ODS was purchased or received.

3. ODS-Containing Appliances

3.1 Background

Currently, laws prohibit venting of refrigerant at appliance service and disposal. There are no federal requirements governing the recovery and reclamation/destruction of ODS foam. The EPA runs the voluntary Responsible Appliance Disposal (RAD) Program, which aims to ensure compliance with laws relating to the treatment of ODS refrigerant and hazardous waste (e.g., PCBs and mercury), while also promoting the proper removal and reclamation/destruction of ODS foam. The program emphasizes the energy savings and climate benefits that can result if a rebate is offered to encourage removal of old units from the electricity grid.

3.2 Description of Process/Program

Section 608 of the 1990 Clean Air Act Amendments requires that the emissions of refrigerant during the service and disposal of equipment must be minimized to the greatest extent possible. However, there is no national program or standard procedures in place for disposing of appliances; rather, practices vary by location. Most appliance recycling efforts are run by municipalities, utilities, and retailers.

Appliance collection and disposal services run by municipalities vary greatly from one to the other. Some provide curbside pick-up at no additional cost to residents in excess of municipal taxes; some require up-front costs to residents for curbside pick-up (typically within the ranges of $15 to $40 per appliance); others require residents to transport their units to a dump themselves (where they may need to pay the waste station $2.50 to $25). Typically, municipalities have contracts with third parties for the removal and/or disposal or recycling of household appliances, which is often a component of a more comprehensive solid waste management contract. Because a variety of third parties tend to be involved with appliance disposal activities, most municipalities may not be able to account for the ultimate fate of refrigerant or other appliance components. Municipal contractors typically recycle ferrous materials due to their high economic value, but plastics and glass, which have a lower market value, are often landfilled.

Some states have implemented innovative measures to supplement the greater cost of appliance disposal relative to other solid waste and reduce illegal dumping. For example, North Carolina generates revenues through an Advance Disposal Fee (ADF) on the purchase of major appliances. Through this program, an additional charge of $3.00 is levied on each new appliance purchase, and the funds are distributed to counties to be used for cleaning up illegal dump sites, establish and/or maintain recycling programs, or make other improvements to white goods management. Other municipalities charge residents for appliance recycling services at the time of collection and/or disposal.

Exhibit VII-2: Refrigerators at ARCA, Inc. (Appliance Recycling Centers of America) awaiting processing (left) and being drained of refrigerant (right).

Old refrigerators collected by retailers at the time new units are delivered are handled by third-party contractors. Third-party contractors typically pay the retailer several dollars per unit to remove the old unit from customers' homes, since the old units are often resold on domestic or international markets for several hundred dollars each. It is estimated that 40 percent of old refrigerators collected through retail channels are resold. Appliances not fit for resale are disassembled, but the specific fates of appliance components may vary by third party contractor, which in turn vary by region and retail establishment. In general, metals are recycled, foam is landfilled, and all other durable components are either recycled or landfilled. If contractors are in compliance with the law, refrigerant is recovered for reclamation or destruction.

Because electric utilities are under pressure to implement demand-side management measures, some appliance disposal programs have been implemented by utilities to reduce energy consumption of old, inefficient refrigerators/freezers. Under a typical utility appliance disposal program, utilities hire a third-party contractor to collect and process appliances and administer and/or market the program. In most cases, a small monetary incentive is given to residents for disposing old units and/or a rebate is offered towards the purchase of a new unit that has earned the government's ENERGY STAR® label[38] after the old unit is

[38] The U.S. Department of Energy and the U.S. Environmental Protection Agency created the Energy Star label for energy-efficient products. To bear the Energy Star label, a product must operate significantly more efficiently than its counterparts, while maintaining or improving performance.

recycled. Because third-party contractor activities are closely tracked and scrutinized, compliance with proper appliance disposal laws is assured. In addition, many utilities have gone beyond federal requirements and required their third party recycling contractors to recover and reclaim or destroy ODS foam.

Exhibit VII-3: Refrigerant recovered from old refrigerators at JACO Environmental Inc.

To promote the responsible disposal of refrigerated appliances, the EPA launched the voluntary Responsible Appliance Disposal (RAD) Program in 2006. RAD partners must recover ODS from old refrigerators, freezers, air conditioners, and dehumidifiers using best practices to ensure that (1) refrigerant is recovered and reclaimed or destroyed as required by law; (2) foam is recovered and destroyed or the foam blowing agent is recovered and reclaimed; (3) metals, plastic, and glass are recycled, to the extent possible; and (4) PCBs, mercury, and used oil are recovered and properly disposed as required by law. RAD partners include utilities, municipalities, retailers, manufacturers, universities, and other interested organizations (e.g., military). Partners join the RAD Program for a number of reasons; they may wish to green their public image, fulfill greenhouse gas emission reduction goals (e.g., university signatories of the American College and University Presidents Climate Commitment), or promote environmental stewardship. Utilities often incorporate appliance recycling programs into mandated Demand Side Management strategies, which lead to cost savings for consumers and utilities (through reduced energy use and the foregone need to build new power plants, respectively). Currently, the RAD Program has 11 utility partners and 1 major retailer partner. Appliances are collected in each partner's territory (i.e., utility partners collect appliances from their service areas). Existing utility partners are located in California, Colorado, Idaho, Nevada, Oregon, Texas, Utah, Washington, Wyoming.

3.3 Costs

The cost to implement appliance recycling programs depends on the level of services provided and the selected treatment of appliance components. Services offered may include some or all of the following:

- Recovery and reclamation/destruction of refrigerant;
- Recovery and destruction of used oil, PCBs and mercury;
- Recycling of metal, plastic, and glass;
- Recovery and destruction of foam blowing agent;
- Recordkeeping and program administration;
- Transportation for appliance collection;
- Advertising (marketing and outreach);
- Bounty/monetary award to encourage consumers to turn in their old appliances early.

The upper and lower bound cost estimates for each of these potential services are presented Exhibit VII-4. Prices are based on the processing of at least 10,000 refrigerators/year for at least three years; this is the minimum volume and time period deemed viable to establish a new appliance recycling facility. The costs are based on estimates provided by appliance recyclers that offer turn-key programs for the collection and recycling/disposal of appliances—primarily full-sized refrigerators and freezers.

Exhibit VII-4: Estimated Program Component Costs per Appliance[a]

Program Component	Lower Bound	Upper Bound
Required		
Recovery & proper treatment of refrigerant,[b] used oil, PCBs, mercury	$18.00	$20.00
Recycling of metal, plastic, and glass[c]	NA	
Recovering and destroying foam blowing agent[d]	$10.00	$20.00
Recordkeeping and program administration	$2.50	
Transportation	$10.00	$20.00
Costs paid to retailer to cover resale	$20	
Subtotal	*$60.50*	*$82.50*
Optional		
Marketing and Outreach	$25	
Bounty/Monetary Award in the form of a Rebate/Incentive[e]	$35	
Coverage of pick-up/disposal fees imposed by retailers[f]	$10	
Subtotal	*$70*	
TOTAL	$130.50	$152.50

NA= Not applicable; no costs or cost savings are applied to the price charged by appliance recyclers.

[a] The program costs presented are for utility programs that collect full-size refrigerators and freezers between 10 and 27 cubic feet. Per unit costs are based on a program that collects at least 10,000 units/year for three years. Certain cost components may vary when handling smaller refrigerators and window air conditioners.

[b] Refrigerant is assumed to be reclaimed (not destroyed) for all scenarios.

[c] Recycling of durable materials is a cost savings. See text box on page 4 for more information.

[d] Foam is assumed to be destroyed (not reclaimed) in a municipal solid waste incinerator following recovery for all scenarios.

[e] According to appliance recycling industry sources, rebates for the turn in of old appliances offered by municipalities and utilities average $35 (Kolwey 2006).

[f] A waiver for the fee charged to pick-up and dispose of old appliances, which averages $10, can be offered by retailers (Sears 2006).

3.4 Statistics on Collection

Approximately 9.4 million refrigerators, 3.4 million freezers, and 4.5 million AC units are disposed of annually in the United States (AHAM 2001, US Census Bureau 2002b). Of these, it is estimated that more than 1 million refrigerators/freezers will be disposed of responsibly through the RAD Program in 2008. Outside of the RAD program, the fate of ODS refrigerant and foam contained in household appliances cannot be confirmed.

Exhibit VII-5 below shows the average amount of refrigerant and foam blowing agent that is recovered per refrigerator, freezer, and window air conditioner, based on data reported by selected appliance recyclers.

Exhibit VII-5: Amount of Refrigerant and Foam Blowing Agent Recovered per Appliance

Appliance Type	Average Amount per Appliance (kg)	
	ODS Refrigerant	ODS Blowing Agent in Foam
Refrigerators	0.23 (CFC-12) 0.16 (HFC-134a)	0.45 (CFC-11) 0.38 (HCFC-141b)
Freezers	0.23 (CFC-12) 0.16 (HFC-134a)	0.45 (CFC-11) 0.38 (HCFC-141b)
Window Air Conditioners	0.51 (HCFC-22)	NA

NA= Not applicable.

3.5 Challenges

In municipalities without free curbside pick-up programs, residents may be compelled to leave their appliances on curbsides or dump them illegally. Such appliances are prone to be collected by peddlers, who typically either resell old units, or extract the metal components, which are then re-sold to recyclers, while all other parts are landfilled. Peddlers are unlikely to reclaim refrigerant as required by law.

Further, because third parties are involved in municipal and retailer appliance disposal activities, some municipalities/retailers may not be able to account for the ultimate fate of refrigerant (or other appliance components). Also, technician certification is not required for individuals removing refrigerant from appliances in the waste stream, so the environmental education among technicians in this sector may be low. The extent of contractor non-compliance with federal regulations is, therefore, unknown. Moreover, the resale of appliances is common, which means that energy-inefficient units are placed back on the energy grid either in-country or abroad, where they may not be properly disposed when they reach end of life.

3.6 Lessons Learned

EPA's voluntary RAD program, which accounts for the disposal of approximately 6% of disposed refrigerated appliances in the United States, will be assessed on an annual basis beginning in 2008. This assessment will determine the actual number of units properly recycled/disposed by RAD partners, as well as the quantity of ODS refrigerant and foam blowing agent recovered.

Apart from the voluntary program, EPA's enforcement activities help ensure technician compliance with the ODS venting prohibition (i.e., recovery at service and disposal events). To date, EPA has pursued about 5 civil enforcement actions in the last 5 years against companies and individuals for violations related to the proper recovery of refrigerant from disposed appliances.

4. Bulk ODS Refrigerants

4.1 Background

As described in Section 2, the Clean Air Act and Resource Conservation and Recovery Act both govern the treatment and collection of bulk ODS. In stationary equipment, recovered ODS may only be recycled/reused in equipment owned by the same individual/company; if the refrigerant is to be recharged into a unit owned by a different individual/company, it must be reclaimed by an EPA certified reclaimer in accordance with ARI Standard 700.

In addition, a new economic incentive has recently been introduced to promote the destruction of ODS whose production has been phased out; beginning January 1, 2007, the Chicago Climate Exchange (CCX) has allowed its members to redeem ODS destruction offset "credits" through the proper destruction of phased out ODS in a licensed hazardous waste combustor. The CCX is North America's only active voluntary, legally binding integrated trading system to reduce emissions of all six major greenhouse gases (GHGs), with offset projects worldwide (CCX 2007).

4.2 Description of Process/Program

When ODS-containing equipment reaches the end of its useful life, federal law requires that ODS be recovered from the system before the system is disposed. Similarly, federal law requires that ODS be recovered during service events. All recovered ODS must either be stored, recycled, reclaimed, or destroyed. No government or industry-sponsored "programs" are in place to collect, transport, reclaim, or destroy bulk refrigerant, but over time, infrastructure has been established by private companies to perform these service. In particular, there are 48 EPA-certified refrigerant reclaimers and about 10 known facilities that commercially destroy ODS. In addition, there are a significant number of non-commercial, byproduct destruction facilities in the U.S. that have destroyed ODS-containing wastes.

While the extent of refrigerant recycling/reuse is not known, refrigerant reclamation is more common than refrigerant destruction in the United States. This is because refrigerant destruction is always associated with a cost that must be paid by technicians (though such costs can be passed on to consumers), whereas refrigerant reclamation can often be free or even profitable for technicians (see Section 4.3).

Large users may send ODS directly to a destruction facility, while smaller users may return used ODS to their distributor who in turn sends it to a destruction facility. Large users and distributors may also send used ODS to reclamation facilities, but even in such cases, some of the ODS may end up being sent for destruction if contamination levels are high, or if it is not economically viable to reclaim. On a technical basis, more than 98% of collected ODS can be physically/chemically reclaimed. The main issue is economic feasibility; whether the market value of a given type of ODS is high enough such that the reclaimed product can be resold at a price that outweighs the reclamation costs. In the United States, where there continues to be high ODS servicing needs, and where there is a tax placed on new Class I ODS, the reclamation of ODS (even mixtures) can often be economically viable for companies.

Exhibit VII-6: Hazardous waste at Clean Harbors, Inc. awaiting destruction (left) and cylinders being moved for incineration (right).

ODS are generally stored in pressurized containers such as gas cylinders or bulk storage tanks. ODS that has been recovered from equipment is stored in cylinders made specifically to hold recovered refrigerant, which are typically 30 to 50 pounds (0.01 to 0.02 MT). ODS can also be transferred from one container to another by connecting the two with transfer hoses in order to consolidate it before shipping. Bulk ODS is most commonly stored in pressure vessels ranging from 250 to 500 gallons (approximately 1.4 to 2.8 MT of HCFC-22) that are built to the specifications of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. Pressure vessels are sealed tanks that do not have breathing losses (i.e., losses that occur when changes in the temperature displace vapor from a non-pressurized storage tank).

One company offers a complete portfolio of recovery, reclamation, transportation, destruction, refrigerant banking, recharging, and ODS replacement. The company performs on-site recovery and buys refrigerant from industrial sources that wish to sell their ODS. The material is either destroyed by plasma arc or reclaimed, when permitted by law. The company also maintains a bank of permitted ODS that it sells to industrial users. It has also developed a mobile recovery and reclamation unit for on-site ODS reclamation.

When technicians or reclamation facilities send ODS to be destroyed, ODS may be shipped in various types of containers (e.g., steel cylinders, bulk storage tanks, ISO containers, tanker trucks, rail cars), which can range in size from 30 lbs to 200,000 lbs (13.6 kg to 90,700 kg). When ODS containers arrive at destruction facilities, they are commonly stored for a week to a month before the ODS is fed into the destruction unit. All of the known commercial ODS destruction facilities in the United States, with the exception of one, are hazardous waste-permitted HWCs and, therefore, must meet a 99.99% DRE. The non-permitted facility uses plasma arc technology and has a DRE greater than 99.999%.

Exhibit VII-7: One of Clean Harbors' destruction facilities.

4.3 Costs

The price of ODS destruction depends on the type of ODS, composition/purity, quantity, the type of container the ODS is stored in, and transportation needs. In general, per-pound costs are greater to destroy ODS delivered in smaller versus large containers (e.g., cylinders versus ISO tanks). Additionally, if a destruction facility has a large amount of refrigerant to destroy in a given week, prices may increase or the facility may even refuse to accept the waste. Estimates for the cost to destroy ODS range from \$0.80 to \$6.00 per pound (\$1.75-\$13.20 per kg). These prices do not include transportation, and depend on the facility and the ODS type to be destroyed.

Costs associated with transporting ODS to a destruction facility can vary greatly depending on distance and quantity, and whether the transport is within or beyond state borders. Bulk quantities in-state are the most economical to transport. According to one destruction company, a railcar carrying 190,000 pounds (86,000 kg) of waste-containing ODS costs approximately $800 for in-state shipments (about $0.42 per 100 pounds of ODS [$0.92/100 kg]); these costs approximately double for out-of-state shipments. The same source estimates that a tank truck carrying 42,000 pounds (19,000 kg) of ODS waste can cost as much as $700 for in-state shipments ($1.67 per 100 pounds [$3.67/100 kg]); corresponding prices for out-of-state shipments were not provided by the source, as they are highly variable. Another destruction company reported the cost to transport waste refrigerant varies from $0.15 to $0.30 per pound ($0.33-$0.66/kg), depending on the refrigerant type. Another company charges $4.00 per mile ($6.45/km) for transport in a pressurized ISO tanker, or the tanker can be leased (with a minimum 1-year lease) for $1,000 per month.

The capital and operating costs of commercial destruction facilities can be substantial since these facilities generally destroy large quantities of waste including some bulk ODS that are classified as hazardous waste. Destruction facilities have to generally limit bromine and fluorine feed rates because of equipment corrosion and air emissions control limitations; based on the size of the facility upgrades such as fluorine-resistant brick can cost over $1 million. One ODS destruction facility in Arkansas, that incinerates containerized solid and liquid hazardous waste at the rate of 55,000 lbs per hour (24,947 kg per hour), indicated that they spend $2 million in operating costs per year on natural gas consumption. The facility has spent over $37 million in upgrades since 1972 to be compliant with federal emissions standards.

4.4 Statistics on Collection

Between 2005 and 2006, companies reported to EPA that they reclaimed nearly 9,400 metric tons of ODS. Most of the ODS reclaimed in the United States have been HCFC-22, CFC-11, CFC-12, and HCFC-123; significant quantities of CFC-113 and CFC-114 have also been reclaimed (see Exhibit VII-8). During the period 1995 to 2005, more than 27,000 metric tons of used ODS were imported into the United States for the purpose of reclamation or destruction. In 2005 and 2006, all ODS imported was destroyed. The previously used ODS imported into the U.S. for reclamation and reuse includes CFC-11, CFC-12, Halon 1301 and HCFC-22.

Exhibit VII-8: Reported Data on ODS Reclamation and Destruction in the United States (kg)

ODS Type	2005		2006	
	Reclamation[a]	Destruction[b]	Reclamation[a]	Destruction[b]
CFC-11	447,274	54,973	539,456	39,652
CFC-12	269,379	3,923	335,271	3,710
CFC-113	49,025	3,693	60,614	5,067
CFC-114	31,819	302	22,166	119
HCFC-22	2,802,148	256,922	3,875,082	303,598
HCFC-123	145,071	3,801	144,481	638

[a] Of these quantities, none were reportedly imported.
[b] All quantities were reported as imports with the following exception: in 2005, only 12.5% of the total HCFC-22 destroyed was imported; in 2006, 22.3% of total HCFC-22 destroyed was imported.
Sources: US EPA 2006, 2008.

Of the total refrigerant recovered or imported for the purpose of destruction or reclamation, approximately 40% was reclaimed in 2003, and 60% was reclaimed in 2004. The total amount of destroyed ODS includes all Class I and Class II substances; the total amount of ODS reclaimed includes R-11, R-12, R-113, R-114, R-500, R-502, R-22, and R-123.

4.5 Challenges

To ensure that ODS is properly destroyed at end of life, the United States relies on regulations, technician certification/training, and enforcement. However, because there is a cost burden associated with ODS destruction, there is an economic *dis*incentive to destroy unwanted ODS. Indeed, apart from the CCX ODS destruction credit program—which has not yet been widely used—there are no market forces driving proper ODS disposal, which could lead to the indefinite storage or venting of ODS.

4.6 Lessons Learned

The US has successfully encouraged the collection of bulk ODS (1) by establishing a strong foundation in training and certifications, (2) by relying on market demand to create economic incentives for recovery, recycling and reclamation, and (3) by strongly enforcing provisions that prohibit venting.

More specifically, through technician certification, which is required in order to purchase ODS refrigerant, basic technical and environmental training has been provided to all technicians dealing with ODS-containing equipment. The EPA also engages in a wide variety of outreach and education activities (e.g., website/print materials, stakeholder meetings, conference events, etc.) to ensure that technicians and consumers know and understand their legal obligations.

In addition, US regulations have effectively manipulated market forces to induce good refrigerant management by reducing supply while allowing demand to continue. In particular, by (1) restricting ODS supply through production/import phaseout, (2) increasing ODS prices by taxing CFCs, and (3) allowing the continued use of recycled/reclaimed ODS, there is an economic incentive to collect bulk ODS for recycling and reclamation. Without this market demand to service existing ODS equipment, used or stockpiled ODS would have no economic value, and technicians would have no financial incentive to recover. Based on reported information on imports of previously used ODS and reclamation, this market-based approach is believed to be successfully meeting market demand while minimizing emissions of ODS.

The effectiveness of EPA regulations is also evaluated by assessing the trends in enforcement cases. EPA is authorized to assess fines of up to $37,500 per day for any violation of refrigerant regulations, including failure to recover ODS refrigerant at service and disposal events. EPA has pursued over 1,000 civil enforcement actions since 1992 against companies and individuals for violations of the regulatory requirements to properly recover, recycle, reclaim, and dispose of ODS. Penalties for violations of requirements for the proper recovery, recycling, reclamation and disposal of ODS have been as high as $4.5 million.

Finally, it should be noted that the EPA has promoted the collection of ODS with the stakeholders support. Stakeholders have encouraged EPA to extend its regulatory requirements and the enforcement of those requirements to other substances used within various industrial sectors. Stakeholders have also provided EPA with additional non-compulsory information about the market in ODS and ODS-substitutes.

5. Mobile Air Conditioning

5.1 Historical Perspective

The first MAC regulation in the US under Section 609 of the Clean Air Act was published in July, 1992. That regulation established standards for handling of CFC-12 refrigerant. Regulations were updated in 1998 to include HFC-134a refrigerant. Updated recovery equipment standards were approved in 2007 and other updates to the regulation to further reduce emissions from this sector are forthcoming.

5.2 Description of Process/Program

Although regulations under Section 609 of the Clean Air Act (U.S. national law) prohibit venting refrigerant during the servicing of MAC equipment, there are no nationwide programs to facilitate refrigerant recovery and recycling. It is the responsibility of each technician to recover and either recycle/reuse, reclaim, store, or destroy refrigerant. Although there is no data on actual refrigerant recovery from MACs at service or disposal, refrigerant recovery from MACs is believed to be common practice. From an economic standpoint, it is cost-effective to recover and recycle/reuse (non-contaminated) refrigerant from MACs at service. At disposal, used refrigerant can be collected for reclamation, which can be quite profitable—especially CFC-12. There is no financial incentive, however, to destroy contaminated or unwanted refrigerant from MACs.

5.3 Costs

The average retail price of a recovery/recycling device for MACs is $3,500. The average lifetime of these devices is 7 years. According to industry sources, the destruction of refrigerant costs approximately $2.45/lb. Reclaimers will pay $2-7/lb (~$5-$14/kg) for used CFC-12 refrigerant, while R-134a is commonly accepted for free.

5.4 Statistics on Collection

An estimated 20-25 million MACs are professionally serviced annually in the US. In 2000, an estimated 13 million cars and light trucks were disposed of, and approximately 6% of disposed vehicles were abandoned (MACS 2007). It is unlikely that refrigerant was recovered from those MACs in abandoned vehicles.

5.5 Challenges

The level of refrigerant recovery at MAC service and vehicle end of life is unknown. The viability of refrigerant recovery, particularly at vehicle end of life, may be questionable, given the small size of MACs charge sizes and the potential for refrigerant contamination. Further, technician certification is not required for individuals removing refrigerant from appliances in the waste stream. Thus, enforcement activities are needed to ensure that proper recovery occurs.

5.6 Lessons Learned

As previously mentioned, EPA's technician training and enforcement activities help ensure technician compliance with the ODS venting prohibition (i.e., recovery at service and disposal events). To date, EPA has pursued about 100 civil enforcement actions per year since 1992 against companies and individuals for violations related to the proper recovery of refrigerant at MAC service and disposal.

6. Halon Banking

EPA prohibits the intentional release of Halon 1211, Halon 1301, and Halon 2402 during the testing, repairing, maintaining, servicing or disposal of halon-containing equipment or during the use of such equipment for technician training. The rule also requires appropriate training of technicians regarding emissions reduction and proper disposal of halon and halon-containing equipment at end of life.

The Halon Alternatives Research Corporation (HARC), a non-profit trade association formed in 1989, serves as a facilitating organization and information clearinghouse on issues related to halon replacement, halon recycling, and halon regulation. The Halon Recycling Corporation (HRC), a voluntary, non-profit trade association formed by HARC and the fire protection industry, also assists users of halon fire fighting chemicals to redeploy the existing installed bank of halons from applications where alternatives are feasible to those unique situations that still require halons. HRC assists in selling and finding halons as well as keeping halon users informed about changes in international and domestic regulations that can impact continued halon use.

The Defense Logistics Agency (DLA) manages the Department of Defense (DoD) halon bank for the U.S. military in order to maintain a reserve of halons 1202, 1211, and 1301 to support "mission critical" requirements when commercial sources are not available. DLA has a policy to rely primarily on DoD turn-ins of recovered halons for future use.

Appendix B: Article 5 Country Case Studies

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VIII. Colombia

1. Introduction

1.1 Country Information

Located in Northern South America, Colombia has a land area of 1,038,700 sq km. After Mexico and Brazil, Colombia has the third largest population in Latin America of 44,379,598. Bogota, the capital of Colombia, has a population of 7,050,133. Colombia has a population density of about 41 people per square kilometer, and the majority of the population, about 74%, lives in urban areas.

Exhibit VIII-1: Colombia Source: CIA World Fact Book 2007.

Colombia is considered to be the most industrially diverse member of the five-nation Andean Community. Colombia's main industries include textiles and clothing, leather products, processed foods and beverages, paper and paper products, chemicals and petrochemicals, cement, construction, iron and steel products and metalworking (US Department of State 2007).

1.2 ODS Market Characterization

The refrigeration/air-conditioning sector represents the most significant source of continued ODS use in Colombia. The demand for CFC-12 has declined significantly over time, with consumption being only 619.75 tons in 2006 for the refrigeration/air-conditioning sector (see Exhibit VIII-2).

Exhibit VIII-2: Consumption of ODS in Colombia, 2006

ODS Type (Annex A, Group I)	Sector						
	Fire Extinguishing	Foams	MDI	Refrigeration Manufacture	Refrigeration Service	Solvents	Total
CFC-11			0.56		18.76		19.32
CFC-12		15.42	1.65		619.75		636.81
CFC-113							0
CFC-114							0
CFC-115					9.32		9.32
Halon							0
CTC						0.54	0.54
Methyl Bromide							0
Total	0	15.42	2.21	0	647.83	0.54	665.99

Colombia has four manufacturers of domestic refrigeration equipment, 10 large manufacturers of commercial refrigeration/AC equipment, and five large importers of bulk ODS (with another 15 smaller importers). The majority of all refrigerant consumption is used in the servicing sector, mostly sold in disposable cylinders. Much refrigerant is also sold in small cans.

While CFCs have been completely phased out in new equipment production since 2007, there is a significant CFC bank. For example, there are an estimated 2,000,000 to 4,000,000 CFC-based domestic refrigerators in use. Because the average lifetime of a household refrigerator in Colombia is roughly 25 years, and import of CFC-based domestic refrigerators only stopped in 1997, these units will continue to be used for many years to come. There are approximately 700,000 new refrigerators/freezers sold per year in Colombia.

There are also an estimated 60 CFC centrifugal chillers installed in Colombia. Colombia will be participating in a UNDP/GEF demonstration project (along with other countries in South/Central America) to replace these chillers.

2. Relevant Legislation and Regulations

Colombia has laws in place governing the consumption of ODS. Specifically, import quotas and import licensing schemes for CFCs and other Class I ODS have been in place in Colombia since 2001. To obtain a license, importers must pay a fee (which varies between 0.4%-1% of the declared value of the imports) and provide an environmental impact statement/management plan for the handling of ODS. Beginning in 2006, import licenses have also been required for HCFCs, although no quotas are in effect.

Colombia has also begun to address the management of unwanted ODS within its legal framework. According to Article 32 of Decree 4741 (December 30, 2005), unwanted ODS are defined as hazardous wastes[39] and may not be released to the atmosphere. To support this law, the Colombian Ozone Unit, Unidad Tecnica Ozono (UTO), must develop a national strategy for the management of unwanted ODS, which will be complete by 2010.

In addition, Article 20 of Decree 4741 establishes producer responsibility requirements for three types of hazardous wastes in Colombia: pesticides, batteries, and expired medication. Because unwanted ODS are classified as hazardous wastes, there may be scope within the legal framework to apply similar producer responsibility requirements in the ODS sector in future.

In the next year or so, Colombia plans to mandate technician certification in the stationary and mobile refrigeration/AC servicing sector. Currently, technician certification in the stationary sector is voluntary, although some companies already require it of their employees. Of Colombia's estimated 10,000 technicians, 2,500 have already obtained certification. *Normas de Competencia Laboral* (NCL) is the body that established the national technician training standards. *The Servicio e Nacional de Aprendizaje* (SENA) is the government institution that implements the training program. Certification through SENA is free, but requires roughly one year to obtain. For a fee, technicians can take a shorter certification program from a private certification body, ICONTEC—Colombia's national standardization institute—which typically takes only 6 months to complete. The government aims to have a total of 5,000 technicians certified by 2010. No certification scheme is yet in place for the mobile sector, but UTO is developing standards/certification for this sector, which should be complete by the end of 2008.

[39] Colombia is a signatory to the Basel Convention; because Colombia defines unwanted ODS as hazardous waste, the import/export of ODS for reclamation or destruction purposes must be addressed under the framework of the Basel Convention.

3. ODS Collection and Destruction

3.1 Background

There are no destruction or reclamation facilities in Colombia currently permitted to destroy ODS. While UTO is working on developing a comprehensive strategy for managing unwanted ODS by 2010, no regulations or infrastructure are currently in place to facilitate the reclamation or destruction of unwanted ODS in Colombia. UTO is trying to minimize the amount of unwanted ODS by promoting recycling/reuse.

3.2 Appliance Collection and Recycling

There is no unified or structured process for collecting and recycling appliances in Colombia. Metals, plastics, and glass in domestic appliances are recycled for a profit. The channels for appliance collection are varied, but mainly involve the informal sector. Appliances may be left at the curb and collected by "scavengers," collected by municipalities, or dropped off by consumers to nearby scrap yards (in which case the consumer is likely to receive a small fee). Appliance components are often sold to China. There is no recovery of refrigerant, foam, PCBs, mercury, or used oil from appliances.

Currently, UTO is in negotiations with the *Asociación Nacional de Empresarios de Colombia* (ANDI)—an association representing Colombian appliance manufacturers and importers—to establish a pilot program to collect and recycle 10,000 refrigerators/freezers in Bogotá. If the pilot project is realized, refrigerant would be recovered and exported for destruction to a facility yet to be identified (based on a cost assessment). Foam would be manually recovered and incinerated at a cement kiln (owned by Holcim) about 4 hours away from Bogotá. It is unclear what would be done with PCBs and mercury. The cost to responsibly recycle/destroy each unit is estimated at 30,000 Colombian pesos (roughly US$15); it has not yet been decided who would bear this cost, although appliance manufacturers/importers may be willing to do so if the recycling program were to include a component to incentivize the replacement of old units.[40] Industry estimates that it would take at least 100,000 Colombian pesos (~$50/unit) to incentivize consumers to replace their old units.[41] Identifying the funding source for this additional incentive cost is where the impasse currently lies. The pilot would allow UTO and industry to develop the necessary infrastructure for appliance disposal, as well as a concrete understanding of how such a program can best be run.

3.3 Treatment of Unwanted ODS Contained in Bulk

About 10 years ago, Colombia began a recovery/recycling program in the stationary refrigeration/AC service sector. At the time, 337 recovery-only units and 13 recovery/recycling units (in addition to recovery cylinders and leak detectors) were acquired and disbursed by UTO. The average cost of this equipment was $800/unit. Thirteen centralized refrigerant recycling centers were also established, with the aim of recycling the refrigerant recovered by technicians for a fee. However, because the prices of CFC refrigerants were so low, virgin refrigerant could be purchased for less than the cost to recycle recovered refrigerant at the refrigerant recycling centers. Only the recovery/recycling units could be used cost-effectively. Moreover, the recovery equipment was heavy and difficult to transport, which caused many technicians not to use it. As a result, the program failed.

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[40] From an industry perspective, a more rapid appliance replacement rate translates into greater sales; from an environmental perspective, this also translates into significant energy savings.

[41] The fee offered to consumers must be greater than the dollar value they could otherwise obtain from the resale of their units.

Learning from past experience, Colombia has embarked on the second phase of its recovery/recycling program and purchased equipment that addresses the practical needs and constraints of technicians. Specifically, UTO acquired 275 additional units, including: 250 portable (lightweight) recovery-only units (some with and some without compressors) for use in the domestic refrigeration sector; 10 portable recovery/recycling units for the MAC sector; and 15 large recovery/recycling equipment for the commercial stationary sector. The average cost of this equipment was $2,000/unit. The equipment is expected to be disbursed in early 2008.[42] This will be an important start to having recovery/recycling become standard practice within the industry. Apart from the recovery/recycling units provided by UTO, there are a number of large companies and commercial equipment servicing companies that have purchased their own equipment, but overall, the percent of the industry that owns such equipment is believed to be very small.

As part of this second phase, Colombia is also working to set up a small-scale reclamation facility. The facility would be operated by bulk ODS importers, who would reclaim refrigerant collected by the 250 contractors with recovery-only units. So far, however, no bulk importer has agreed to move forward on this venture, given that refrigerant reclamation would not currently be a profitable business in Colombia in light of low refrigerant prices. UTO is continuing to work on this and hopes to have a reclamation center operating by the end of 2008.

Meanwhile, UTO is receiving inquiries from companies and certified technicians about what should be done with their contaminated or unwanted ODS. UTO simply tells them to store it until procedures are established for destruction; this typically leads to the venting of ODS, as technicians/companies do not have the space to store materials indefinitely, and because they need to use the cylinders for other purposes.

One large electric company (ISAGEN) has over 8 tons of unwanted halon and is negotiating the sale of this stockpile to the United States (RemTec) to be used for critical uses.

3.4 Costs

Colombia is trying to establish a small-scale, non-continuous reclamation device which is estimated to cost between US$50,000- US$100,000. The low cost of refrigerants in Colombia undermines the viability of reclamation today, although the situation is expected to change in future as CFC-12 becomes scarce. Currently, the import price of CFC-12 is about US$6.50/kg. Similarly, HCFC-22 will also become scarce in Colombia, and it will be important to recover and reclaim it in order to avoid supply shortfalls and undue abandonment of equipment. The current import price of HCFC-22 in Colombia is about US$1.70/kg.

3.5 Statistics on Collection

As shown in Exhibit VIII-3, there are nearly 9,500 kg of *known* unwanted ODS and ODS substitutes that have been recovered and are awaiting reclamation or destruction. These quantities have been reported by companies seeking advice from UTO regarding where their unwanted stocks should be taken. As described above, UTO has been asking companies to store their stocks until a management plan is in place. However, many companies are not likely to have adequate space to store ODS indefinitely, or may need to use the storage cylinders for other purposes.

[42] Administrative requirements have delayed disbursement by over a year.

Exhibit VIII-3. Known Stocks in Colombia Awaiting Reuse/Reclamation/Destruction

Company	City	Substance	Quantity (Kg)	State
Laboratorios Chalver de Colombia S.A.	Bogotá	CFC-11 residue	120	Residue
ETB	Bogotá	CFC-11	350	Virgin
ISAGEN	Medellín	CFC-11	777	Recovered
ISAGEN	Medellín	Halon-1301	8,196	Virgin
Bavaria S.A.	Bogotá	CFC-12	11	Recovered
Bavaria S.A	Bogotá	HCFC-22	5	Recovered
Bavaria S.A	Bogotá	HFC-134a	39	Recovered
TOTAL			9,498	

In addition, there have been incidents of illegal imports of CFC-12 into Colombia. To date, illegal CFC imports have been confiscated and sold/donated by the Customs Department to the military or not-for-profit organizations. But any illegal imports of ODS that do not have an economic value would pose a problem for the Customs Department, as they lack adequate storage capacity to store bulk chemicals indefinitely, as well as the funds needed to transport and destroy them.

3.6 Lessons Learned

Based on the first phase of Colombia's refrigerant recovery program, a revised scheme for recovery/recycling is now being deployed. Colombia has learned that technicians require recovery equipment that allows for the reuse of refrigerants without being too heavy or cumbersome to use. Technicians also require a cost-effective solution for dealing with recovered refrigerant that cannot be reused. This will provide some technicians in Colombia with a feasible means of recovering refrigerant, which is the first step in ensuring that unwanted ODS are not released to the environment.

4. Improving the Management of Unwanted ODS: Challenges and Opportunities

4.1 Challenges

Colombia is facing numerous challenges in developing an effective scheme for recovering refrigerant for reclamation or destruction. At the most basic level, many technicians lack recovery and recovery/recycling equipment, which is a fundamental necessity. Service technicians and companies are not required by law to own such equipment—which makes sense at this stage, given that the government cannot yet offer practical solutions for reclaiming or destroying any recovered refrigerant. And therein lay the other challenges:

1. How to establish a viable reclamation facility when refrigerant prices are so low that reclamation is not currently cost-effective?

2. Who will bear the cost of destruction, and what is the most feasible means to destroy small but steady amounts of unwanted ODS?

Regarding the latter point, UTO has considered developing centralized depots for unwanted ODS in Cali and Medellin, but the lack of destruction capacity and economic barriers are challenges that would need to be overcome. For example, the nearest known ODS destruction facility is in Venezuela; the cost to transport and destroy Colombia's unwanted ODS in Venezuela—should Venezuela agree to accept it—would require financial support beyond what UTO could provide or ask of technicians/companies.

Further, since Colombia defines unwanted ODS as hazardous waste, it would need to fulfill the administrative requirements specified under the Basel Convention in order to export it to Venezuela, which would add time and complexity. In addition, significant expenditures would be needed if Colombia were to utilize its existing infrastructure (i.e., cement kilns) to destroy ODS, as costly modifications, testing requirements, and emissions monitoring would be needed.

4.2 Opportunities

UTO is committed to developing a management plan for unwanted ODS, and is working with industry to establish a small-scale reclamation facility. Should they succeed in building this facility, Colombia will have a means to reuse refrigerant that will eventually be in high demand and short supply.

Regarding domestic appliances, UTO is making progress in working with industry to develop some type of producer responsibility scheme for refrigerators. Should the pilot program get off the ground, many important lessons will be learned regarding how such a program can work best, and how it can be applied more broadly. Further, there may be opportunity within Colombia's legal framework to mandate producer responsibility in the domestic appliance sector in future.

IX. India

1. Introduction

1.1 Country Information

India is the seventh largest country by geographic area and the second most populous country in the world. According to the latest census report, the population of India was 1.028 billion in 2001 (Census of India 2001a) with a total geographic area of 3,287,240 square kilometers (Census of India 2001b). Approximately 28% of the population lives in urban areas. There are 35 cities with a population of over one million, with Mumbai, Delhi, and Kolkata being the largest metropolitan cities.

Exhibit IX-1: India Source: Word Travels Travel Guides 2008.

1.2 ODS Market Characterization

There are 4 major CFC manufacturers in India, including SRF Ltd., Chemplast Sanmar Limited, Gujarat Flurochemicals, and Navin Fluorine International Ltd, with an estimated stockpile of around 1682 metric tons of ozone depleting substances (as of 2006) (GTZ). As India has regulations to phase out CFC production and consumption completely by 2010 (Ozone Cell 2008), the producers, after 2010, will have to destroy the ODS or may export it to other countries, such as Middle Eastern or African countries that do not have any ODS import regulations.

There are many sources of unwanted ODS in India. According to the Consumer Electronics and Appliances Manufacturers Association (CEAMA), the refrigerator market has been growing at a rate of about 15% per year, while the consumer durables industry as a whole has grown at almost 8%. The total yearly demand for new refrigerators is estimated to be 4.2 million units for the year 2006-07 (CEAMA). The penetration of refrigerators is considerably higher in urban areas, which account for 75% of the demand.

Refrigerators and air conditioners are not generally disposed of in India. They remain in the market even after the end of their economic life cycle, resold as secondhand appliances. These appliances may contain ODS in both refrigerant and in insulating foam. There are no large quantities of confiscated ODS as custom officers have been trained in handling ODS; whatever ODS has been confiscated needs to be re-exported within 6 months.

Ozone Cell, the Indian government's national ozone office, established a National Halon Reclamation and Banking Facility that comprehensively tracked and catalogued the halon stocked by major users and provided facilities for reclaiming halon, among other activities. This allowed for old halon stocks to be purified and reused for critical use. However, the initiative had limited success, and halon is still stocked in old fire extinguishers in India.

2. Relevant Legislation and Regulations

The ODS (Regulation and Control) Rules of 2000, implemented by the Ministry of Environment and Forests, restricts the manufacturing of CFCs and CFC-based refrigeration equipment, as well as the consumption of CFCs. These rules set a deadline of January 1, 2003 for the complete phase-out of CFCs in the refrigeration and air-conditioning (RAC) manufacturing sector. It has stipulated that dealers, procurers, and users engaged in the manufacture/use of ODS, including CFCs, HCFCs, carbon tetrachloride (CTC), halon, methyl chloroform, and methyl bromide, were required to register their activities before July 19, 2002. Additionally, CFC-based equipment will be phased out of production completely by 2010.

According to these rules, no person is allowed to import or cause to import from or export or cause to export any ozone depleting substance to any country that is party to Montreal Protocol, unless he obtains a license issued by the Director General of Foreign Trade.

However, no legislation is in place for the prevention of venting of unwanted ODS and incentives to recover, store, and dispose of these materials are weak. The necessary strategy for phase out from the servicing sector is being formulated by the Ozone Cell of the Ministry of Environment and Forests (MoEF) with assistance from Germany (GTZ), Switzerland (SDC and Infras), UNEP, and UNDP.

Finally, ODS destruction or reclamation facilities need to be registered with the small industries services institute under the small industries development organization in the Ministry of small scale, agro and rural industries.

3. ODS Collection and Destruction

3.1 Background

The National CFC Consumption Phasing-out Plan (NCCoPP) is India’s final CFC phase-out project for the refrigeration and air conditioning (RAC) servicing sector. The project also aims to completely phase-out the CFC service consumption of 1,500 metric tons (1999 baseline) by January 1st, 2010 to secure India’s compliance with the phase out schedules of the Montreal Protocol. NCCoPP is funded by the MLF. In parallel, the production of CFCs in India (and elsewhere around the world) is being phased out. Compared to the 1999 baseline, the production sector sales had been reduced to 50% by 2005. They need to have been reduced further, down to 15% of the 1999 volumes by 2007.

3.2 Appliance Collection and Recycling

Once the economic life cycle of an appliance is over, the used appliances are repaired and sold to the customers who wish to buy secondhand appliances. If the servicing is too difficult or costly, then the useful parts, such as the compressor, are taken out, and the plastic and metals are sold to the local scrap metal collectors who recycle them; in this process, the ODS is vented out. There is no organized sector involved in repairing or recycling. Public-private partnerships need to be encouraged to develop facilities for efficient appliance disposal and for the recovery of ODS, as well as for the recycling of metals and plastics. Existing municipal waste-handling infrastructure and local scrap metal dealers can be organized for this purpose.

3.3 Treatment of Unwanted ODS Contained in Appliances and in Bulk

NCCoPP currently has a presence in all the States of India. It aims to encourage good servicing practices among all refrigerator servicing centers, with a special focus on those firms consuming more than 50 kilograms of CFC per year.

The project's main scope is training refrigeration servicing technicians in servicing refrigeration and air-conditioning equipment that operates on either ODS or non-ODS alternatives. It also covers training for Mobile Air-Conditioning (MAC), Open Type Compressor (OTC) and specifically targets the railways as a key institutional user of CFC refrigerants. The project adopts a multi-prolonged approach to achieve its targets. To date, 16,000 technicians and training institutes have been trained in environmentally friendly technologies and in handling alternative substances. In addition to training, the program includes equipment support, awareness building, and information dissemination, and the education of customs officers on illegal ODS trade.

There are mobile servicing units that recover the CFCs and send them to reclamation units. There are two ODS reclamation centers established under NCCoPP, at Chandigarh and Bangalore. The reclamation units were provided at 20% of the full cost, with the balance funded through the MLF. The quantity of CFC reclaimed till now is very small - 67 metric tons. The cost of virgin CFC ranges typically around INR 600/kg (approximately $15.30/kg), while the costs of reclaiming CFCs are about INR 400/kg (approximately $10.20/kg). Thus, it makes economic sense to recover/reclaim CFCs rather than using virgin CFCs for servicing. However, the number of reclamation units is currently quite low in India, keeping the cheaply recovered CFCs out of reach of many potential consumers. New reclamation units are planned all across the country, and the number of reclamation centers will reach 29 by 2009 under the NCCoPP with the help of MLF funding. The reclamation units are transportable, further increasing their outreach.

Some private companies like Godrej have taken initiatives to retrofit old refrigerators with new kits to use non-ODS hydrocarbon refrigerants. The kit was subsidized considerably with the help of funding from GTZ and MLF. This program has just been launched as a pilot project.

There is no ODS destruction facility in India currently. The nearest destruction facility is located in Indonesia. There are no regulations that prevent export of ODS to other countries, but a license is required.

Ozone Cell also set up a National Halon Reclamation and Banking Facility in 2004. The Facility prepared a comprehensive database of halon kept in stock by some of the large users, such as oil companies and power plants. Furthermore, it provided facilities for the purification and reclamation of halon in the form of liquefied compressed gas (LCG). The Facility also prepared educational material for training halon users for better management and established a panel of experts to determine the essential uses of banked halon.

The most important part of this halon banking and recycling program was the recovery and purification facility, established with help from Australia and Canada. This system was envisioned to enable parties with unused and poorly stored halons, to properly decommission systems or cylinders, which could then be purified and reused. The banking arrangement enabled a parties having unwanted halon to sell it to those who need it for critical uses, thereby ensuring proper handling and disposition. In practice, however, the initiative did not meet much success due to a lack of initiatives by producers and a lack of regulations or procedures to support a well managed supply chain. Hence, a large quantity of halon is still stocked in old fire extinguishing systems and hand held devices, awaiting recovery, and subsequent reclamation or destruction.

3.4 Costs

The cost of recovered / reclaimed CFCs is approximately INR 400 per kilogram (GTZ).

3.5 Statistics on Collection

Exhibit VIII-2: Total CFC recovery/reclamation details for India under NCCoPP

Application	Quantity of CFCs per Piece of Equipment (grams)	Total CFC Recovered (metric tons)	Total Amount of CFC Recovered and Reused (metric tons)
Domestic Refrigeration	100	34	NA
Commercial refrigeration	200	22	NA
Mobile Air Conditioning	400	24	NA
Open Type Compressors	1000	4	NA
Total		83	67

3.6 Lessons Learned

- Reclamation units need to be mobile for increasing their outreach and business.
- Recovery and reclamation should be delinked. When providing licenses for the ODS reclamation units, the units should be licensed to sell ODS as well. This will ensure that reclamation units can purchase contaminated ODS from servicing companies, reclaim/recycle it, and sell it back to the servicing units, rather than the servicing units attempting reclamation of the ODS.
- Infrastructure needs to be provided for collection of ODS as transportation costs become problematic for a vast country like India.

4. Improving the Management of Unwanted ODS: Challenges and Opportunities

4.1 Challenges

- There is lack of awareness and information amongst consumers about the impact of ODS on the ozone layer, about recovery and recycling, and about drop-in substitutes and alternative refrigerants. More information needs to be provided to consumers regarding the economic and environmental benefits of the recovery/reuse of ODS over using virgin CFCs for servicing equipment.
- The modifications required for facilities (cement kilns, electric arc furnaces, and municipal waste incinerators) in order to create destruction facilities in India may be too costly.
- There are logistical difficulties associated with collecting and transporting unwanted ODS for a vast country like India.
- Very few enterprises in India handle more than 500 kilograms per year of CFC (Devotta et. al.) and most of them have a turnover of less than INR 0.5 million. Recovery and recycling (R&R) is not economically attractive for small work shops and low-volume refrigerant vendors unless the R&R units are subsidized. The volume of CFC recovered from the Indian RAC service sector may be low, and the process can be time consuming, further discouraging recovery.
- A manufacturer responsibility system may not work in India due to a lack of government regulations. Manufacturers will not be ready to bear the burden of the ODS recovery without financial support from the government.

4.2 Opportunities

Legal incentives

- National policies need to be formulated for R&R, reclamation, and destruction using international best practices.
- Direct regulations may not work in an Article 5 country like India, but certification programs for R&R systems and operators is required, along with continuous monitoring and review of the program.
- Current gas cylinder rules do not permit the filling of cylinders, while R&R requires the filling of recovered refrigerant into temporary cylinders for transportation. Rules need to be changed in order to facilitate servicing and to allow recovery cylinders.
- Indian standards need to be developed by Bureau of Indian Standards (BIS) to assist the RAC industry in evaluating the quality of refrigerants and the performance of refrigerant R&R equipment.

Training and awareness programs

- Consumer and technician awareness needs to be built for the responsible disposal of unwanted ODS and to make them understand their role in preserving the ozone layer.
- A comprehensive training program needs to be provided to service technicians
- Service technicians need to be provided with R&R equipments, across the country
- Training needs to be provided to scrap metal collectors (as most of the unused equipment is sold to scrap metal collectors for recycling metals and plastic) in handling unwanted ODS and safe disposal.

Financial incentives

- Innovative financial incentives and subsidies are important for India as the R&R systems are quite expensive, especially considering the low CFC handling capacities of servicing stations.
- Low interest loans for the purchase of R&R equipment, import duty exemptions on R&R equipment, a deposit-refund system for CFCs, and R&R equipments on hire can all help to reduce the operating costs.
- Programs like exchanging of used refrigerants for non-CFC refrigerants, exchanging excess refrigerants for cash, cylinder pick-up and delivery, cheap R&R facilities, and other similar incentives for end users will all help to reduce consumption of CFCs.
- Rebates can be offered to technicians for the amount of ODS recovered or recycled. This will not be difficult as they currently report annual quantities reclaimed or recovered to Ozone Cell.
- An expansion of the pilot program that retrofits refrigerators with non-ODS refrigerants, using kits, would be very useful.

Formulating a recycling/reclamation and destruction strategy

- It will be important to identify high CFC consumption zones and sectors and then to sketch a recycling/reclamation plan giving priority to large CFC consuming regions and targeting sectors with high ODS recovery potential.
- In the domestic refrigeration sector, the CFC-12 charge quantity per unit is very small, thus R&R may not be a cost-effective option unless a fee is levied. Commercial, industrial, and mobile air conditioning units need to be targeted as they have a high growth rate and the average charge quantity is high.

- A regional ODS destruction facility with ODS collection infrastructure should be established, taking into consideration CFC consumption patterns and logistical details.
- Decentralizing R&R systems – service workshops needs to be equipped with R&R units. Mobile R&R equipments will help in recycling at the customer's premises, thus avoiding transportation costs of large refrigeration units.
- ODS destruction facilities need to be established to destroy the contaminated ODS that cannot be recycled. If an ODS destruction facility is established in India, then neighboring countries like Bhutan and Nepal would also use the facility for destruction, as there are no ODS destruction facilities anywhere in the subcontinent and the countries face the same problem of disposing of contaminated ODS.

Appendix C: Surveys

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Survey on Appliances for Non-Article 5 Countries

ICF INTERNATIONAL

Collection and Treatment of Unwanted ODS:

Questionnaire for Non-Article 5 Countries Selected for Field Visits

Part A: Refrigerated Appliances

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INTRODUCTION

As CFCs and other ozone-depleting substances (ODS) are phased out of production, large stocks of equipment containing these substances—especially refrigeration and air-conditioning equipment—continue to be used worldwide. As these equipment reach the end of their useful lifetimes, it is important that the remaining refrigerant charge contained in equipment components be fully recovered for recycling/ reclamation or disposal. From a market perspective, the recycling/reclamation of ODS refrigerant will likely be essential to satisfy after-market servicing demand in Article 5 countries post-2010 (to avoid shortfalls). From an environmental perspective, the destruction of 1) unusable or 2) unwanted refrigerant will be essential to avoid venting of unwanted/unusable ODS to the atmosphere.

To obtain comprehensive knowledge from non-Article 5 countries that will be used as a guide by Article 5 countries to establish appropriate management systems for the treatment of unwanted ODS, ICF International (ICF) has been contracted by the Multilateral Fund Secretariat to conduct a study. The final contract specifies that your country will be visited by ICF to obtain information regarding the management systems for the treatment of unwanted ODS. Country visits will occur in the Autumn of 2007.

PURPOSE

This questionnaire was designed by ICF to obtain general knowledge from your country and other non-Article 5 countries that will be used as a guide by Article 5 countries to establish appropriate management systems for the treatment of appliances containing unwanted ODS. More specifically, this questionnaire aims to elicit insight into what and how appliance collection and disposal procedures have been implemented successfully, and what framework conditions (cultural, legal, economic) may be required for different approaches to succeed elsewhere–particularly in Article 5 countries.

Note that this questionnaire is intended to solicit *basic* information in order to provide a starting point for future, more detailed discussions to be held between ICF and key stakeholders during country visits.

INSTRUCTIONS

This questionnaire is intended to capture information regarding all relevant program(s) and procedure(s) in place in your country for collecting and destroying ODS contained in refrigerated appliances—including refrigerators, freezers, air conditioners, and dehumidifiers. Accordingly, disparate information may need to be collected from various stakeholders (e.g., electric utilities, municipal governments) depending on the structure of the programs/procedures in place. Depending on the number and complexity of programs/procedures in place in your country, you may wish to submit several copies of this questionnaire, each covering a specific program/procedure.

Submission

Please complete this survey by **September 28, 2007**, and return to **Mr. Mark Wagner** at:

Email: Unwanted_ODS@icfi.com
Fax +1-202-862-1144
Address: ICF International
1725 Eye Street, NW, Suite 1000
Washington, DC, 20006 USA

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

General Description of Procedures for Collecting Appliances and Handling ODS Contained in Appliances

Please describe the procedures in place in your country for collecting refrigerated appliances and recovering and treating ODS contained in appliances by checking all boxes that apply and providing explanatory text in the space below.

1. Description of Program

☐ Voluntary government program
☐ Mandatory government program
☐ Voluntary industry initiative
☐ Other (specify:)

Additional Explanation:

2. Operating Entities (i.e., who runs the program?)

☐ National government
☐ Local/municipal governments
☐ Equipment manufacturers
☐ Electric utilities
☐ Industry organization (specify:)
☐ Industry/government (specify:)
☐ Other (specify:)

Additional Explanation:

3. Drivers for Establishing Appliance Collection Program

☐ Regulatory requirement related to reducing ODS emissions
☐ Regulatory requirement related to the treatment of waste
☐ Energy savings
☐ Other (specify:)

Additional Explanation:

4. Program Scope

4a. What is the geographical scope of the appliance collection program (e.g., appliances are collected from one major municipality, several provinces, nationwide)?

4b. What refrigerated appliances are collected under the program (e.g., refrigerators, freezers, room air-conditioning units)?

4c. Additional Explanation:

Detailed Procedures: How Appliances Are Handled

Please describe the path that refrigerated appliances follow, outlining where appliances are generally taken and by whom they are generally handled from the point where they leave the consumer to the point where they are disassembled. If several programs or procedures are in place, please provide a separate description of each. Please describe each of the following steps in your response:

5. Consumer Disposal

For example, how do consumers dispose of refrigerated appliances? Do they bring the appliance to a central location or is appliance pick-up available?

5a. Description:

5b. Size of Consumer Population Served (number of households):

5c. Geographical Area Served:

5d. Entities Involved and Specific Roles Played:

5e. Contacts for Entities Involved (name, phone, email):

6. Appliance Collection and Storage

For example, what entities collect refrigerated appliances and through what means? Are appliances transported to a centralized storage facility or several semi-centralized facilities before being disassembled? If so, what is the average and maximum distances they are transported?

6a. Description:

6b. Average Distance Appliances are Transported for Storage (in kilometers):

6c. Maximum Distance Appliances are Transported for Storage (in kilometers):

6d. Entities Involved and Specific Roles Played:

6e. Contacts for Entities Involved (name, phone, email):

7. Appliance Disassembly and ODS Collection

For example, are there several facilities that disassemble refrigerated appliances or one centralized facility that processes all appliances? What is the approximate ratio of disassembly facilities to households served?

7a. Description:

7b. Average Approximate Distance Appliances are Transported from Storage to Disassembly Facilities (in kilometers):

7c. Ratio of Disassembly Facilities to Households Served:

7d. Entities Involved and Specific Roles Played:

7e. Contacts for Entities Involved (name, phone, email):

Legal Framework
Please describe the legal framework in place pertaining to the treatment of ODS-containing appliances at end of life in the space below.
8. Describe any laws in place that govern the treatment of ODS-containing appliances at time of disposal (e.g., laws prohibiting venting of refrigerant).
9. Describe any laws in place that assign responsibility for the disposal of ODS-containing appliances to specific stakeholders. For example, are local governments mandated to perform a certain administrative role (such as collecting appliances separate from general waste), or are appliance retailers/manufacturers mandated to provide take-back programs?
10. Describe any other government influences that have shaped the programs/processes in place in your country for properly disposing of appliances (e.g., voluntary programs to encourage industry to responsibly dispose of refrigerated appliances).

Treatment of ODS Refrigerant

Please describe the procedures in place in your country for handling ODS refrigerant recovered from appliances by checking all boxes that apply and providing explanatory text in the space below.

11. Refrigerant Reclamation (Recycling)

11a. Is refrigerant reclaimed (recycled)?

- ☐ Yes, in-country
- ☐ Yes, in another country (specify:)
- ☐ No (specify:)
- ☐ Other (e.g., it is stored indefinitely) (specify:)

11b. On average, how far must ODS refrigerant be transported from the facility where it is recovered to the facility where it is reclaimed (in kilometers)?

11c. How long is ODS refrigerant typically stored before being reclaimed (in days)?

11d. Where is ODS refrigerant typically stored before being reclaimed?

11e. Please provide contact information for the reclamation facilities involved (name, phone, email).

12. Refrigerant Destruction

12a. Is refrigerant destroyed?

- ☐ Yes, in-country
- ☐ Yes, in another country (specify:)
- ☐ Other (e.g., it is stored indefinitely) (specify:)

12b. On average, how far must ODS refrigerant be transported from the facility where it is recovered to the facility where it is destroyed?

12c. How long is ODS refrigerant typically stored before being destroyed?

12d. Where is ODS refrigerant typically stored before being destroyed?

12e. What technologies are used for destruction of refrigerant (please check all that apply)?

- ☐ Cement kilns
- ☐ Argon Plasma Arc
- ☐ Nitrogen Plasma Arc
- ☐ Reactor Cracking
- ☐ Rotary Kiln Incineration
- ☐ Liquid Injection Incineration
- ☐ Gaseous/Fume Oxidation
- ☐ Microwave Plasma
- ☐ Inductively Coupled Radio Frequency Plasma
- ☐ Gas Phase Catalytic Dehalogenation
- ☐ Superheated Steam Reactor
- ☐ Other (specify:)

12f. Please provide contact information for the refrigerant destruction facilities involved (name, phone, email).

Treatment of ODS Foam

Please describe the procedures in place in your country for handling ODS foam contained in appliances by checking all boxes that apply and providing explanatory text in the space below.

13. Is foam recovered from the appliances?

☐ Yes (specify procedure used:)

☐ No; foam is:
- ☐ Shredded
- ☐ Incinerated
- ☐ Landfilled

14. If foam is recovered, is the blowing agent contained in the foam destroyed or reclaimed?

☐ Destroyed (specify technology used:)

☐ Reclaimed (specify technology used:)

15. On average, how far must ODS foam blowing agent be transported from the facility where it is recovered to the facility where it is destroyed/reclaimed?

16. How long is ODS foam blowing agent typically stored before being destroyed?

17. Where is ODS foam blowing agent typically stored before being destroyed?

18. Please provide contact information for the foam recovery and destruction/reclamation facilities involved (name, phone, email).

Financing and Incentives

In the spaces below, please describe the annual cost and source of financing for appliance collection/disposal, as well as any incentives or disincentive for participation in the program. Please also provide additional cost information, as available—such as the cost per kilogram for reclaiming or destroying refrigerant. For all responses, please indicate the currency in which costs are provided.

19. Total Appliance Collection/Disposal Costs

19a. What is the total annual cost associated with appliance collection/disposal programs, and what entity(ies) incur(s) this cost? If possible, please specify the approximate number of appliances associated with this cost. If disaggregated data is available on the cost of individual program components (e.g., appliance collection, transportation of appliances, disassembly, ODS recovery, destruction, and/or reclamation), please specify.

19b. Are any fees charged to entities to offset the costs of the programs/procedures? For example, are appliance owners charged a fee at time of appliance collection, or appliance manufacturers charged an upfront fee as part of producer responsibility laws? If so, please specify the amount the entities must pay and to which entities those fees go.

19c. If no fees are charged, please describe how the appliance collection/disposal program or procedures are funded. If different components of the program (e.g., appliance collection, transportation, disassembly, and handling of ODS) are funded differently, please describe.

20. Incentives

What, if any, incentive is offered to appliance owners to dispose of their appliances through the programme? How is the cost of the incentive covered?

21. Disincentives

Are there any disincentives for non-participation in the appliance collection program, such as law enforcement (e.g., criminal penalties such as fines or prison time)? If so, please describe the disincentives and the entities for whom they apply (e.g., are fines assessed for appliance dismantlers who fail to destroy the ODS refrigerant, or are there penalties for consumers who fail to turn in their appliances?).

22. Other Relevant Cost Information (such as the cost per kilogram to reclaim or destroy refrigerant)

23. Additional Comments on Financing and Incentives

Outcomes

Please complete the questions below related to the outcomes of programs/processes in place for the collection and disposal of ODS-containing appliances.

24. How many refrigerated appliances have been collected each year? Please complete the table below to the best of your ability.

Appliance Type	Number of Units							
	2000	2001	2002	2003	2004	2005	2006	2007
Refrigerators								
Freezers								
Window Air Conditioners								
Dehumidifiers								
Other (please specify:)								

25. How many units of each appliance type do you anticipate will be collected per annum in the future?

Appliance Type	Number of Units		
	2008	2009	2010
Refrigerators			
Freezers			
Window Air Conditioners			
Dehumidifiers			
Other (please specify:)			

26. In total, how many refrigerated appliances are generated each year within your program's territory? (Please specify number by appliance type, if known)
27. Of the total number of appliances disposed of by consumers within the given territory each year, what percent of those units are collected by your program?
28. Of the total number of appliances disposed within your program's territory each year (whether collected through your program or not), what percent have the ODS refrigerant recovered?
29. Of the total number of appliances disposed within your program's territory each year (whether collected through your program or not), what percent have the ODS foam recovered?
30. What is the average amount of refrigerant and foam that is recovered per appliance?

Appliance Type	Average Amount per Appliance (kg)	
	ODS Refrigerant	ODS Blowing Agent in Foam
Refrigerators		
Freezers		
Window Air Conditioners		
Dehumidifiers		

What Has Worked and What Hasn't?
The questions below aim to elicit insight into what and how appliance collection and disposal procedures have been implemented successfully in your country, to help advise Article 5 countries on how best to establish management systems for the treatment of appliances containing unwanted ODS.
31. Is the effectiveness of the program/procedures assessed? If so, what measures/metrics of success are used and what entity carries out the assessment? Please attach a copy of any past assessment reports or summarize the findings below.
32. In what areas have the program/procedures achieved success (i.e., the stated goals)? In these areas, what have been the keys to success?
33. In what areas have the program/procedures NOT achieved success (i.e., the stated goals)? For example, has the program been successful in collecting ODS but not destroying it?
34. What could be done to improve the success of the program/procedures?
35. Do any external factors divert appliances disposed within your program's territory from being channelled through your program, which may ultimately undermine the recovery of ODS refrigerant from disposed appliances? For example, do economic factors cause appliances to end up in the hands of scrap metal recyclers that may not recover ODS refrigerant from appliances?
36. What could be done to better ensure that appliances are channelled through your program to guarantee refrigerant recovery at end-of-life?
37. Apart from the current program/processes in place, have any other approaches been implemented for the collection and disposal of appliance in the past and considered unsuccessful (e.g., different incentive structures)?
38. Are stakeholders generally supportive of the program(s)? Please describe experiences that show supportive and non-supportive stakeholder behavior (be as specific as possible).
39. Has the current legal framework led to the establishment of effective processes for ensuring the proper treatment of ODS-containing appliances in your country? Have any lessons been learned with regard to how the legal framework should best be structured?
40. Additional Comments

Conditions Critical for Success
The questions below aim to elicit insight into what conditions may be required for successful appliance collection/disposal approaches to succeed in Article 5 countries.
41. What framework conditions—demographic, geographical, cultural, legal and economic—may be required for similar programs/procedures to succeed elsewhere, particularly in Article 5 countries? (E.g., centralized service population, strict regulatory environment, consumer education.)
42. What infrastructure would be required for similar programs/procedures to succeed elsewhere–particularly in Article 5 countries? (E.g., existing hazardous waste handling procedures, access to destruction facilities.)
43. From capacity and legal standpoints, could Article 5 countries make use of existing infrastructure in your country, such as ODS destruction technologies? Please consider any restrictions on hazardous waste shipment, such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

Survey on Bulk ODS for Non-Article 5 Countries

Collection and Treatment of Unwanted ODS:

Questionnaire for Non-Article 5 Countries Selected for Field Visits

Part B: Bulk ODS

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INTRODUCTION

As CFCs and other ozone-depleting substances (ODS) are phased out of production, large amounts of these substances continue to be used worldwide. ODS used in commercial refrigeration and air-conditioning equipment (e.g., chillers) must be fully recovered for recycling/reclamation or destruction to prevent emissions of these substances. Stockpiles of unused (virgin) ODS also need to be properly handled. The treatment of such ODS, referred to as bulk ODS, must be carefully planned from both a market perspective and an environmental perspective. From a market perspective, the recycling/reclamation of ODS will likely be essential to satisfy after-market servicing demand in Article 5 countries post-2010 (to avoid shortfalls). From an environmental perspective, the destruction of 1) unusable or 2) unwanted refrigerant will be essential to avoid venting of unwanted/unusable ODS to the atmosphere.

To obtain comprehensive knowledge from non-Article 5 countries that will be used as a guide by Article 5 countries to establish appropriate management systems for the treatment of unwanted bulk ODS, ICF International has been contracted by the Multilateral Fund Secretariat to conduct a study. The final contract specifies that your country will be visited by ICF to obtain information regarding the management systems for the treatment of unwanted ODS. Country visits will occur in the Autumn of 2007.

PURPOSE

This questionnaire was designed by ICF to obtain general knowledge from your country and other non-Article 5 countries that will be used as a guide by Article 5 countries to establish appropriate management systems for the treatment of unwanted bulk ODS. More specifically, this questionnaire aims to elicit insight into what and how ODS collection and destruction procedures have been implemented successfully, and what framework conditions (cultural, legal, economic, etc.) may be required for different approaches to succeed elsewhere–particularly in Article 5 countries.

Note that this questionnaire is intended to solicit *basic* information in order to provide a starting point for future, more detailed discussions to be held between ICF and key stakeholders during country visits.

INSTRUCTIONS

This questionnaire is intended to capture information regarding all relevant program(s) and procedure(s) in place in your country for collecting and destroying bulk ODS. Please note that while some of the questions in this survey are similar to those in the questionnaire on Collection and Destruction of ODS from Refrigerated Appliances, this survey is designed to solicit information on program(s) and procedures(s) in place to handle bulk ODS, i.e., ODS contained in cylinders or other containers—not ODS contained in appliances. For the purposes of this survey, **bulk ODS includes stockpiles of virgin (unused) or reclaimed ODS, as well containers of used ODS that has been recovered from equipment during service or disposal events (e.g., by technicians).**

Note that disparate information may need to be collected from various stakeholders (e.g., refrigeration and air-conditioning equipment servicing contractors, refrigerant manufacturers, owners of large refrigeration and air-conditioning equipment such as chillers) depending on the structure of the programs/procedures in place. Depending on the number and complexity of programs/procedures in place in your country, you may wish to submit several copies of this questionnaire, each covering a specific program/procedure.

SUBMISSION

Please complete this questionnaire by **September 28, 2007**, and return to **Mr. Mark Wagner** at:

Email: Unwanted_ODS@icfi.com
Fax: +1-202-862-1144
Address: ICF International
1725 Eye Street, NW, Suite 1000
Washington, DC, 20006 USA

Contact Information

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

General Description of Procedures for Collecting and Treating Bulk ODS

Please describe the procedures in place in your country for collecting and treating bulk ODS by checking all boxes that apply and providing explanatory text in the space below.

1. Description of Program

☐ Voluntary government program

☐ Mandatory government program

☐ Voluntary industry initiative

☐ Other (specify:)

Additional Explanation:

2. Operating Entities (i.e., who runs the program?)

☐ National government

☐ Local/municipal governments

☐ Equipment manufacturers

☐ Electric utilities

☐ Industry organization (specify:)

☐ Other (specify:)

Additional Explanation:

3. Drivers for Establishing Bulk ODS Collection and Treatment Program

☐ Regulatory requirement related to reducing ODS emissions

☐ Regulatory requirement related to the treatment of waste

☐ Other (Specify:)

Additional Explanation:

4. Programme Scope

What is the geographical scope of the ODS collection program (e.g., ODS are collected from servicing contractors in one major municipality, several provinces, nationwide)?

Detailed Procedures: How Bulk ODS Is Handled

Please describe the path that bulk ODS (i.e., ODS collected from commercial equipment by servicing technicians) follows, outlining where ODS is taken and by whom it is generally handled from the point that the ODS is collected to the point where it is reclaimed or destroyed. If several programs or procedures are in place, please provide a separate description of each. Please address the following steps in your response:

5. ODS Collection and Storage

For example, how is bulk ODS collected from servicing contractors and other owners of bulk ODS? Are ODS transported to a centralized storage facility or several semi-centralized facilities before being reclaimed/destroyed?

5a. Description:

5b. Geographical Area Served:

5c. Average Approximate Distance ODS is Transported for Storage (in kilometers):

5d. Maximum Distance ODS is Transported for Storage (in kilometers):

5e. Entities' Roles and Responsibilities:

5f. Contacts for Entities Involved (name, phone, email):

6. ODS Processing: Reclamation or Destruction

For example, are there several facilities that reclaim and/or destroy bulk ODS?

6a. Description:

6b. Average Approximate Distance Appliances are Transported from Storage to Reclamation/Destruction Facilities (in kilometers):

6c. Maximum Distance Appliances are Transported from Storage to Reclamation/Destruction Facilities (in kilometers):

6d. Entities' Roles and Responsibilities:

6e. Contacts for Entities Involved (name, phone, email):

Legal Framework
Please describe the legal framework in place pertaining to the treatment of bulk ODS at end of life in the space below.
7. Describe any laws in place that govern the treatment of bulk ODS (e.g., laws prohibiting venting of refrigerant).
8. Describe any laws in place that assign responsibility for the disposal of bulk ODS to specific stakeholders. For example, are local governments mandated to perform a certain administrative role (such as collecting bulk ODS for reclamation or destruction)?
9. Describe any other government influences that have shaped the programs/processes in place in your country for recovering and destroying bulk ODS (e.g., voluntary programs).

Treatment of ODS

Please describe the procedures in place in your country for collecting bulk ODS and reclaiming/disposing of that ODS by checking all boxes that apply and providing explanatory text in the space below.

10. ODS Reclamation (Recycling)

10a. Is ODS reclaimed (recycled)?

- ☐ Yes, in-country
- ☐ Yes, in another country (specify:)
- ☐ Sometimes, depending on the purity level (specify purity threshold:).
- ☐ No (specify:)
- ☐ Other (e.g., it is stored indefinitely) (specify:)

10b. On average, how far must ODS be transported from the facility where it is stored to the facility where it is reclaimed (in kilometers)?

10c. How long is ODS typically stored before being reclaimed (in days)?

10d. Where is ODS typically stored before being reclaimed?

10e. Please provide contact information for the reclamation facilities involved (name, phone, email).

11. ODS Destruction

11a. Is ODS destroyed?

- ☐ Yes, in-country
- ☐ Yes, in another country (specify:)
- ☐ Sometimes, depending on the purity level. Please specify purity threshold:
- ☐ No (specify:)
- ☐ Other (e.g., it is stored indefinitely) (specify:)

11b. On average, how far must ODS be transported from the facility where it is stored to the facility where it is destroyed (in kilometers)?

11c. How long is ODS typically stored before being destroyed (in days)?

11d. Where is ODS typically stored before being destroyed?

11e. What technologies are used for destruction of ODS (please check all that apply)?

- ☐ Cement kilns
- ☐ Nitrogen Plasma Arc
- ☐ Argon Plasma Arc
- ☐ Reactor Cracking
- ☐ Rotary Kiln Incineration
- ☐ Gaseous/Fume Oxidation
- ☐ Inductively Coupled Radio Frequency Plasma
- ☐ Microwave Plasma
- ☐ Liquid Injection Incineration
- ☐ Gas Phase Catalytic Dehalogenation
- ☐ Superheated Steam Reactor
- ☐ Other (specify:)

11f. Please provide contact information for the ODS destruction facilities involved (name, phone, email).

Financing and Incentives

Please describe the annual cost and source of financing for the collection and treatment of bulk ODS, as well as any incentives or disincentive to encourage the recovery and collection of ODS. If you have additional cost information—such as the cost per kilogram for reclaiming or destroying ODS—please provide this information in the space below. For all responses, please indicate the currency in which costs are provided.

12. Total Collection/Disposal Costs

12a. What is the total annual cost associated with programs and procedures in place for collecting and treating bulk ODS, and what entity(ies) incur(s) this cost? If possible, please specify the approximate amount of ODS collected and reclaimed/destroyed for this cost. If disaggregated data is available on the cost of individual program components (e.g., ODS collection, transportation, destruction, and/or reclamation), also provide below.

12b. Are any fees charged to entities to offset the costs of the programs/procedures (e.g., charging a levy on the import of virgin ODS)? If so, please specify the amount entities must pay, and to which entities those fees go.

12c. If no fees are charged, please describe how ODS collection and treatment are funded. If different components of the program (e.g., ODS collection, transportation, and treatment) are funded differently, please describe.

13. Incentives

What, if any, incentive is offered to encourage disposal of bulk ODS through the program (e.g., a rebate on used refrigerant brought in)? How is the cost of the incentive covered?

14. Disincentives

Are there any disincentives for non-participation in the bulk ODS collection/destruction program, such as law enforcement (e.g., criminal penalties such as fines or prison time)? If so, please describe the disincentives and the entities for whom they apply (e.g., are fines assessed for refrigeration technicians who fail to recover ODS refrigerant at service events?).

15. Other Comments or Cost Information (such as the cost per kilogram to reclaim or destroy ODS)

Outcomes

Please complete the questions below related to the outcomes of programs/processes in place for the collection and disposal of bulk ODS.

16. What amount of bulk ODS has been collected each year? Please complete the table below to the best of your ability.

ODS Type	Kilograms Collected (Non-ODP Weighted)							
	2000	2001	2002	2003	2004	2005	2006	2007
CFC-11								
CFC-12								
HCFC-22								
Other (please specify:)								

17. What amount of bulk ODS do you anticipate will be collected per annum in the future (in non-ODP weighted kilogrammes)?

ODS Type	Kilograms Collected (Non-ODP Weighted)		
	2008	2009	2010
CFC-11			
CFC-12			
HCFC-22			
Other (please specify:)			
TOTAL			

18. Of the total amount of bulk ODS that is collected, what percent of that amount is reclaimable (e.g., meets the purity threshold, is not a blend)?

19. Of the total amount of bulk ODS that is collected, what percent of that amount is generally reclaimed?

20. Of the total amount of bulk ODS that is collected, what percent of that amount is generally destroyed?

What Has Worked and What Hasn't?
The questions below aim to elicit insight into what and how bulk ODS collection/destruction procedures have been implemented successfully in your country, to help advise Article 5 countries on how best to establish effective ODS management systems.
21. Is the effectiveness of the program/procedures assessed? If so, what measures/metrics are used and what entity carries out the assessment? Please attach a copy of any past assessment reports.
22. In what areas have the program/procedures achieved success (i.e., the stated goals)? In these areas, what have been the keys to success?
23. In what areas have the program/procedures NOT achieved success (i.e., the stated goals)? What could be done to improve the success of the program/procedures in these areas?
24. What challenges have the program/procedures faced in terms of collecting bulk ODS? What could be done to improve the success of the program in ensuring that ODS is recovered for reclamation or destruction?
25. Apart from the current ODS reclamation/destruction program(s) in place, have any other approaches been implemented in the past and considered unsuccessful (e.g., different incentive structures)?
26. Are stakeholders generally supportive of the program(s)? Please describe experiences that illustrate supportive and non-supportive stakeholder behavior (be as specific as possible).
27. Has the current legal framework led to the establishment of effective processes for ensuring the recovery and recycling/destruction of ODS in your country? Have any lessons been learned with regard to how the legal framework should best be structured to achieve this?
28. Additional Comments

Conditions Critical for Success
The questions below aim to elicit insight into what conditions may be required for successful ODS collection/destruction approaches to succeed in Article 5 countries.
29. What framework conditions—demographic, geographical, cultural, legal and economic—may be required for similar programs/procedures to succeed elsewhere, particularly in Article 5 countries? (E.g., centralized service population, strict regulatory environment, technician education.)
30. What infrastructure would be required for similar programs/procedures to succeed elsewhere–particularly in Article 5 countries? (E.g., existing hazardous waste handling procedures, access to destruction facilities.)
31. From capacity and legal standpoints, could Article 5 countries make use of existing ODS destruction facilities in your country? Please consider any restrictions on hazardous waste shipment, such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

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Survey for Article 5 Countries

Collection and Treatment of Unwanted ODS: Questionnaire for Article 5 Countries

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INTRODUCTION

As CFCs and other ozone-depleting substances (ODS) are phased out of production, large stocks of equipment containing these substances—especially refrigeration and air-conditioning equipment—continue to be used worldwide. As this equipment reaches the end of its useful lifetime, it is important that the remaining refrigerant charge contained in equipment components be fully recovered for recycling/reclamation or disposal. From a market perspective, the recycling/reclamation of ODS refrigerant will likely be essential to satisfy after-market servicing demand in Article 5 countries post-2010 (to avoid shortfalls). From an environmental perspective, the destruction of 1) unusable or 2) unwanted refrigerant will be essential to avoid venting of unwanted/unusable ODS to the atmosphere.

ICF International (ICF) has been contracted by the Multilateral Fund Secretariat to conduct a study to develop an information resource for Article 5 countries in efforts to establish appropriate management systems for the treatment of unwanted ODS.

PURPOSE

This questionnaire was designed by ICF to obtain general knowledge from your country and other Article 5 countries on the scope of the problem of unwanted ODS, the barriers faced in effectively managing unwanted ODS, and potential policy measures to address the problem. The information collected through these surveys will be used to inform a final report providing guidance and recommendations on the types of management systems that have been effective in non-Article 5 countries and could potentially be successfully replicated in Article 5 countries.

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 **October 29, 2007**, and return to **Mr. Mark Wagner** at:

Email: Unwanted_ODS@icfi.com
Fax: +1-202-862-1144
Address: ICF International
1725 Eye Street, NW, Suite 1000
Washington, DC, 20006 USA

Contact Information

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

General Information on Unwanted ODS

Please answer the questions below by checking all boxes that apply and providing explanatory text in the space below. Note the following definition of terms:

- Recovery: The collection and storage of ODS from machinery, equipment, containment vessels, or other sources, during servicing or prior to disposal.
- Recycling: The re-use of recovered ODS following a basic cleaning process, such as filtering and drying. Recycling of refrigerant is performed on-site using a machine and involves recharge back into equipment. Recycled ODS is not as pure as reclaimed ODS.
- Reclamation: The re-processing and upgrading of recovered ODS through mechanisms such as filtering, drying, distillation and chemical treatment in order to restore the substance to a specified standard of performance. Reclaimed refrigerant is essentially identical to new, unused refrigerant. Reclamation is performed off-site.

1. In your country, what are the main sources of unwanted ODS?

☐ ODS recovered during equipment servicing events (lack of recycling equipment prevents reuse)

☐ ODS recovered from or contained in disposed equipment (lack of reclamation facilities prevents reuse)

☐ Confiscated ODS that has been illegally imported

☐ Stockpiles of newly imported/produced and recovered ODS with no or very minimal end user demand

☐ Recovered ODS that has been mixed or contaminated such that reclamation is not technically or economically feasible

☐ Other (specify:)

Additional explanation:

2. In the past, has any unwanted ODS from your country been reclaimed or destroyed?

☐ Yes, reclaimed

If yes, where was reclamation performed?
☐ In-country
☐ Out-of-country; please specify where:

☐ Yes, destroyed

If yes, where was destruction performed?
☐ In-country
☐ Out-of-country; please specify where:

☐ No

If unwanted ODS has been reclaimed and/or destroyed:

2a. What type and amount of ODS was reclaimed and/or destroyed (e.g., 100 kg of halon destroyed)?

kg

2b. Please describe the processes by which the reclamation/destruction was undertaken (e.g., where was it conducted, what technologies were used?):

If no amount of unwanted ODS has been destroyed or reclaimed:

2c. Does your country have any plans to reclaim or destroy any unwanted ODS in future? Please describe.

3. In the past, has your country established procedures/programs for collecting and reclaiming/destroying unwanted ODS contained in appliances or in bulk (i.e., ODS contained in cylinders or other containers)?

☐ Yes. If yes, please be sure to complete the final section of this questionnaire on "Existing Management Practices for Unwanted ODS"

☐ No. If no, you may skip the final section of this questionnaire on "Existing Management Practices for Unwanted ODS"

4. How are appliances most often disposed of in your country?

Process used:

☐ Landfilled (whole) ☐ Mechanically-shredded ☐ Manually-disassembled

Treatment of ODS refrigerant:

☐ Recovered ☐ Not recovered

Treatment of ODS foam:

☐ Recovered ☐ Not recovered

Treatment of durable components:

☐ Metals recycled ☐ Glass recycled ☐ Plastics recycled ☐ No durable components recycled

Treatment of hazardous substances:

☐ PCBs removed and safely disposed ☐ Mercury removed and safely disposed ☐ Used oil removed and safely disposed ☐ No hazardous substances removed for safe disposal

Additional explanation:

Existing Legislation and Legal Barriers

Please describe the existing legislation in your country that is relevant for the collection and treatment of unwanted ODS by checking all boxes that apply and providing explanatory text in the spaces below.

5. In your country, is the deliberate atmospheric release (i.e., venting) of ODS legally prohibited or is such regulation pending or under consideration?

☐ Regulations are in place ☐ Regulations are pending ☐ Regulations are under consideration ☐ No such regulations are in place, pending or under consideration

Additional explanation:

6. Are you aware that recovery/reuse takes place in your country?

☐ Yes ☐ No

If yes, are significant quantities of ODS being recovered? And if so, is there any way to verify this?

7. What other legislation has been enacted in your country that could support a program to collect and treat unwanted ODS?

☐ Hazardous waste treatment laws ☐ Metal recycling laws (for ODS-containing appliances) ☐ Ban on disposable cylinders ☐ Other (specify:) ☐ None

Additional explanation:

8. In your country, is it legal to export ODS to another country for destruction or reclamation? If no, please describe the regulations that prevent the legal export of ODS for destruction (e.g., party to a multilateral, regional and bilateral agreement, such as the Bamako Convention or Waigani Convention).

☐ Yes ☐ No

Law(s) preventing ODS export:

9. What additional legal barriers, if any, does your country face vis-à-vis collecting and treating unwanted ODS? (e.g., status as non-party to Basel Convention means that Parties to the Convention cannot accept your country's exports of unwanted ODS)

Existing Infrastructure

Please describe the existing physical infrastructure in your country that could be used for the collection and treatment of unwanted ODS by checking all boxes that apply and providing explanatory text in the spaces below.

10. What infrastructure or logistical procedures exists in your country that could be used for collecting unwanted appliances that contain ODS?

☐ Municipal waste collection services
☐ Retailer delivery channels (appliance stores)
☐ Scrap metal recyclers
☐ Other (specify:)

Additional explanation:

11. What disposal facilities exists in your country that could potentially be used for destroying unwanted ODS (in bulk containers)?

☐ Municipal solid waste incinerators
☐ Cement kilns
☐ Electric arc furnaces
☐ Other (specify:)

Additional explanation:

12. What barriers may prevent the above types of facilities in your country from being used to destroy unwanted ODS?

☐ Costly modifications to facilities would be required
☐ Trial operation and measurements of key emission parameters would be required
☐ Operational and monitoring procedures not in place
☐ Training of operational staff at the disposal facility would be required
☐ Insufficient capacity for storing ODS in the short-term
☐ Environmental impact assessment would be required
☐ Quantity of unwanted ODS is insufficient for destruction to be economically viable
☐ Logistical difficulties associated with collecting and transporting ODS
☐ Disposal facility lacks sufficient capacity
☐ Other (specify:)

13. Are any ODS reclamation facilities located in your country?

☐ Yes
Please state where the facility(ies) is (are) located:

☐ No
Do you know in which country the nearest facility is located? If so, please specify where:

14. Are there any other foreseen barriers associated with utilizing existing infrastructure for collecting, reclaiming, and/or destroying unwanted ODS?

Challenges

A variety of challenges may be associated with the collection and treatment of unwanted ODS contained in appliances and in bulk. For example, some countries have such geographically dispersed populations that appliance collection from residences to a central recycling facility may not be economically feasible. In other countries, the high value of recycled metals has given rise to "scavengers" that strip metals and vent refrigerant from appliances before they can be collected and responsibly dismantled by certified appliance recyclers. In this section, please describe any such significant challenges faced by your country in effectively managing the collection and treatment of unwanted ODS.

15. Does your country face any challenges in regard to the effective collection and treatment of unwanted ODS contained in <u>appliances</u>? If so, please describe.

16. Does your country face any challenges in regard to the effective collection and treatment of unwanted ODS contained in <u>bulk</u>? If so, please describe.

17. Are there any other thoughts or issues of note in your country or region that should be considering in assessing how best to manage the collection and treatment of unwanted ODS?

Needs and Incentives

Please respond to the questions in this section by checking all boxes that apply and providing explanatory text in the spaces below.

18. What incentives may be most effective in your country for encouraging participation in a program to collect household refrigerated appliances from consumers?

17a. Legal incentives:

☐ No venting laws ☐ Manufacturer take-back laws ☐ Mandated municipal appliance collection services ☐ Other (specify:)

Additional explanation as to why the above incentives may or may not work:

17b. Financial incentives:

☐ Offer rebate to consumers for turn-in of old appliance ☐ Offer rebate for each kilogram of ODS sent for destruction/ reclamation ☐ Other (specify:)

Additional explanation as to why the above incentives may or may not work:

17c. Other incentives, please describe:

19. What may be an effective way to raise funds for an appliance disposal program in your country?

☐ Charge appliance owners a fee for appliance disposal ☐ Charge appliance manufacturers an upfront fee based on number of units produced ☐ Other (specify:)

Additional Explanation:

20. What incentives may be effective for encouraging the recycling/reclamation or destruction of unwanted ODS in your country?

19a. Legal incentives:

☐ No venting laws ☐ Other (specify:)

Additional explanation as to why the above incentives may or may not work:

19b. Financial incentives:

☐ Offer rebate to technicians for each kilogram of ODS brought for destruction/ reclamation ☐ Offer rebate to reclaimers and destruction facilities for each kilogram of ODS reclaimed/ destroyed ☐ Require deposit for turn-in of refillable cylinders ☐ Other (specify:)

Additional explanation as to why the above incentives may or may not work:

19c. Other incentives, please describe:

21. What may be an effective way to raise funds for an ODS collection/destruction program in your country?

☐ Tax on new refrigerant produced or imported ☐ Other (specify:)

Additional Explanation:

22. Additional comments for creating incentives to foster effective management of unwanted ODS:

Existing Management Practices for Unwanted ODS*

*To be completed only if management practices are currently in place

Please describe the procedures in place in your country for managing unwanted ODS by providing explanatory text in the spaces below.

Appliances Containing ODS

23. Please describe the procedures/programs in place to collect refrigerated appliances from consumers, including a brief explanation of how the program works and who runs it (e.g., national or local government, equipment manufacturers, electric utilities, industry associations).

24. Please describe the path that refrigerated appliances follow, outlining how appliances are collected from consumers, transported, and ultimately processed—and by whom.

25. Have the procedures/program in place been effective in collecting and treating refrigerated appliances? Please briefly describe what has worked, what hasn't worked, and what could be done to improve the program.

Bulk ODS

26. Please describe the procedures/programs in place to collect and process unwanted bulk ODS (e.g., in cylinders), including a brief explanation of how the program works and who runs it (e.g., national or local government, equipment manufacturers, electric utilities, industry associations).

27. Please describe the path that unwanted ODS follow, outlining how unwanted ODS is collected, transported, and ultimately reclaimed/destroyed—and by whom.

28. Have the procedures/program in place been effective in collecting and reclaiming/destroying unwanted ODS? Please describe what has worked, what hasn't worked, and what could be done to improve the program.

Thank you for your participation!

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Appendix D: List of Individuals Interviewed for this Report

Australia

- Steve Anderson, Executive Director, Refrigerants Australia
- Michael Bennett, Chief Executive, Refrigerant Reclaim Australia
- John Dickenson, Coffey Environments Pty Ltd
- Damien Hall, Department of the Environment and Heritage
- Brian Hobsbawn, Assistant Director, Department of the Environment and Heritage
- Chris Lindeman, Proprietor, Fluoroclaim
- Louise McCann, Senior Account Manager, A-Gas Pty Ltd
- Patrick McInerney, Director, Department of the Environment and Water Resources
- Kevin O'Shea, Cold Rae Pty. Ltd.
- Ian Rae, Professor of History and Philosophy of Science, University of Melbourne
- Greg Rippon, Department of the Environment and Heritage
- Steve Spurling, A-Gas Pty Ltd
- Andrew Tape, Senior Manager, Department of Defence
- Neville Taylor, Project Engineer, BCD Technologies
- Alan Woodhouse, Australian Refrigeration Council, Ltd.
- Barry Walker, Joint Managing Director, Solvents Australia Pty. Ltd.

Canada

- April Gucciardo, Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI)
- Warren Heeley, President, Refrigerant Management Canada
- Barry Nickers, Halifax Regional Municipality
- Nancy Seymour, Ozone Protection Programs, Chemicals Management Division, Environment Canada

Czech Republic

- Jakub Achrer, Ministry of the Environment of the Czech Republic
- Lada Dauschingerová, Praktik Systems, s. r. o.
- František Gregor, Ministry of the Environment of the Czech Republic
- Roman Hrdý, Chief Executive Officer, Esto Cheb Ltd.
- František Janda, General Director, Ekotez spol. s.r.o.
- Pavel Linhart, Senior Business Manager, Praktik Systems, s.r.o.
- Richard Masek, Elektrowin a. s.
- Vladimíra Sádecká, Business Director, Ekotez spol. s.r.o.

Germany

- Christoph Becker, RAL Gutegemeinschaft
- Olaf Böse, Plant Environmental Manager, Solvay Fluor
- Dr. Cornella Elsner, Umwelt Bundes Amt [UBA]
- Rolf Engelhardt, Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety
- Rudolf-Günter Fleischmann, Plant Operations Manager, Entsorgungsgesellschaft Niederrhein mbH [EGN Refrigerator Recycling]
- Dr. Ralf Herkelmann, Plant Manager, Solvay Fluor

- Ulrich Johann, Sales Agent International, RCN Chemie GmbH
- Andreas Neu, RCN Chemie GmbH
- Christiane Schnepel, Umwelt Bundes Amt [UBA]
- Martin Selt, Production Manager, Solvay Fluor
- Christian Spicker, Technical Expert for CFC Distillation Unit, RCN Chemie GmbH
- Juergen Usinger, Proxima
- Hans Peter Wickel, Plant Manager, Solvay Fluor

Japan

- Hiroaki Aoi, Japan Auto Recycling Partnership
- Norio Baba, Chief Manager, Japan Refrigeration and Air Conditioning Industry Association (JRAIA), Refrigerant Recovery Promotion and Technology Center (RRC)
- Hideo Endoh, Ministry of Economy, Trade, and Industry
- Masahito Fukami, Ministry of the Environment
- Ma Aye Aye Han, Kankyosoken Co., Ltd.
- Susumi Ishii, Chair of Operations, Japan Association of Refrigeration and Air Conditioning Contractors (JARAC), Refrigerant Recovery Promotion and Technology Center (RRC)
- Takeshi Ito, Deputy General Manager, Association for Electric Home Appliances (AEHA)
- Daishin Kashiwagi, Kankyosoken Co., Ltd.
- Makoto Kato, Japan Auto Recycling Partnership
- Kyoshi Katsuyama, Ministry of Economy, Trade, and Industry
- Shiro Kawanishi, Japan Refrigeration and Air Conditioning Industry Association (JRAIA), Refrigerant Recovery Promotion and Technology Center (RRC)
- Masashi Kondo, Ministry of the Environment
- Kazuaki Minato, General Manager, R Station Corporation
- Tahehiro Miura, President, R Station Corporation
- Satoshi Mizuta, Japan Association of Refrigeration and Air Conditioning Contractors (JARAC), Refrigerant Recovery Promotion and Technology Center (RRC)
- Tsuyoshi Nojima, Japan Auto Recycling Partnership
- Wataru Ono, Consultant, PREC Institute
- Yasuki Seyama, Deputy General Manager, Association for Electric Home Appliances (AEHA)
- Shinji Suzuki, Deputy Plant President, Kanto Eco Recycle Co., Ltd.
- Toshio Takada, Director, Kanto Eco Recycle Co., Ltd.
- Shinichiro Toyomura, Ministry of the Environment
- Katsuharu Uehara, President, Kanto Eco Recycle Co., Ltd.
- Rikii Wakabayashi, General Manager, R Station Corporation
- Yuji Yamaguchi, Ministry of the Environment
- Masayoshi Yamamoto, Japan Association of Refrigeration and Air Conditioning Contractors (JARAC), Refrigerant Recovery Promotion and Technology Center (RRC)
- Hitoshi Yoshizaki, Ministry of the Environment

United Kingdom

- Julie Ann Adams, Operations Manager, M Baker Recycling
- Elizabeth Chrominska, Policy Advisor, Department for Environment, Food, and Rural Affairs
- Davica Farrell-Evans, Assistant Policy Advisor (European Council liaison), Department for Environment, Food, and Rural Affairs
- Adrian Harding, Policy Advisor, Environmental Agency

- Alan Morgan, Senior Policy Advisor, Enterprise and Business Group, Department for Environment, Food, and Rural Affairs
- Andrew Slaney, Managing Director, M Baker Recycling

United States

- Michael Dunham, Director, Energy & Environmental Programs, JACO Environmental, Inc JACO Environmental, Inc.
- Tom Land, Stratospheric Protection Division, Office of Air and Radiation, U.S. Environmental Protection Agency (U.S. EPA)
- Richard Marcus, President, RemTec International
- Bruce Wall, Vice President, Appliance Recycling Centers of America (ARCA)

Colombia

- Angélica Antolínez, Unidad Técnica Ozono, Ministerio de Ambiente, Vivienda y Desarrollo Territorial
- César Buitrago Gómez, Director de Desarrollo Sectorial Sostenible, Ministerio de Ambiente, Vivienda y Desarrollo Territorial
- Florencia Leal del Castillo, Directora Ejecutiva, Cámara del Sector de Electrodomésticos, Asociación Nacional de Industriales (ANDI)
- Nestor Lopez, Dirección de Impuestos y Aduanas Nacionales de Colombia
- Nidia Mercedes Pabón Tello, Unidad Técnica Ozono, Ministerio de Ambiente, Vivienda y Desarrollo Territorial
- Antonio Orozco Rojas, Unidad Técnica Ozono, Ministerio de Ambiente, Vivienda y Desarrollo Territorial.
- Jorge Enrique Sánchez Segura, National Coordinator, Unidad Técnica Ozono, Ministerio de Ambiente, Vivienda y Desarrollo Territorial

India

- R.S. Agarwal, Professor of Mechanical Engineering, Indian Institutes of Technology, Delhi
- Dr. S. Satapathy, National Program Manager, Ozone Cell , Ministry of Environment and Forests
- Mr. Markus Wypior, Project Manager, GTZ

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Appendix E: Known Commercial ODS Destruction Facilities Worldwide

Commercial ODS destruction facilities using technologies approved by the TEAP are in operation in many countries worldwide. Based on information collected for this report, as well as other available information, such facilities are located in at least 20 countries, as shown in Exhibit E-1. While data on the ODS destruction capacities of these technologies are not complete, known destruction capacities for ODS range from roughly 40 to 600 MT/year. The cost to destroy ODS at these facilities varies by country, technology, capacity, and ODS type. Overall, however, ODS destruction costs range between roughly $2 and $13 per kilogram, with an average of roughly $7/kg. Information on the number and types of destruction technologies in use by country are summarized below, as well as associated destruction capacity and costs, where data are available.

In addition to the commercial ODS destruction facilities listed above, any existing cement kilns can be upgraded to destroy ODS as well. Indeed, the high temperatures required for cement production can destroy ODS and other hazardous wastes without having an effect on the cement produced (CKRC 2007). In the U.S. alone, there are 118 cement plants, 15 of which collectively destroy approximately 910,000 MT of hazardous waste each year (CKRC 2007). China and India, as the top two cement producers of the world (PCA 2008), are likely to have a high number of cement kilns which could potentially be prime targets for future ODS destruction.

In addition, there are a large number of known facilities capable of destroying polychlorinated biphenyls (PCBs)—one of the most difficult to destroy compounds. With modifications, these facilities are capable of destroying ODS to the destruction efficiencies required by TEAP. Rotary kiln incinerators, liquid injection incinerators, and cement kilns are all used for PCB destruction. According to a 1998 study prepared by the Inter-Organization Programme for the Sound Management of Chemicals (IOMC), in addition to ODS destruction capacity listed in Exhibit E-1, PCB destruction facilities were identified in a host of countries—including Brazil, Cameroon, China, Norway, Korea, and Mexico.

Exhibit E-1: ODS Destruction Facilities Worldwide

Country	Number of Known ODS Destruction Facilities in Operation	Technologies Utilized	ODS Destruction Capacity (except where indicated)*	Destruction Costs (US$)
1. Argentina	NA	NA	NA	NA
2. Australia	1	Argon Plasma Arc	600 MT/year	$7/kg
3. Austria	NA	NA	NA	NA
4. Belgium	NA	Rotary Kiln	NA	NA
5. Brazil	NA	Rotary Kiln	NA	NA
6. Canada	1	Rotary Kiln	~75 MT/year*	$12/kg
7. Czech Republic	1	Rotary Kiln	40 MT/year	NA
8. Denmark	> 3	NA	NA	NA
9. Finland	NA	Rotary Kiln	545 MT/year	NA
10. Germany	6	Hazardous Waste Incinerator Reactor Cracking	1,600 MT/year** (reactor cracking)	NA
11. Hungary	> 4	Rotary Kiln, Liquid Injection Incineration, among others	~75 MT/year* (rotary kiln)	NA
12. Indonesia	1	Cement kiln	Operating rate: 600 MT/yr	NA
13. Japan	80	Cement Kilns/Lime Rotary Kilns (7) Nitrogen Plasma Arc (8) Rotary Kiln Incineration/ Municipal Solid Waste Incinerators (24) Liquid Injection Incineration (7) Microwave Plasma (5) Inductively Coupled Radio Frequency Plasma (1) Gas-Phase Catalytic Dehalogenation (1) Superheated Steam Reactors (25) Solid-Phase Alkaline Reactor (1) Electric Furnace (1)	36 MT/yr (one catalytic facility) 2,600 MT/year** (one incinerator)	Rotary kilns: $4/kg Superheated steam: $5/kg Plasma arc: $9/kg Reactor cracking: $4-6/kg Gas Phase Catalytic Dehalogenation: $5-7/kg
14. Netherlands	> 2	NA	NA	NA
15. Poland	NA	NA	NA	NA
16. Sweden	> 3	Air Plasma, among others	100 MT/year (air plasma)	NA
17. Switzerland	> 4	Rotary Kiln, among others	910 MT/year** (rotary kiln) > 320 MT/year (others)	NA
18. United Kingdom	2	High-Temperature Incineration	NA	NA
19. United States	< 10	Rotary Kilns	318 MT/year (plasma arc)	$2 - $13/ kg

Country	Number of Known ODS Destruction Facilities in Operation	Technologies Utilized	ODS Destruction Capacity (except where indicated)*	Destruction Costs (US$)
		Plasma Arc Fixed Hearth Units Liquid Injection Units Cement Kilns Lightweight Aggregate Kilns	6,188,600 MT/year** (US total hazardous waste destruction capacity)	
20. Venezuela	NA	NA	NA	NA

NA= Not available.
* = Number represents approximate ODS destruction capacity based on known overall plant capacity and typical ODS feed rates for rotary kilns [to be confirmed].
** = Capacity is not specific to ODS; value shown refers to capacity for all hazardous wastes and/or other types of wastes.
Sources: Swan Hills Treatment Centre (2005), SITA CZ (2007), PT Holcim Indonesia TbK, TEAP (2002b), ICF International (2007), [others to be provided].

Appendix F: Information That Must Be Reported Under the Basel Convention

Information to be provided on notification

1. Reason for waste export
2. Exporter of the waste 1/
3. Generator(s) of the waste and site of generation 1/
4. Disposer of the waste and actual site of disposal 1/
5. Intended carrier(s) of the waste or their agents, if known 1/
6. Country of export of the waste

   Competent authority 2/
7. Expected countries of transit

   Competent authority 2/
8. Country of import of the waste

   Competent authority 2/
9. General or single notification
10. Projected date(s) of shipment(s) and period of time over which waste is to be exported and proposed itinerary (including point of entry and exit)3/
11. Means of transport envisaged (road, rail, sea, air, inland waters)
12. Information relating to insurance 4/
13. Designation and physical description of the waste including Y number and UN number and its composition 5/ and information on any special handling requirements including emergency provisions in case of accidents
14. Type of packaging envisaged (e.g. bulk, drummed, tanker)
15. Estimated quantity in weight/volume 6/
16. Process by which the waste is generated 7/
17. For wastes listed in Annex I, classifications from Annex III: hazardous characteristic, H number, and UN class
18. Method of disposal as per Annex IV
19. Declaration by the generator and exporter that the information is correct
20. Information transmitted (including technical description of the plant) to the exporter or generator from the disposer of the waste upon which the latter has based his assessment that there was no reason to believe that the wastes will not be managed in an environmentally sound manner in accordance with the laws and regulations of the country of import
21. Information concerning the contract between the exporter and disposer.

Notes

1/ Full name and address, telephone, telex or telefax number and the name, address, telephone, telex or telefax number of the person to be contacted.

2/ Full name and address, telephone, telex or telefax number.

3/ In the case of a general notification covering several shipments, either the expected dates of each shipment or, if this is not known, the expected frequency of the shipments will be required.

4/ Information to be provided on relevant insurance requirements and how they are met by exporter, carrier and disposer.

5/ The nature and the concentration of the most hazardous components, in terms of toxicity and other dangers presented by the waste both in handling and in relation to the proposed disposal method.

6/ In the case of a general notification covering several shipments, both the estimated total quantity and the estimated quantities for each individual shipment will be required.

7/ Insofar as this is necessary to assess the hazard and determine the appropriateness of the proposed disposal operation.

Information to be provided on the movement document

1. Exporter of the waste 1/
2. Generator(s) of the waste and site of generation 1/
3. Disposer of the waste and actual site of disposal 1/
4. Carrier(s) of the waste 1/ or his agent(s)
5. Subject of general or single notification
6. The date the transboundary movement started and date(s) and signature on receipt by each person who takes charge of the waste
7. Means of transport (road, rail, inland waterway, sea, air) including countries of export, transit and import, also point of entry and exit where these have been designated
8. General description of the waste (physical state, proper UN shipping name and class, UN number, Y number and H number as applicable)
9. Information on special handling requirements including emergency provision in case of accidents
10. Type and number of packages
11. Quantity in weight/volume
12. Declaration by the generator or exporter that the information is correct
13. Declaration by the generator or exporter indicating no objection from the competent authorities of all States concerned which are Parties
14. Certification by disposer of receipt at designated disposal facility and indication of method of disposal and of the approximate date of disposal.

Notes

The information required on the movement document shall where possible be integrated in one document with that required under transport rules. Where this is not possible the information should complement rather than duplicate that required under the transport rules. The movement document shall carry instructions as to who is to provide information and fill-out any form.

1/ Full name and address, telephone, telex or telefax number and the name, address, telephone, telex or telefax number of the person to be contacted in case of emergency.