

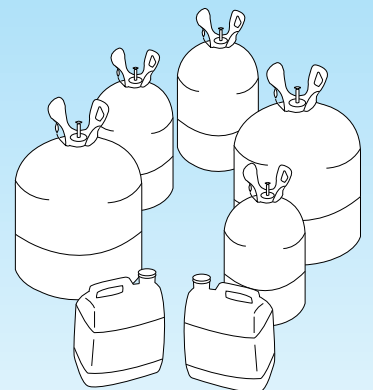
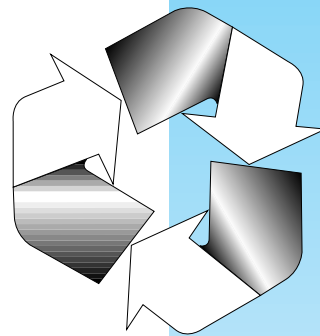


RECOVERY & RECYCLING SYSTEMS

GUIDELINES

Phasing out ODS in Developing Countries

REFRIGERATION SECTOR



Multilateral Fund for the Implementation
of the Montreal Protocol



United Nation Environment Programme
Division of Industry, Technology & Economics
OzonAction Programme



UNEP

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1999



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Foreword

Most CFCs in developing countries are used in refrigeration, and the majority of the consumption within the refrigeration sector is for maintenance and servicing of CFC-containing equipment. Poor servicing procedures and the absence of refrigerant recovery and recycling often lead to the emission of a significant proportion of the refrigerants directly into the atmosphere.

Use of CFCs

The ozone layer, high in the Earth's stratosphere, is vital to life on the planet's surface. It acts as a shield and prevents the harmful UV-radiation from reaching the Earth. In the 1970s scientists discovered that the released CFCs damage the ozone layer. In September 1987, nations around the world concerned about the depletion of the ozone layer signed the Montreal Protocol on Substances that Deplete the Ozone Layer, a landmark agreement that identified the major ozone-depleting substances (ODS) and established a timetable for the reduction and eventual elimination of their use world-wide.

Ozone layer protection

The consumption of CFCs has been phased out in developed countries by the beginning of 1996, except the about 10,000 tons required for essential uses. Developing countries are given a grace period, and from July 1999 their first control measure - the freeze on the production and consumption of Annex A CFCs at 1995-97 levels - has been effective. Total phase-out of CFCs in these countries is to be achieved by 2010.

Phase-out schedule

The phase-out of CFCs in the refrigeration sector in developing countries is best achieved through an integrated national strategy that addresses the key technical and policy issues – a 'Refrigerant Management Plan'. Such a plan includes – and prioritises – activities such as public awareness campaigns, training and certification of service technicians, conversion projects, establishment of refrigerant recovery and recycling (R&R) systems and suitable policy and regulatory support frameworks, improvement of data collection systems and control and monitoring of CFC consumption.

Phase-out strategy

The supply of R&R equipment and the establishment of R&R systems alone do not ensure the successful operation of such systems. They must be supported by regulatory structures involving command and control tools as well as incentives for the end-users.

The objective of these Guidelines is to help developing country governments and industry design and establish such R&R systems, and to operate them efficiently. The establishment of such R&R systems represents a cost-effective step in reducing the consumption of virgin CFC refrigerants without major capital investment, and in allowing existing CFC-based equipment to run until the end of its economic life.

Objective

Further publications These Guidelines are part of a series of self-help guides produced by UNEP's OzonAction Programme under the Multilateral Fund, in order to assist developing countries to implement the Montreal Protocol. They should be read and followed in conjunction with other similar publications prepared by the OzonAction Programme, specifically:

- ODS Import/Export Licensing Systems
Policy Design and Setting Up of Legislation [12]
- Guidebook on Implementation of Codes of Good Practices -
Refrigeration Sector [13]
- Training Manual on Good Practices in Refrigeration [3]
- Training Manual on Chillers and Refrigerant Management [4].

More information can be found on the World Wide Web at:
<http://www.unepie.org/ozonAction.html>.

Mr. Rajendra Shende, Chief
UNEP DTIE, Energy & OzonAction Unit

Keep in mind...

Much of the Montreal Protocol's success can be attributed to its ability to evolve over time to reflect the latest environmental information and technological and scientific developments. Through this dynamic process, significant progress has been achieved globally in protecting the ozone layer.

As a key agency involved in the implementation of the Montreal Protocol, UNEP DTIE's OzonAction Programme promotes knowledge management in ozone layer protection through collective learning. There is much that we can learn from one another in adopting the guidelines for recovery & recycling of ozone depleting substances.

The guidelines for recovery & recycling systems are neither comprehensive nor exhaustive. They are prepared based on limited experience in developed and developing countries. As more experience is gained, by the world community, the guidelines will become more and more extensive and effective.

We encourage you to share your experiences with the OzonAction Programme so that we can inform others involved in this issue about the lessons you learned. Send us an e-mail, fax or letter about your experiences and successes in recycling. We will consider it as an important part of collective learning.

Based on the feedback and information received, UNEP will update these guidelines on a periodic basis to reflect the latest developments. We will also disseminate your experiences through a variety of channels, including the OzonAction Newsletter and the OzonAction Programme's website (www.unepdtie.org/ozonaction.html). If we use the information you provide, we will send you a free copy of one of our videos, publications, posters or CD-ROMs as thanks for your cooperation.

So take a pen and write to us. Let us learn collectively to protect the ozone layer.

Energy & OzonAction Unit

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Common abbreviations

A/C	Air-conditioning
CFC	Chlorofluorocarbon
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
IBRD	International Bank for Reconstruction and Development
LVC countries	Low-volume-ODS-consuming countries
MAC	Mobile air-conditioning
MFS	Multilateral Fund Secretariat
NOU	National Ozone Unit
ODP	Ozone-depleting potential
ODS	Ozone-depleting substance
OZAP	OzonAction Programme
RMP	Refrigerant Management Plan
R&R	Recovery & Recycling
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP DTIE	UNEP Division of Technology, Industry and Economics
UNIDO	United Nations Industrial Development Organisation

1. Introduction to these Guidelines ...

Objectives

The objective of these Guidelines is to help developing country governments and industry design and establish Recovery & Recycling systems (together with related legislation), and to operate them efficiently. The establishment of such R&R systems represents a key step in reducing the consumption of virgin CFC refrigerants without major capital investment, and in allowing existing CFC-based equipment to run until the end of its economic life.

Design and establishment of R&R systems

Successful R&R systems will make recovered or recycled refrigerant available for reuse, which will reduce the need for virgin CFC refrigerants and allow existing CFC-based equipment to operate until the end of its economic life. This is particularly important as virgin CFC refrigerants become increasingly scarce and expensive – which they will do once the phase-out schedules required by the Montreal Protocol come into force, and imports of CFCs are controlled through licensing systems.

Reuse of CFCs

The long-term objective of these Guidelines is to eliminate CFC emissions to the atmosphere completely, and to contribute to a smooth transition to non-CFC technology within the refrigeration and air-conditioning sector.

Elimination of CFCs

Target groups

These Guidelines are aimed at:

- National Ozone Units (NOUs) and other relevant government institutions.
- Industry and trade associations.
- Managers and technicians from refrigeration service companies.
- Suppliers and wholesalers of refrigerants who are involved in the implementation and promotion of CFC recycling.
- Technical training institutes.

Scope

The Guidelines describe the design, establishment and operation of "Recovery and Recycling Systems" for CFC refrigerants, where:

- Recovery**
 - "Recovery" means the removal of refrigerant in any condition (vapour, liquid, or mixed with other substances) from a system and its storage in an external container.
- Recycling**
 - "Recycling" means the reduction of contaminants contained in used refrigerants by separating oil, removing condensables and using devices such as filter dryers to reduce moisture, acidity and particulates.

Reclamation or disposal In the case of contaminated refrigerants or mixtures, "reclamation" or "disposal" may be necessary. However, the reclamation and disposal of CFC refrigerants under current conditions is neither economically nor technically feasible at national level, and therefore not included in these Guidelines.

Refrigerant types The Guidelines focus on the three most common CFC refrigerants: CFC-11, CFC-12 and CFC-115 (as a component of the R-502 mixture). These are defined by the Montreal Protocol as 'Annex A Group 1' substances, and have their own phase-out schedule. Non-CFC refrigerants such as HCFCs, HFCs, hydrocarbons and other 'natural refrigerants' (e.g. carbon dioxide or ammonia) are not dealt with here.

Structure

- Chapter 2** *Chapter 2* describes how R&R systems can be put in place through Refrigerant Management Plans.
- Chapter 3** *Chapter 3* sets out in detail the steps necessary to plan, establish and operate R&R systems, and including monitoring and review.
- Chapter 4** *Chapter 4* deals with data collection, and contains forms for collecting data on existing equipment and consumption of refrigerants, and tools for calculating recycling potential.
- Chapter 5** *Chapter 5* describes the technical components of the different types of R&R systems for CFC refrigerants.
- Chapter 6** *Chapter 6* explains the factors, which need to be taken in to account when determining the feasibility and performance of R&R systems.
- Chapter 7** *Chapter 7* discusses the regulatory framework and the various legislative

options necessary to support the establishment of CFC recycling systems.

Annexes 1-4 include case studies of R&R systems in Ghana, Guatemala, Malaysia and Denmark. The information included was collected in 1997, and some figures, especially costs, have changed since. Further technical recommendations can be found in "Case Studies: Refrigerant Recovery and Recycling", UNEP, 1994 [1]. **Annexes 1-4**

Annex 5 contains a glossary with explanations and definitions of technical terms used in the Guidelines. **Annex 5**

Annex 6 lists further documents, which may be useful in establishing R&R systems – these are sometimes cross-referenced in the text. **Annex 6**

Annex 7 gives an introduction to UNEP DTIE's OzonAction Programme. **Annex 7**

Figure 1, on the following page, summarises how to use these Guidelines.

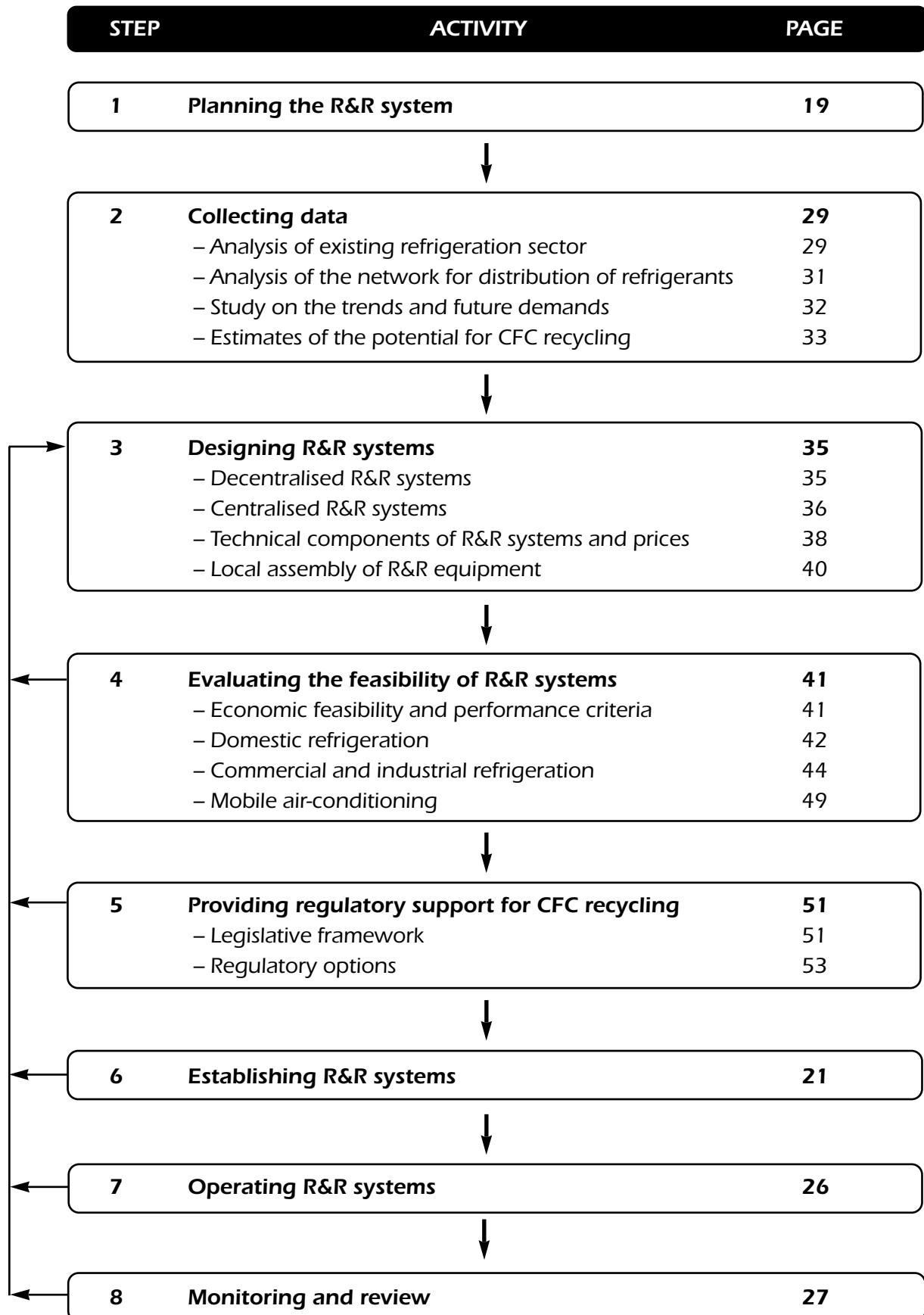


Figure 1: How to use the Guidelines.

2. Setting the Framework

In the past, the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol has approved numerous stand-alone R&R projects. However, the success of such projects depends on whether appropriate support measures accompany the project implementation in order to ensure their political, technical and economic viability and self-sufficiency. These accompanying measures may include the implementation of:

- Institutional Strengthening activities and a National Ozone Unit
- Import/export licensing system [12]
- Ban of import of equipment containing CFC
- Economic incentives and disincentive
- System for monitoring of ODS consumption and data reporting
- Codes of good practices in refrigeration [13]
- Ban of venting of or flushing with CFCs
- Industry association in the refrigeration sector
- Certification scheme for refrigeration technicians
- Disposal/destruction strategy
- Training of refrigeration technicians
- Training of customs officers
- Conversion of manufacturing facilities
- Public awareness campaigns
- Other country specific related activities.

Support measures for R&R systems

The Refrigerant Management Plan

An appropriate mixture of these support measures and their co-ordinated implementation in the framework of a Refrigerant Management Plan (RMP) may ensure the successful phase-out of CFCs in the refrigeration sector. The selection of the most appropriate support measures must be based on a thorough analysis of the specific conditions in the country in question: the structure of the refrigeration sector, the existing regulatory framework and economic, technical and educational standards.

Specific country conditions

The aim of a RMP is to design and implement an integrated and overall strategy for cost-effective phase-out of CFC in the refrigeration sector,

Strategy for CFC phase-out

including the most relevant technical and policy options. Projects previously implemented in isolation from one another can thus be brought together in an overall approach, and supported by the wider policy framework.

Support measures For example, some recently completed R&R projects have had only modest results, with recovery and recycling rates far behind the projected quantities, because the abundant availability of cheap CFC refrigerants and the continuous import of CFC-using equipment has undermined the market for recovery and recycling. A successful RMP will ensure that other policy measures – for example, equipment import bans, and economic incentives – help to ensure that recycled and alternative refrigerants can compete successfully with virgin CFCs.

Country Programme These Guidelines assume that the country has already formulated its Country Programme - the national programme for the phase-out of ODS. The Country Programme establishes a baseline survey on the use of controlled substances and describes the past, present and anticipated future consumption of controlled substances by sector (refrigeration, aerosols, foams, solvents, methyl bromide etc.). It includes appropriate policies and phase-out strategies, and provides a work plan, including a prioritised list of projects. The development of the national ODS phase-out programme is described in "Elements for Establishing Policies, Strategies and Institutional Framework for Ozone Layer Protection", UNEP, 1995 [6].

Refrigeration sector For low-volume-consuming (LVC) countries, the refrigeration sector accounts for the bulk of their ODS consumption, so this sector warrants particular attention within the Country Programme. The relationship between the RMP, the R&R system and the Country Programme is illustrated in *Figure 2*.

UNEP's "Guidelines for the Preparation of Refrigerant Management Plan", UNEP, 1997 [10] contain additional details on the elements of a RMP.

Recent decisions Recent decisions of the Executive Committee and the Meeting of the Parties have stressed the need for R&R systems to be designed and implemented in line other measures to reduce the consumption CFC refrigerants:

- Decisions 22/33**
- In order to ensure the successful implementation of R&R programmes, the Executive Committee at its 22nd meeting decided that future R&R projects "... should be prepared within the context of the Refrigerant Management Plan / Strategy of the country concerned" and urged the Implementing Agencies "... to ensure that the prerequisites for success were put in place before R&R projects were implemented" (Decision 22/33, para 41).
 - As a consequence, the Executive Committee requests the Implementing Agencies of recently approved of R&R programmes

"... not to proceed with the disbursement of funds approved for the R&R programme until the regulatory and legislative requirements and fiscal steps proposed by the Government ... are put into place".

- One important milestone to fulfil the necessary regulatory and legislative requirement is the establishment of an import/export licensing system for ODS which was made mandatory for all parties to the Montreal Protocol at their 9th meeting (Decision 9/8).

Decisions 9/8

- It is in this context that the Executive Committee at its 27th meeting decided "*... that no funds should be expended on customs training projects until either the relevant legislation was already in place or until substantial progress had been made towards promulgating such legislation*" (Decision 27/19, para 44).

Decisions 27/19

- In the context of the above decisions, some R&R programmes experienced significant implementation delays. At its 28th meeting, the Executive Committee requested the Implementing Agencies to report "*... on the steps taken at the national level to expedite the provision of the necessary regulatory and legislative measures required for successful recovery and recycling projects*" (Decision 28/10, para 24).

Decisions 28/10

Future decisions of the Meeting of the Parties and the Multilateral Fund will be compiled by the Ozone Secretariat in "Policies, Procedures, Guidelines and Criteria" which can also be consulted at the Secretariat's homepage: <http://www.unep.org/unep/secretar/ozone.htm>.

Future decisions

3. Planning, Establishing and Operating R&R Systems

The National Ozone Unit (NOU) should be closely involved in the preparation of the RMP and Country Programme proposals, as well as the feasibility study for the R&R programme. The RMP and its individual projects are then approved separately by the Executive Committee of the Multilateral Fund.

Proposal and approval

Once approved, the planning and establishment of the R&R programme should be co-ordinated by the NOU, in consultation with the relevant stakeholders and with the support of local and international consultants and the relevant Implementing Agency. This chapter assumes that the NOU is the co-ordinating body for the establishment of the R&R system.

Planning and establishment

R&R systems proceed through three key phases, which are described in the rest of this chapter: planning, establishment and operation. When they are up and running, monitoring and review should be carried out to ensure satisfactory progress.

Operation and monitoring

Planning R&R systems

During the planning phase, the NOU should focus on the following activities:

1. Collect the necessary data
2. Evaluate the need for the R&R system
3. Identify and involve the relevant stakeholders
4. Design the R&R system
5. Define equipment specifications and quantities
6. Evaluate the feasibility and economic viability of the system
7. Define the time schedule
8. Prepare project proposals and financing.

These eight steps are explained in more detail below.

The first step in establishing the R&R system is to conduct a baseline survey of the existing refrigeration sector in order to assess the potential and economic feasibility of CFC recovery and recycling. *Chapter 4* deals in more details with data collection, and provides templates of data sheets to be

Collect the necessary data

used for the data collection and presentation.

Evaluate the need The NOU should evaluate the need for the R&R system under the national ODS phase-out programme. The NOU's recommendations may be discussed internally in the National Environmental Protection Agency or the appropriate institutions within the Ministry of the Environment.

The need for the R&R system depends on factors such as:

- The commitment to protect the ozone layer
- The dependency on CFC-using refrigeration equipment in important industry sectors
- The lifetime of existing CFC-using refrigeration equipment, and its need for servicing
- The expected availability of new CFCs in the open market
- The need to save resources.

Identify and involve the relevant stakeholders The ultimate success of an R&R system depends on its acceptance by the various stakeholders – refrigeration service companies and their associations, government bodies, wholesalers and importers and exporters of CFC refrigerants. It is therefore essential to involve these organisations in the development of the R&R system, and to ensure their commitment, at an early stage.

Design the R&R system There are two types of R&R systems: decentralised and centralised. In certain cases, a combination of both types of system is appropriate. These different types of R&R systems are described in Chapter 5.

Different refrigerants such as R-11, R-12 or R-502 require different R&R equipment because of their thermodynamic properties. An overview of the necessary R&R equipment is provided in Chapter 5, and additional details are included in Annex 5.

Define equipment specifications and quantities Once the data is available, and the R&R system designed, the equipment specifications can be defined, and the required quantities of equipment (including vehicles) determined. This has implications for the cost and feasibility of the system. Items, which need to be specified, include:

- The required R&R capacity
- The quality requirements of the recycled CFCs
- The number and type of equipment
- The number of cylinders
- The number of filters and spare parts
- The number of vehicles.

Evaluate the feasibility and economic viability of the system The feasibility of R&R systems needs to be investigated for each sub-sector, as well as for the refrigeration sector as a whole, since the conditions and performance criteria in each sub-sector may be different.

Appropriate R&R systems should be selected based on performance criteria such as environmental impact, cost-effectiveness and profitability. Chapter 6 examines the feasibility criteria in more detail.

The time schedule for the establishment of the R&R system and the training of the recipients depends of course on the time required for the project preparation and approval as well as the logistics for the purchase and distribution of the equipment.

Define the time schedule

However, it is more important that the necessary legislative framework and other support measures as mentioned in the Chapters 2 and 7 are implemented to ensure the successful operation of the system.

Once the feasibility of the R&R system has been demonstrated, the NOU should discuss with the national/international consultant in charge of preparing the RMP proposal how the different elements of the R&R system can be implemented.

Prepare project proposals and financing

The R&R system may be economically viable in itself. In this case, the NOU should – in consultation with relevant stakeholders – discuss the direct implementation of the system and ensure the commitment of the stakeholders.

Otherwise, government financing, or support by the Multilateral Fund of the Montreal Protocol, should be investigated. Project proposals need to include detailed time schedules and budgets. All financial considerations should take into account the cost implications of the necessary support measures, as described in Chapter 7. The procedures for requesting financial support are described in reference documents [6] and [10].

Establishing R&R systems

Once the R&R system has been planned, the NOU should establish a work plan including the following steps:

1. Identify and approach service workshops and wholesalers
2. Purchase and distribute the R&R equipment
3. Train and supervise personnel
4. Establish transport logistics
5. Inform the public
6. Adopt quality procedures for recycled refrigerants
7. Adopt a strategy for the disposal of non-recyclable refrigerants
8. Manage financial and administrative issues.

Each of these steps is briefly described in the following sections.

Identify and approach service workshops and wholesalers

The first step in establishing the R&R system is to identify the workshops, which use CFC refrigerants. Wholesalers, importers and refrigeration associations should be approached in order to establish a register of service workshops. Workshops in the informal sector may be difficult to identify, as they are usually small and not registered to any organisation. However, wholesalers, importers or the larger workshops will often be able to provide information on the potential number of service workshops in the country.

When all the workshops have been identified, they should be informed of the planned R&R system – their full commitment to participation is important.

Purchase and distribute the R&R equipment

The purchase of R&R equipment will usually be co-ordinated by the Implementing Agency. The NOU needs to define the distribution criteria for the equipment, and organise the actual hand-over to the major servicing workshops.

The *equipment purchase* process includes the following:

- Specifying the required equipment
- Conducting a bidding procedure
- Ensuring guarantee and servicing in the country
- Selecting the appropriate suppliers
- Contracting.

The *distribution of the equipment* includes the following activities:

- Define the criteria, and establish the procedures, for selecting service workshops
- Plan the logistics of the equipment distribution
- Give a price to the equipment to ensure commitment and ownership
- Provide relevant information about the conditions to the service workshops
- Establish contractual agreement with the participating service workshops
- Distribute and hand over the equipment.

It is advisable to involve independent experts in the selection, purchase and distribution of the equipment.

Train and supervise personnel

The local refrigeration service companies scheduled to participate in the R&R system and receive R&R equipment should be closely involved in project preparation. Their service technicians should receive one-day introductory training on the specific features of the R&R equipment.

If the number of service workshops due to receive R&R equipment is limited (e.g. less than 30 companies), this introductory training can be provided directly. Where the numbers of service workshops and technicians are larger, the train-the-trainers approach should be considered.

This introductory training should be co-ordinated or combined with other training programmes, e.g. those on good practices in refrigeration, which are usually implemented at an early stage of the RMP and using the train-the-trainers approach. These good practice courses provide training and practical hands-on sessions on the following subjects:

- Phase-out schedules for ODS under the Montreal Protocol
- The national Refrigerant Management Plan
- The effects of ozone layer destruction
- Basic principles of refrigeration
- Good servicing practices, including recovery and recycling
- Use of R&R devices
- Preventive maintenance programmes and record keeping
- Retrofitting to alternative refrigerants
- General trade safety
- The RMP concept at the company level
- Refrigeration associations and certification schemes.

The trained trainers receive a participation certificate issued by the Government and they are supposed to train the remaining service technicians in the country on good practices in refrigeration.

All R&R systems require logistical arrangements for the transport of R&R equipment, as well as for the refrigerant cylinders. These can be tied into existing distribution systems, e.g. for virgin refrigerants or spare parts. Chapter 4 describes data collection on existing distribution systems.

Establish transport logistics

In general, it is important to minimise the need for transport as much as possible, and to carefully plan the routes. Centralised R&R systems require more transport than decentralised systems. Decentralised systems, on the other hand, require a greater number of recycling machines. The costs of each option have to be taken into account.

Keeping track of the logistics of the refrigerant movements requires a well-organised reporting system as an integral part of the logistics system. This reporting system should include appropriate labelling of cylinders, declaration of recovered refrigerant and the completion of forms.

R&R systems will function more effectively if the general public, the owners and managers of refrigeration and air-conditioning units, and technicians of refrigeration service companies, understand why they are important. This includes a recognition that servicing of CFC-based equipment should only be done by fully equipped and trained service personnel.

Inform the public

A range of information and public awareness tools are available: leaflets, posters, articles in newsletters, radio interviews, TV announcements, interventions at public schools and training institutes, and so on. These campaigns should be well co-ordinated with other awareness programmes

within the Country Programme and the RMP.

Adopt quality procedures for recycled refrigerants

The proper operation of refrigeration equipment depends, amongst other factors, on the purity of the refrigerant. When charging recycled CFCs into a refrigeration system it is therefore important to ensure that the refrigerant meets the prescribed quality requirements of the equipment manufacturer and supplier. This is important not only to ensure the proper operation and long lifetime of the equipment but also to fulfil the manufacturer's guarantee conditions. The owners of the refrigeration equipment should be informed that they are receiving recycled refrigerants.

A full chemical analysis of recycled refrigerant requires sophisticated laboratory equipment such as a gas chromatograph, and will in general not be available for routine quality control. There are, however, other reliable and cost-efficient means for quality control, including:

- Using only certified R&R equipment
- Following the manufacturer's instructions on changing oil and filters
- Employing only skilled personnel and providing appropriate training
- Testing acidity with paper strips
- Performing random chemical analysis checks as appropriate
- Performing preventive and visual inspections of the oil and the lubricant through the sight glasses
- Applying good practices and proper procedures
- Avoiding mixing refrigerants
- Using refrigerant identifiers to identify the type of the refrigerant or refrigerant mixtures
- Never using refrigerants after compressor burn-out (acidity)
- Using evaporation processes during recycling.

Procedures to ensure the quality of the recycled refrigerants is an important issue in the planning of the R&R system, and should feature strongly in training courses for users of recycling machines.

Adopt a strategy for the disposal of non-recyclable refrigerants

Experience shows that about 10-20% of recovered refrigerants cannot be recycled. This includes:

- Refrigerant recovered after compressor burn-out
- Mixtures of different types of refrigerant
- Residues from R&R processes.

In some countries, non-recyclable refrigerant can be returned through the chain of wholesalers to the refrigerant manufacturers responsible for disposal.

In other cases, this is not possible, but venting of contaminated or mixed refrigerant is bad practice and must be avoided – countries may ban the intentional venting. An economically feasible strategy for dealing with non-recyclable refrigerant should therefore be adopted as part of the R&R system.

There are two main options:

Destruction strategies

Destruction technologies, such as rotary kiln incinerators, liquid injection incinerators, cement kilns, reactor cracking or gaseous/fume oxidation are currently limited to a few developed countries and are very cost-intensive. They are, in general, not yet available to LVC countries.

Containment strategies

Until appropriate destruction capacity is available to LVC countries, an intermediate containment strategy could be adopted – such as long-term storage until final destruction or shipping to established plants.

The immediate storage cost will be less than the destruction cost. The long-term cost for storage and destruction, however, may be higher if no alternative and cheaper technologies can be established, such as chemical neutralisation of the refrigerant.

Careful monitoring and control of the use of the R&R equipment, and the budget for the R&R system, is essential.

Manage financial and administrative issues

To help ensure that service companies feel responsible for using the R&R equipment in a proper way, the equipment could be sold, or rented at a subsidised price. Prices should be balanced against the company's benefit from using the equipment.

It is important that service companies follow instructions on reporting, so that the amount of recycled CFC can be monitored and experience on recycling activities evaluated and disseminated to other users, as well as to the Ozone Secretariat and the Executive Committee of the Multilateral Fund.

Further cost implications centralised R&R systems are discussed in *Chapter 5*.

Operating R&R systems

Operating R&R systems requires the proper management of the recovery stations, recycling centers and transport logistics. Data on the performance of the R&R system needs to be collected to perform the necessary reporting and monitoring functions. The next section deals with monitoring and review.

All relevant individuals and stakeholders should be made aware of how the different aspects of the R&R system are managed and what their specific responsibilities are - e.g. concerning the collection of data and reporting. This is especially important in centralised systems, where many companies have to co-operate.

Centralised and decentralised R&R system

Lessons learned for recent R&R programmes show that some difficulties may occur during the operation of both centralised and decentralised R&R systems (see Chapter 5). Corrective measures should be taken as soon as possible where the following conditions apply:

Price levels of refrigerants

- The price levels of CFC refrigerants are low compared to those of alternative refrigerants. Therefore it may be more profitable to use the R&R machines for alternative refrigerants rather than for CFC refrigerants.

Cost-benefit analyses

- Owners or managers of service workshops are not aware that R&R of refrigerants is profitable. Appropriate information and training may help to conduct proper cost-benefit analyses.

User-friendliness

- The R&R equipment is not accepted by service technicians because it is not designed in a user-friendly manner. It should be portable or equipped with wheels, should not require heavy physical work (hand pumps), should run with the right voltage and should not require adapters or transformers, etc.

Selection of companies

- The use of the R&R equipment is not profitable for some of the participating service companies because the amount of refrigerant, which they can potentially recover/recycle, is too small. This situation may occur when companies applying for R&R equipment provide unreliable consumption data, knowing that only larger CFC consumers would receive R&R equipment. Especially companies servicing mainly domestic appliances may have difficulties to recover sufficient quantities of refrigerant.

Life time of R&R systems

- As technology develops towards alternative solutions, the share of CFC equipment and thus the recovery potential decreases over time. This may influence the viability of an R&R scheme for CFC refrigerants.

In centralised systems, where the service workshops are equipped with recovery machines only, some additional difficulties may occur during the operational phase:

- The economics for the individual service workshop can make it more profitable to recharge the recovered refrigerant directly back to the same equipment than transport it to the recycling center and pay a fee for recycling. That depends on the recycling fee and the price levels for virgin and recycled CFC refrigerants.
- Some individual service workshops do not transport the recovered refrigerant to the recycling center because of the additional efforts and time required. A periodic collection of the recovered refrigerants and collective transport to the recycling center may improve the situation. However, the costs for operating such collection system need to be covered e.g. through the recycling fees at the recycling center.
- In some cases, workshop owners or managers do not agree to the rules and prices for exchanging recovered and recycled CFCs between the service workshops and the recycling center and therefore refuse to provide recovered refrigerant to the center. For some companies it even proved to be cost-efficient to purchase their own recycling machine. The involvement and commitment of all relevant stakeholders at an early design stage is important and appropriate training may support such commitment. The above mentioned rules depend on whether the recycling center is run as a profit center, whether it is run as a refrigerant bank, whether it is responsible for the collection of recovered refrigerants, whether it also functions as a disposal center for contaminated refrigerant and whether it is run by a private company.
- The recycling center may control the prices as well as the distribution of the recycled refrigerant and gain a monopolistic position especially in small countries with few recycling centers. Running the recycling center as a refrigerant bank where the provider of recovered refrigerant has the right to purchase the similar quantity of recycled refrigerant at reduced prices may help. The price policy of the recycling center should be controlled e.g. through the government.

Centralised systems

Profitability for service workshops

Collecting recovered refrigerants

Exchanging recovered and recycled refrigerants

Price control

Monitoring and reviewing

In order to ensure the efficient functioning of the R&R system, the main performance indicators should be monitored and reviewed on a regular basis and corrective measures taken if necessary. These indicators are identical with the criteria used for the feasibility studies in *Chapter 6*:

Performance indicators

- Environmental impact
- Cost-effectiveness
- Profitability.

Data collection A local consultant should perform this task, in consultation with the NOU and in close co-operation with participating service workshops and recycling centers. Clear procedures need be established for the transfer of data between all involved stakeholders and the following data necessary for efficient monitoring of the R&R system should be provided to the NOU:

- Register of service workshops providing recovered refrigerant to the recycling centers or performing R&R themselves
- Register of the of R&R equipment in operation at the service workshops or the recycling centers
- The amount of refrigerant recovered, the number of operations and the reason for servicing
- The amount of refrigerant recycled by the service workshops or the recycling centers
- The amount of refrigerant recovered which is directly reused in the same appliance without recycling
- The amount of recycled refrigerant recharged to refrigeration appliances
- The estimation of the required resources (cost, time, labour) for R&R of refrigerant from different appliances and for individual workshops
- The potential for recovery and recycling of refrigerants
- The price levels of virgin, recovered and recycled refrigerants
- The quantity of imported of refrigerants.

Data reliability The collection of reliable data represents a major problem in most R&R programmes. In centralised systems, the amounts of refrigerant received and recycled at the recycling center is usually available. It is already more difficult to keep track of the refrigerants, which are recovered and reused in the same appliance, without passing through the recycling center. This is also the case for decentralises R&R systems, where individual service workshops perform both, recovery and recycling.

Indirect data Indirect data may become available once the import of virgin CFC refrigerants is restricted, through the rate of retrofiting. The establishment of trade registers at importer/wholesaler level may also provide indicators of whether service companies are applying R&R practices.

4. Collecting Data

The first step in establishing an R&R system is to conduct a baseline survey of the existing refrigeration sector in order to evaluate the potential for CFC recovery and recycling and its economic feasibility.

Base line survey

The baseline survey should include the following activities, which are described in this chapter:

1. Analysis of the existing refrigeration sector
2. Analysis of the network for distributing refrigerants
3. Study of the trends, and future demands for refrigeration technology and CFC consumption
4. Estimates of the potential for recycling CFCs.

Analysis of the existing refrigeration sector

The following data needs to be collected to acquire an overview of the refrigeration and air-conditioning sector in the country:

Data to be collected

- Numbers of refrigeration and air-conditioning units within each sub-sector (domestic, commercial and industrial refrigeration and air-conditioning, chillers, mobile air-conditioning, etc.)
- Geographical distribution of these units
- Approximate age of the equipment
- CFC consumption within each sub-sector, indicating refrigerant types
- Inventory of service workshops, including their number, size, specialisation, number of employees and their skills levels, and companies maintaining their own refrigeration equipment
- Inventory of importers and wholesalers of refrigerants and equipment
- Inventory of R&R equipment already available in the country
- Projected lifetime of the R&R programme for CFC refrigerants – this will be limited by the phase-out schedules for CFCs under the Montreal Protocol. However, R&R may become increasingly important for other refrigerants, e.g. HCFCs and HFCs, which contribute to global warming.

The starting points for the collection of data should be the Country Programme and the RMP. Further data could be gathered from importers of refrigerants and equipment, and their customers – wholesalers and service workshops.

Data sources

Form sheets The following form sheets (Tables 1–3) should be used as templates for the collection of the basic data, and provide guidance on how to organise the data in a user-friendly manner. RMPs may contain similar form sheets.

Existing systems and their charge Table 1 should be used to collect information on the number of refrigeration and air-conditioning units using CFC refrigerants. It also includes columns for data on the average and total refrigerant charge of the units. If exact data are not available, the procedures explained in Chapter 6 should be used to investigate the feasibility for CFC recovery and recycling.

Refrigeration & A/C sub-sectors	Number of units/plants	Min - max charge	Average charge	Total charge
<i>Units</i>	No.	kg/unit	kg/unit	kg
<i>Formula</i>	A	B1 - B2	$C = (B1+B2)/2$	$A \times C$
Domestic refrigerators				
Small commercial units				
Large commercial/ industrial units				
Mobile air-conditioning				
Total				

Table 1: Overview of the number of existing refrigeration and air-conditioning units and their refrigerant charge.

Refrigerant use for servicing Table 2 should be used to collect information on the current consumption of CFC refrigerants for maintenance. The precise annual CFC loss in each sub-sector depends on the quality of the maintenance procedures. Within each sub-sector, the different types of CFCs should be specified.

Refrigeration & A/C sub-sectors	Total CFC charge per sub-sector for maintenance	Total CFC used annually charge	Specific annual loss per total
<i>Units</i>	kg	kg / year	1 / year
<i>Formula</i>	A	B	B / A
Domestic refrigerators			
Small commercial units			
Large commercial/ industrial units			
Mobile air-conditioning			
Total			

Table 2: CFC consumption within the different refrigerant sub-sectors

Table 3 should be used to collect sector specific-data such as the size and type of the refrigeration workshops. Some service workshops may work in more than one sub-sector – this has to be taken into account when estimating the total number of companies.

Structure of refrigeration sub-sectors

Sub-sectors serviced	Number of larger workshops with > 5 employees	Number of smaller workshops with > 5 employees	Number of per sub-sector
<i>Units</i>	kg	kg / year	1 / year
<i>Formula</i>	A	B	B / A
Domestic refrigerators			
Small commercial units			
Large commercial/ industrial units			
Mobile air-conditioning			
Total			

Table 3: Overview of number of refrigeration service workshops

Analysis of the network for distributing refrigerants

In many cases, the existing distribution network for virgin refrigerants can also be used for the R&R system – e.g. to transport recovered refrigerant to the recycling centers. This is particularly important for centralised R&R systems, which rely heavily on transport services. For this reason, the structure of the existing distribution system should be investigated, including:

Data to be collected

- Number of importers
- Intermediate dealers
- Amount of CFC refrigerants sold through the different wholesalers
- Distribution channels for CFC refrigerants
- Modes of distribution for CFC refrigerants, e.g. the packaging (type and size of cylinders, refillable or non-refillable), means of transport, etc.
- Availability of cylinders for re-distribution of recycled refrigerants.

This data is also needed to establish a mass balance for the total flow of refrigerants, and to identify the individual consumers of CFC refrigerants, in the country.

Analysis of trends and future demands

Data to be collected Future demand for CFC refrigerants in the country can be estimated once the following data is known:

- Current trends in consumption, and stock (charge) of CFC refrigerants, in the various types of refrigeration equipment
- Ages of refrigeration and air-conditioning equipment and expected rates of replacement
- Plans for retrofitting of equipment and possible schedules for banning imports of refrigeration equipment
- Trends in the development of new refrigeration technology world-wide
- Current levels of recovery and recycling of CFC refrigerants, amounts of CFC refrigerants being recovered and recycled and number of existing recycling machines.

Potential for R&R Recovery and recycling of CFC refrigerants may be applied during:

- Servicing and repair of CFC units
- Retrofitting of CFC units for alternative refrigerants
- Decommissioning of CFC units.

Demand for refrigerants Demand for CFC refrigerants arise in the following cases:

- The initial charge of newly installed CFC units, including refrigerants for testing purposes (to be avoided in future)
- Recharging during servicing and repair of existing CFC units.

Table 4 should be used to estimate the future demand for virgin CFC refrigerants.

Refrigeration & AVC sub-sector	Total CFC used for maintenance in year X	Replacement or retrofitting rate per year	Total CFC used for maintenance in year X + 1	Total CFC recovered and recycled per year	Virgin CFC used for maintenance in year X + 1
<i>Unit</i>	<i>kg / year</i>	<i>%</i>	<i>kg / year</i>	<i>kg / year</i>	<i>kg / year</i>
<i>Formula</i>	<i>A</i>	<i>B</i>	<i>A x (1-B)</i>	<i>C</i>	<i>A x (1-B) - C</i>
Domestic refrigerators					
Small commercial units					
Large commercial / industrial units					
Mobile air-conditioning					
Total					

Table 4: Future demand for CFC refrigerants

Estimation of the potential for refrigerant recycling

Table 5 can be used to estimate the potential amount of CFC refrigerant available for recovery and recycling. The average refrigerant charge for each sub-sector or equipment category has to be estimated.

Refrigeration & A/C sub-sector	Number of units (from Table 1)	Average refrigerant charge	Service & scrapping rate	Potential for recovery
<i>Units</i>	<i>No.</i>	<i>kg/unit</i>	<i>No. units/year</i>	<i>kg/year</i>
<i>Formula</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>A x B x C</i>
Domestic refrigerators		0.10...0.25		
Small commercial units		5...10...100		
Large commercial / industrial units		100...1000		
Mobile air-conditioning		0.65...1.50		
Total				

Table 5: Potential amount of CFC refrigerant available for R&R

The type and amount of CFCs used in domestic refrigerators differs from model to model, depending on the size and capacity of the refrigeration system. Refrigerators usually contain 0.1–0.25 kg of refrigerant.

Domestic refrigerators

Experience from France shows that more than 90% of the initial charge of yet unopened refrigerators can be recovered. However, Danish experience in the recovery of CFC refrigerant from old refrigerators brought to central recycling centers shows that they tend to contain only about 30% of the initial charge – the remainder is lost mainly through leaks caused during transport to the center.

When end-of-life refrigerators are disposed of in LVC countries, most of the refrigerant tends to be lost through leakage, or is effectively non-recyclable because of compressor burnout. LVC countries experience higher rates of compressor burnout because of their hot climates and unstable electrical supplies.

Commercial units

Several kinds of refrigeration equipment are used in the commercial sector, including hermetically sealed compressor units for individual display cases, and semi-hermetic and open compressors for centralised refrigeration of a series of display cases and cold rooms.

Hermetically sealed compressor cabinets contain a few kilograms of CFC-12 refrigerant, whereas centralised systems contain between 5–15 kg of refrigerant, depending on the size and number of cabinets connected to the system.

Larger systems, with several cabinets and/or storage rooms, contain as much as several hundred kilograms of CFC-12, HCFC-22 or R-502 (a blend of CFC-115 and HCFC-22) refrigerants.

Recommended charge ratios of refrigerant for commercial refrigeration are approximately 1.5 kg/kW_{ref} for evaporation temperatures between –15 and 0 °C, and 4 kg/kW_{ref} for temperatures between –40 and –35 °C.

When a system is opened for servicing its refrigerant content may range from zero to a full charge. Usually, the actual charge will be less than the initial charge because of system leakage – which is the most common cause for the servicing. Refrigerant loss noticeably reduces the cooling performance of the equipment, and the owners usually react quickly to service the appliance. Most of the remaining refrigerant can therefore be recovered.

Large commercial and industrial units This sub-sector is very diversified, including refrigeration and air-conditioning units as well as chillers. The refrigerant type and charge varies accordingly.

Some units use CFC-12, HCFC-22 or R-502, while others, such as chillers, use CFC-11. The refrigerant content varies from several hundred kilograms to over 1 tonne, with an average of about 400 kg.

For chillers, the recommended charge ratio is between 0.25–0.4 kg/kW_{ref}, while that for special refrigeration plants may be as high as 8 kg/kW_{ref}.

This sub-sector includes air-conditioning systems both for cars, buses, trucks and trains.

Mobile air-conditioning (MAC) Until recently, CFC-12 was used in cars and some other vehicles. The initial refrigerant charge in cars was 0.65–1.5 kg of CFC-12. North American cars contained more than 1 kg of CFC-12, though European and Japanese cars contained less. Although almost all car manufacturers have now switched to HFC-134a as the refrigerant, many older cars still require servicing with CFC-12, which makes recycling relevant.

The average initial charge for buses and trains is several kilograms of refrigerant.

5. Designing R&R Systems

This chapter describes the technical components of the different types of R&R systems for CFC refrigerants. There are two basic designs, decentralised and centralised systems. In certain cases, a combination of both types – a semi-centralised system – may be appropriate, depending on the structure of the existing refrigeration systems.

Basic designs of R&R systems

Decentralised R&R systems

In decentralised R&R systems, the participating service workshops are equipped with both, recovery and recycling units. R&R is either performed locally at the customer's premises, using mobile R&R equipment, or at the service workshop. The recycled refrigerant is usually used to recharge the same refrigeration unit from which it was recovered. The recycling process is controlled by the local workshop (Figure 2).

Design and logistics

The operation of decentralised R&R systems has significant advantages compared with centralised systems because the recycled refrigerant can directly be reused by the service workshop. Thus the transport logistics are reduced and no co-ordination with other service workshops is needed as long as the workshop is able to use all recycled refrigerant itself. However, the successful operation of a decentralised system requires that:

Conditions for successful operation

- the individual service workshops have sufficiently skilled technicians and administrative personnel
- the recycling potential is sufficiently high, which is usually the case for mobile air-conditioning units and larger commercial or industrial plants.
- either the individual workshops have sufficient financial resources to purchase the recycling equipment or it is funded or subsidised through the Government or the Multilateral Fund.
- the individual service workshops must have access to analytical tools, which are necessary to identify recovered refrigerant before the recycling takes place. The workshop has to ensure the quality of the recycled refrigerant and is liable for damage resulting from refrigerant contamination.
- the individual service workshops have access to vehicles for transportation of the recovered refrigerant to the service workshop for recycling or for transportation of the recycling machine to the customer's premises.
- R&R must be profitable for the individual workshop.

Centralised R&R systems

Design and logistics In centralised R&R systems, the participating service workshops are equipped with recovery machines only, and the recovered refrigerant is recycled in a recycling center. In some cases, the recycling center can also be equipped with a reclaim station. The recycling center controls the recycling process (Figure 2).

The recycling center can return the recycled refrigerant to the workshop, which provided it and charge a recycling fee, where the workshop is able to reuse the recycled refrigerant. Alternatively, the recycling center can function as a refrigerant bank, buying recovered and selling recycled CFC refrigerants. If the recycled refrigerant is to be used for other refrigeration systems, its quality must of course be strictly controlled.

Conditions for successful operation However, experience shows that the successful operation of centralised R&R systems is more difficult because of the increased logistics between the service workshops and the recycling center, because of the smaller R&R potential in the domestic sector and because of the increased need for coordination between workshops and recycling centers. The successful operation of centralised R&R systems requires that:

- the individual service workshops have sufficiently skilled technicians and administrative personnel
- the potential for refrigerant recovery is sufficient for the individual service workshop, which is more difficult for companies servicing domestic and small commercial appliances
- the number of small service companies is sufficient to ensure a minimum R&R potential for the recycling center
- Short distances between the service companies and the recycling center in order to limit the necessary logistics
- Collective or individual transport available to transport the recovered refrigerant to the recycling center and to return it once recycled
- each recycling center must be equipped with a refrigerant analyser since it can not rely on the type of refrigerant contained in a recovery cylinder. The center is liable for the quality of the recycled refrigerant and has therefore to control the incoming refrigerants.
- recovery must be profitable for the individual service workshop and the recycling must be profitable for the recycling center.

Lessons learned : close monitoring Lessons learned from recent R&R programmes show that the operation of centralised R&R system may fail if some of the above aspects are not properly taken into account. Therefore it is important to closely monitor the operational phase of the system and to introduce corrective measures if necessary. Further aspects, which should be taken into account, were already discussed in *Chapter 3*.

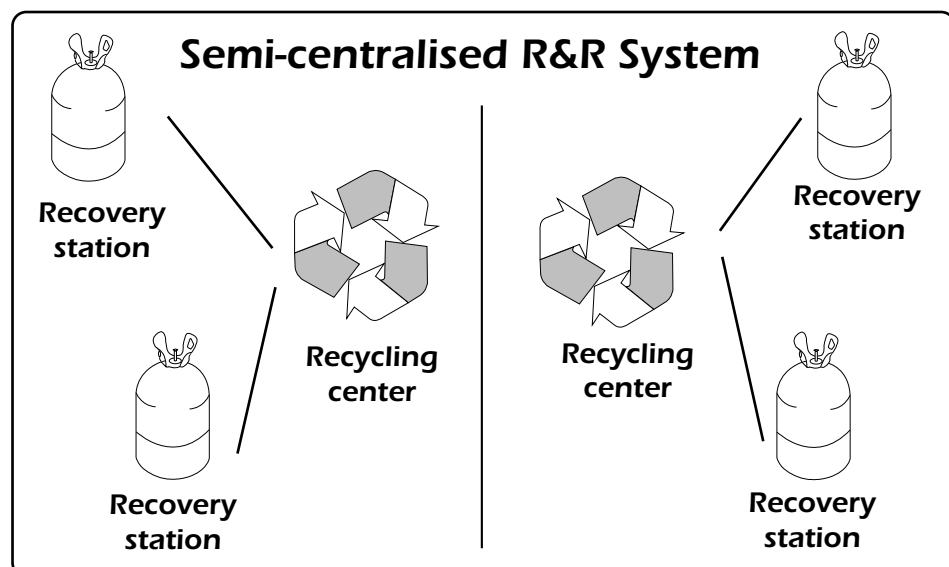
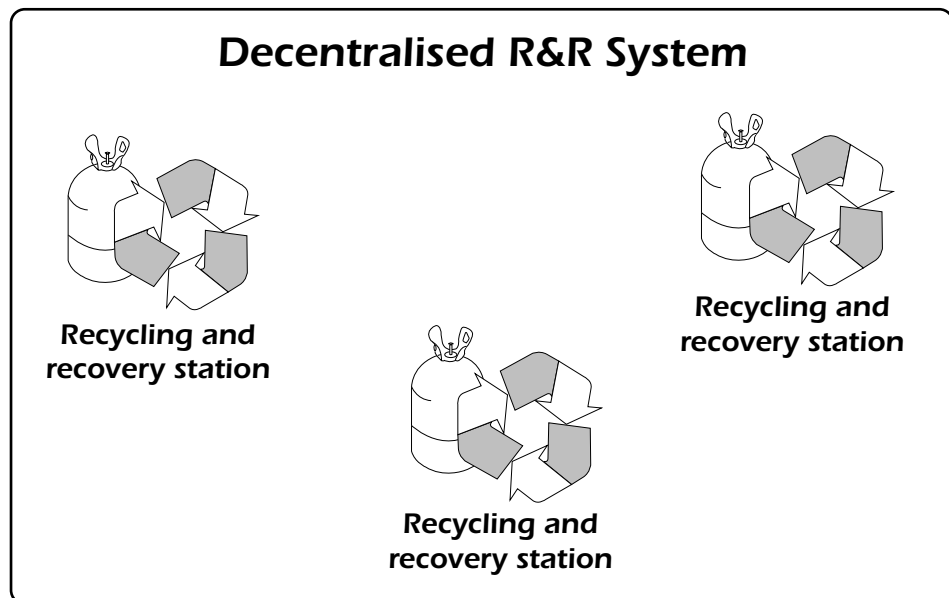
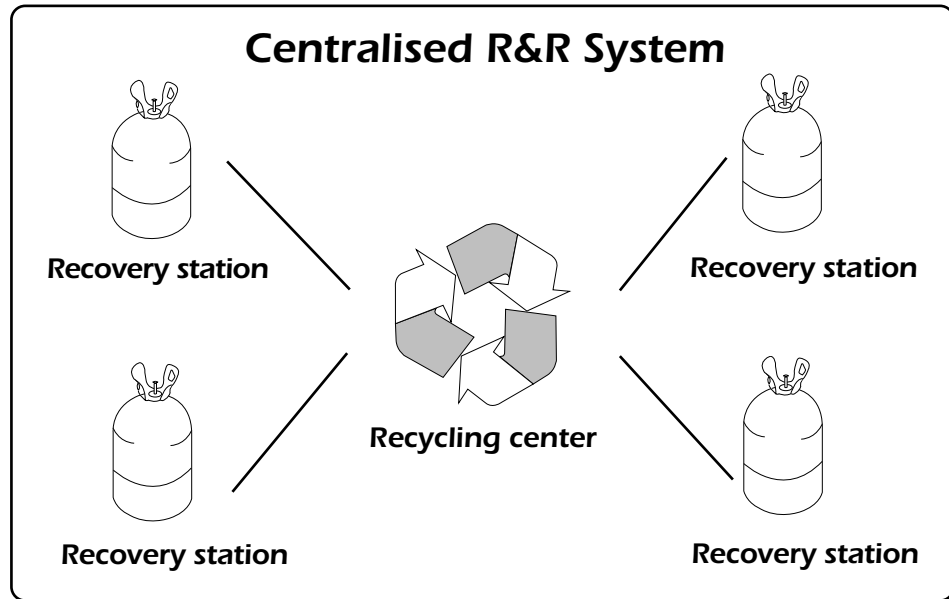


Fig. 2 : Three different ways to organize a CFC Refrigerant R&R System

Technical components of R&R systems

The type and quantity of R&R equipment necessary to operate R&R systems depends on the design and size of the system and the type of refrigeration equipment to be serviced.

Typically, R&R systems require the following types of equipment:

Recovery machines Recovery machines are used to recover refrigerant from refrigeration or air-conditioning systems to be serviced or decommissioned. The recovered refrigerant is pumped into a cylinder for storage.

Recovery does not necessarily include filtering. However, liquid refrigerant is often recovered through a buffer cylinder, which is placed before the recovery machine. This cylinder functions as an oil separator that traps particles and acid.

Some recovery machines are, or can be, equipped with a filter to protect the compressor, as well as additional filter modules for moisture, particles, etc., in order to fulfil the basic recycling function. Such upgraded recovery machines may improve the quality of the recovered refrigerant before recharging to the same refrigeration system. However, they are not certified, and the refrigerant quality cannot be guaranteed.

Recovery machines are usually portable, their weight is approximately 20 kg and their price may range from US\$ 500–1 500, depending on the type and the number of machines purchased.

Recycling machines Recycling machines clean the recovered refrigerant to a given standard – they are usually certified. The recycled refrigerant is pumped into a refillable cylinder. Some recycling machines are also equipped to recharge the recycled refrigerant back into the serviced refrigeration system.

The cleaning system usually involves an evaporation process, and the refrigerant is passed through a separation chamber, filters and dryers.

Recycling machines weigh about 100 kg and are normally equipped with wheels. Prices range from US\$ 2000–5000. Purchasing a recycling machine will avoid costs e.g. for separate recovery machines, cylinders and charging equipment.

The use of refrigerant handling equipment has increased during the last decade, accompanied by the intensive development of new and more cost-efficient models. The characteristics and prices of such equipment should be carefully compared.

Reclaim stations

Reclaim stations are stationary plants, normally used to upgrade contaminated or mixed refrigerant to international quality standards for virgin refrigerants (ARI 700-93). These standards require strict quality control and access to advanced chemical analysis devices such as a gas chromatograph. However, recycling machines may also be able to clean refrigerant, which is not heavily contaminated to similar quality standards.

The price of a reclaim station ranges from US\$ 25,000–50,000. More complex reclaim stations may cost as much as US\$ 150,000. A gas chromatograph may cost up to US\$ 100,000. Because of the high cost, reclaim stations are not cost-efficient for LVC countries.

Cylinders are necessary in all types of R&R systems for the recovery, storage, transport and redistribution of refrigerant. Only refillable cylinders should be used, given that disposable cylinders – often used for distribution of virgin refrigerants – are not strong enough to withstand the filling process.

Cylinders are available in different sizes, 30lb, 50lb, 100lb, 200lb and 1000lb. Smaller workshops with portable recovery machines normally use 30lb or 50lb cylinders. For recycling centers, 100lb or 200lb cylinders are usually adequate. Recovery cylinders should have separate valves for vapour and liquid refrigerant, and be equipped with an over-fill protection (OFP) device. The price for 30lb and 50lb cylinders is approximately US\$ 100 and for 100lb cylinders US\$ 250.

The mixing of different refrigerants should be avoided, as it is not possible to separate mixtures of refrigerants using the equipment described above. This means that the workshops have to be equipped with separate cylinders for the different kinds of recycled refrigerants (CFC-11, CFC-12 and R-502) and rejected refrigerants.

As part of the interim disposal strategy for contaminated and mixed refrigerants, recent R&R programmes provided 1000lb cylinders, allowing storage of the refrigerant until final destruction.

When servicing small refrigeration units such as refrigerators, a specially designed plastic bag can be used to recover and to store the refrigerant during transport from the site to the locations of the recycling machine. The price for a refrigerant bag is approximately US\$ 20.

Electronic leak detectors indicate the presence of specific molecules containing chlorine or fluorine atoms. This should happen before the recovery of the refrigerant and the repair of the system. Leak detectors cost between US\$ 50–300.

Leak detectors

This equipment identifies the type of recovered refrigerant to be recycled and indicates if refrigerants have been mixed together. Recycling centers,

Test kit (refrigerant identifier)

which receive recovered refrigerants from a variety of workshops, require the device.

Hand tools Different types of hand tools and accessories are needed for recovery and recycling operations, including hoses, valves, gauge manifolds, micron gauges, hollow punches, etc.

Other pieces of equipment used for refrigerant recovery and recycling are weighing scales and filters for the recycling machines.

Local assembly of R&R equipment

Some refrigeration service workshops are already equipped with basic tools for handling refrigerants, such as vacuum pumps, refrigerant cylinders, weighing scales and hand tools. The cost for of R&R machines may be significantly reduced through local assembly. Such locally assembled equipment may upgrade the quality of the recovered refrigerant.

In larger countries such as India, the relevant stakeholders and the Government met and decided to develop indigenous charging kits and recovery machines since most service technicians in India cannot afford imported equipment. In the long term, India also plans to develop R&R units, but some research needs to be done concerning the absorption of acid and moisture and the life of the cartridge.

However, unless the R&R equipment is tested and certified, there is no guarantee that the recycled refrigerant complies with established quality standards. Therefore, the recycled refrigerant should only be used to recharge the same appliance from which it was recovered.

6. Evaluating the Feasibility of R&R Systems

This chapter defines the criteria, which should be used in assessing the feasibility and performance of R&R systems. In some cases it may be appropriate to use different types of R&R systems in the various sub-sectors, depending on their specific conditions.

Economic feasibility and performance criteria

The following performance criteria for R&R systems should be used:

- Environmental impact: the amount of recovered and recycled refrigerant in relation to the total potential for recovery and recycling should be maximised **Environmental impact**
- Cost effectiveness: environmental impact in relation to the total cost of the R&R project should be maximised **Cost effectiveness**
- Profitability: the companies involved in the R&R business should make a sustainable profit. **Profitability**

The following more specific criteria should be considered in order to optimise the above performance criteria:

- Minimise costs for R&R equipment
- Minimise time for R&R procedures
- Optimise usage of R&R equipment
- Maximise profits from R&R
- Minimise pay-back time for R&R equipment
- Maximise coverage in the country and in each sub-sector
- Minimise but provide the necessary transport and logistics
- Provide reliable data.

The remaining sections of this chapter examine specific conditions in the different refrigeration sub-sectors: *domestic refrigeration, large commercial and industrial refrigeration and mobile air-conditioning.*

Domestic refrigeration

Recovery and recycling in the domestic refrigeration sector can be applied in the following situations:

- Repair of domestic refrigerators (recovery and recharge).
- Collection and scrapping of old refrigerators (recovery).
- Testing and repair of new refrigerators at the factory (recovery and recharge).

The first activity is usually the most relevant for LVC countries. The second may be relevant if the prices of CFC refrigerants increase drastically. The third activity only applies to the few LVC countries that have manufacturing facilities.

In general, R&R in the domestic refrigeration sub-sector is less efficient and profitable than in the commercial or mobile refrigeration sub-sectors, due to the small amounts of CFCs which can be recovered from domestic appliances.

Repair of domestic refrigerators

Domestic refrigerators do not require regular servicing, and repairs are only needed when a system breaks down. If the reason for repair is leakage in the refrigeration coil, there may not be any refrigerant left. In the case of a compressor burnout, the remaining refrigerant can be recovered but it is contaminated and not recyclable.

Domestic systems are often repaired by technicians from the informal sector who lack formal training. Leakage may not be properly detected and leaking systems may be simply topped up.

In cases where the weight of portable R&R units makes transport to the client difficult, especially where technicians lack appropriate means of transport, recovery bags in combination with a hand pump, can be used instead. This also applies if several service technicians share one R&R unit.

The average recycling potential for refrigerators is 60 grams of CFC-12. This corresponds to a saving of US\$ 0.1, given that new refrigerant costs US\$ 2 per kg. The cost of the recycling operation must therefore be very low to make the operation profitable for the service companies. However, if the R&R equipment is subsidised, locally assembled or is available anyway for the servicing of bigger appliances, the total cost may well balance the savings – particularly if labour costs are low. Once CFC refrigerants become more expensive, the profitability of R&R will increase.

Any feasibility study for R&R in the domestic refrigeration sector should take into account the following factors:

- Potential numbers of refrigerators requiring repair of the refrigeration coil.
- Possible amounts of refrigerant remaining in the refrigerator.
- The number of service companies repairing domestic refrigerators.

When a refrigerator reached the end of its life, after 10–15 years of operation, it may still contain a CFC refrigerant charge. Whether the refrigerator is dumped in a landfill or scrapped in a shredder, its refrigerant charge will finally be emitted to the atmosphere, thus contributing to the depletion of the ozone layer.

Collection of old refrigerators

Although the amount of refrigerant emitted from each individual refrigerator is small, the high number of refrigerators dumped every year contributes significantly to global CFC emissions. Countries like Canada, Denmark, Germany, Sweden and some states in the USA have established schemes for the collection of old refrigerators in order to recover the remaining CFC refrigerant.

Experience from the Danish scheme for the collection of old refrigerators (Annex 6) shows that an average of 60g of CFC can be recovered from each refrigerator. About 80% of the recovered refrigerant can be recycled or reclaimed, and the remaining 20% are incinerated.

In the Danish R&R scheme, the cost of R&R is higher than the actual market price of the recovered CFC. Hence, the R&R scheme needs to be subsidised through a surcharge on new refrigerators, which also covers the cost of scrapping the refrigerators at the end of their economic life. Municipal tax revenues cover the remaining costs. This does not take into account the avoided disposal cost of the refrigerant, since venting is always bad practice and in some cases illegal. R&R may be a cost-effective alternative to expensive incineration or long-term storage.

R&R will be less expensive in LVC countries, which have, in general, lower labour costs. However, the profitability of R&R schemes will strongly depend on price levels and the availability of virgin and recovered refrigerant – which therefore need to be managed by appropriate economic and policy measures.

This section is applicable to those LVC countries, which have manufacturing facilities for domestic refrigerators. Many manufacturers have already converted to alternative refrigerants to avoid the production of new CFC refrigerators. However, R&R as an environmentally sound practice should also be applied to substitute refrigerants, such as HFCs and HCFCs.

Manufacture of refrigerators

Quality control procedures during the manufacturing process usually identify 1–2% of defective refrigerators, which then require emptying and

recharging. Appropriate R&R equipment should be available at the factory in order to recover the refrigerant and to prevent venting.

The economic feasibility of R&R depends on the number of defective refrigerators and the possibility of integrating this process into the repair lines without creating disruptions. Logistics are reduced since many refrigerators require R&R at the same manufacturing site.

Large commercial and industrial refrigeration

Situations for R&R For large commercial and industrial refrigeration, R&R of refrigerants is relevant in the following situations:

- Installation (cleaning and initial charging).
- Repair and servicing (recovery and recharging).
- Retrofitting of equipment (recovery).
- Decommissioning and scrapping (recovery).

In all cases, the recoverable amount of refrigerant will be approximately equivalent to the initial charge as long as there is no leakage in the refrigeration coil.

Time required for R&R The R&R procedure consists of recovery, recycling and recharging, and requires between 15–30 minutes per kilogram of refrigerant charge:

- Recovery of the remaining refrigerant: 5–15 minutes per kg.
- Recycling of the recovered refrigerant (filtering): 10–15 minutes per kg.
- Recharging of the refrigerant: 2–5 minutes per kg.

Process for R&R Most machines perform the R&R process automatically once the hoses are properly connected; the operator has simply to start the process. Since over-filling of cylinders may be dangerous, either the filling needs to be monitored by the operator or the cylinders must be equipped with overflow protection devices. The use of these devices allows the operator to perform other tasks during the R&R process, reducing time requirements and labour cost and therefore increasing profitability. Depending on labour costs and the price levels of virgin refrigerants, R&R from commercial systems may well be profitable.

Table 6 can be used to evaluate the economic feasibility of R&R in commercial and industrial refrigeration for individual service workshops involved in an R&R programme.

Economic feasibility of refrigerant recycling

Non-recurring cost A	R&R machines Other equipment Initial training
Annual operating cost B	Labour Maintenance of R&R equipment including spare parts, filters, oil etc. Rent, electricity, etc. Bank interest Administration, monitoring and reporting costs
Annual savings C*	Refrigerant recycled
Average life time of R&R equipment D	E.g. 5 years
Amount of annually recycled refrigerant E	E.g. 1000 kg
Cost for R&R per kg of recycled refrigerant	$\text{Cost} = (A/D+B)/E$ <p>Non-recurring cost divided by the lifetime of the R&R equipment plus the annual operating cost, both divided by the annual amount of recycled refrigerant in kg</p>
Cost for R&R per kg of recycled refrigerant	Savings = Market price per kg of virgin refrigerant replaced by recycled refrigerant
Cost for R&R per kg of recycled refrigerant	Total savings = Savings – Cost

Table 6: Calculation of economic feasibility of refrigerant recycling

* The annual savings may also include the avoided cost for storage and disposal of refrigerants if applicable.

Decentralised R&R systems

For service workshops participating in a decentralised R&R system and performing both, recovery and recycling, the non-recurring costs include the costs of the R&R equipment and the initial training. The necessary R&R equipment consists of:

- R&R machine
- Refillable cylinders for recovered refrigerant
- Leak detector
- Testing equipment
- Other hand tools.

The service workshop must also invest in the initial training of a selected number of employees, to enable them to use the equipment correctly. As a rule, a couple of days are required to train a skilled technician on good practices in refrigeration, including R&R. The training costs include the labour cost of the people to be trained and, if necessary, their travel and accommodation expenses, as well as the cost to the organisation of the training and trainers.

In order to compare the non-recurring cost with the operating cost, the non-recurring costs must first be annualised, which requires an estimate of the lifetime of the individual investments. The equipment normally has a working life of about 5–10 years, depending on how much it is used and how carefully it is treated and maintained. Training has a long life span in theory, but in practice the turnover of personnel, and promotions within the workshops, might make it necessary to periodically (e.g. every three years) provide refresher courses for new staff.

The operating costs are primarily the labour required to carry out the various processes. These vary according to the kind of equipment being used. The following procedure applies to a semi-automatic recycling machine:

- Transport the R&R machine to the refrigeration system to be serviced
- Connect the R&R machine to the refrigeration system
- Monitor the recovery process if cylinders are not equipped with overfill protection devices
- Disconnect the R&R machine
- Start the recycling process.

The recharging of the refrigeration device is part of the traditional servicing procedure and should not be accounted for. In addition, no time is allowed for venting of the refrigerant, which also requires equipment to evacuate the circuit.

Most recycling machines are equipped with filters that must be changed after every 50 hours of operation. Some cheaper types of filters require changing after 10 hours – the savings in purchase must be set against the higher numbers that will be needed.

Costs for electricity and lubrication oil are insignificant compared to other overheads. The oil must be replaced more frequently in recovery than in recycling machines.

The frequency and quality of the servicing of R&R equipment will affect its useful lifetime, which may range from 5 to 10 years. The useful lifetime will also be limited because the number of CFC appliances requiring servicing will fall in the future.

Reusing recycled refrigerants creates savings, since no virgin refrigerant needs to be purchased and no contaminated refrigerant needs to be disposed of.

The recovery and recycling of refrigerants is economically feasible if there are total savings, the balance between the annualised non-recurring cost and the operating cost. Practical examples of non-recurring and operating costs and the savings made due to R&R operations are presented in the *Annexes 1-4*.

For servicing workshops participating in a centralised R&R system and only performing recovery, the calculation is similar to that for decentralised systems. However, the cost of the recovery units is less than for the R&R units, and no recycling filters need to be purchased. Additional costs arise from the logistics and the transport of the refrigerant to and from the recycling centers, and the fees to be paid to the recycling center for their services (the price difference between recovered and recycled refrigerant).

Centralised R&R systems

Recycling centers participating in a centralised system have lower costs for recovery units, and the labour and logistics of recovery. Additional costs arise from the recovered refrigerant, which needs to be purchased from the service workshops. The profits made by the recycling centers are based on the added value of the recycled refrigerants compared with the recovered ones.

Similar calculations apply to recycling and reclaim stations, but the cost for the chemical refrigerant analysis also need to be considered.

Example from Ghana

Annual non-recurring cost	US\$/year
▪ Equipment is borrowed from technical institute, so no investment costs for the workshops in this respect	0
▪ Training of two technicians	40
Sub-total	40
Annual operating cost	
▪ Labour, 100 operations of 1 hour each	100
▪ Filters, 3 filters of about US\$ 40.- (paid by centers)	0
▪ Other operating costs, estimated	200
Sub-total	300
Annual costs	340
Annual savings	
▪ 5 kg per operation (100 operations), US\$2 per kg	1 000
Total annual savings	
Obviously, it is profitable for the workshop to perform the recycling operation, even with a relatively conservative calculation.	
	660

Table 7: Recycling of CFC from commercial refrigeration plants - one year's operation of a typical service company in Ghana in 1997

Mobile air-conditioning

Recycling of refrigerants from mobile air-conditioning units can be performed through either centralised or decentralised systems, although decentralised systems are the most commonly used.

The feasibility of refrigerant recycling from MACs can be evaluated using the same format applied to commercial and industrial refrigeration, as described above.

Typically, refrigerant recycling from MACs is more economically feasible than from domestic refrigeration, but less feasible than the recycling of refrigerants from larger commercial and industrial refrigeration facilities.

However, the feasibility of MAC recycling projects depends on a number of factors which vary from one country to the other, such as:

- The average charge of the MACs
- The average state of maintenance and thereby the total potential recyclable CFCs
- Labour costs.

Example from Malaysia

Annual non-recurring cost:	US\$/year
▪ The purchase of equipment is subsidised	200
▪ Training of two technicians: approx. four days a year at a labour cost of US\$30 per day	120
Sub-total	320
<hr/>	
Annual operating costs	
▪ Labour, 200 operations of 30 minutes each	375
▪ Filters, 3 filters of about 40 US\$ each	120
▪ Other operating costs, estimated	200
Sub-total	695
<hr/>	
Annual costs	1 015
<hr/>	
Annual savings	
▪ Savings: 0.5 kg per operation (200 operations), US\$2 per kg	200
▪ Service charge: US\$ 8 per operation	1 600
Sub-total	1 800
<hr/>	
Total annual savings	
Obviously, it is profitable for the workshop to perform the recycling operation, even with a relatively conservative calculation.	785

Table 8: Recycling of CFC from mobile air-conditioning at a typical car service station in Malaysia in 1997

7. Providing Regulatory Support

As *Chapter 3* stresses, R&R systems will only operate effectively if they take place within the appropriate regulatory and fiscal framework.

Economic incentives and voluntary initiatives provide important support for R&R systems. However, often the appropriate regulatory framework is needed to make such systems economically viable in the first place, and also to enforce potentially unpopular measures. Only the mix of economic, voluntary, policy and legislative measures appropriate to the country conditions will ensure the successful implementation of R&R systems.

Even in cases where recycling of CFC refrigerants is profitable, it may not occur because of a lack of knowledge, skills and equipment, people's attitudes or simply resistance to change. In such cases, a mix of awareness raising, training and legislation will help.

This chapter describes the possible components of an appropriate regulatory framework.

Legislative framework

The formulation of the legislative framework should consider the following aspects:

1. Existing legislation for refrigerant use and ODS phase-out
2. Expected demand for refrigerants
3. Appropriate price levels for virgin and recycled CFC refrigerants
4. The economic and institutional situation of the country.

Some aspects of the use of CFC refrigerants are already covered by legislation in many countries, through standards for activities such as the setting up of refrigeration facilities and for the handling, transport and labelling of refrigerants.

Existing legislation for refrigerant use and ODS phase-out

Quality standards for refrigerants are particularly important where recycling is concerned, since refrigeration plants require high-quality recycled refrigerants which can only be provided by specific recycling machines and reclaim stations.

From the economic point of view, most countries levy duties on imported goods, and these often include refrigerants. This means that domestically recycled refrigerants have a competitive advantage compared with imported refrigerants.

Countries which design a national ODS phase-out programme and implement legislation in line with the Montreal Protocol will be more likely to succeed with CFC recycling and the related legislation. As a rule, any restriction on the use of virgin CFC in the refrigeration sector will support R&R. For example, a strict phase-out schedule for CFC refrigerants and the introduction of import quotas or taxes will increase the price of CFC refrigerants and consequently make R&R more attractive.

Expected demand for refrigerants

The need for R&R also depends on general market trends. Already the expectation that traditional CFC systems will be replaced by new non-CFC technologies within a few years, and that virgin CFC refrigerants will become scarce and expensive, is reducing the demand for CFC refrigerants and equipment.

However, where existing CFC systems have long remaining lifetimes, and new or second-hand CFC-using equipment is imported (which should not be permitted), there may be a sustained need for CFC refrigerants.

Countries whose key economic sectors depend on refrigeration and air-conditioning should be particularly careful to plan and manage their inventory of refrigeration equipment, and the use of refrigerants, well in advance.

Appropriate price levels for virgin and recycled refrigerants

Given the low price levels and the abundant availability of virgin CFC refrigerants in many Article 5 countries – at a cost of about US\$2 per kg in 1997 – appropriate support measures such as subsidies, duty-free imports of recycling equipment, taxes and import restrictions for CFC refrigerants will be necessary in order to make CFC recycling competitive.

R&R of CFC refrigerants in the commercial and industrial sectors will be more attractive than in the domestic sector because of the higher quantities of refrigerant involved. The economic feasibility of R&R in the different sectors will also depend on the design of the R&R system. A well-designed system will be simple and require little transport, thus being more cost-efficient.

Economic and institutional situation of the country

The establishment and operation of an R&R system for CFC refrigerants requires financial and human resources and major administrative efforts. A decentralised system with several recycling machines requires particularly high investment costs, but is likely to reduce the transport costs.

In order to establish an R&R system, the stakeholders involved need to provide administrative support, especially the NOUs, which are normally

responsible for establishing and monitoring the system. Some of the initial administrative and monitoring work can be supported through the Institutional Strengthening projects under the Multilateral Fund.

Regulatory options

Several regulatory options are available for supporting the establishment of R&R systems:

1. Ban on emissions
2. Ban or quotas for imports
3. Ban or quotas for imports of refrigeration devices
4. Taxes and price regulation (economic disincentives)
5. Subsidies and tax exemptions (economic incentives)
6. Training and certification of service technicians and operators
7. Public information.

Each of these options is discussed below. An overview of legislation for the control and monitoring of ODS in 36 selected countries – Article 5 and non-Article 5 countries – can be found in *"Regulations to Control Ozone-Depleting Substances"*, UNEP, SEI [7].

If emissions are prohibited, larger installations, which are more likely to be inspected, will be encouraged to apply good servicing practices to avoid intentional releases of CFC gases to the atmosphere – and to adopt company policy statements containing these aims. They may also consider retrofitting and replacing equipment to avoid being penalised or because it makes business sense. Recovery from large installations will provide a stock of recycled CFC refrigerants for companies using smaller equipment.

Given that LVC countries do not produce their own CFC refrigerants, the availability and use of CFC refrigerants can be directly reduced by setting a timetable for a strict ban on CFC imports, or the enforcement of an import quota system.

Ban on emissions

A tight schedule for the restriction of imports of CFC refrigerants will create a shortage of refrigerants and push up market prices. This will make the use of alternative substances, and recycling CFC refrigerants, more attractive. This assumes that CFC refrigerants were not stockpiled in previous years.

Sharp increases in CFC prices may also, however, encourage illegal imports of these substances. A tight ODS phase-out schedule, therefore, must be combined with effective import controls.

Ban or quotas for imports

One way to reduce the imports of CFC refrigerants is to establish or strengthen existing import/export licensing systems. Such a system would require importers of CFCs to obtain an import license, granted, for example,

on the basis of the importer's historic import levels and gradually reduced alongside the overall phase-out schedule for CFCs. In addition, large amounts of low-quality CFC refrigerants are sold on international markets, and therefore importers should be required to obtain certificates of quality.

Import/export licensing systems for ODS have become mandatory under the Montreal Protocol. More details can be found in *"Policy Design and Setting up of Legislation: Import/Export Licensing Systems"*, UNEP 1997 [12].

A quota system of this type requires efficient administration and control through the country's government agencies, such as the environmental protection agency or the customs department. Customs officers will need to be trained on the import/export licensing system and the identification of CFC refrigerants.

A number of LVC countries have already implemented similar regulations, including Guatemala (*Annex 4*). Ghana previously suffered from illegal CFC imports with low prices, which made it less attractive to substitute and recycle CFC refrigerants. Ghana's case study in *Annex 1* describes how illegal imports can be curbed and market prices stabilised.

Ban or quotas for imports of refrigeration devices

Most of the refrigeration and air-conditioning equipment used in LVC countries is imported and therefore these countries depend on the equipment available on the world market.

Since developed countries are phasing out CFC refrigerants faster than Article 5 countries, they are generating a surplus of second-hand CFC-using equipment. Some owners and equipment dealers are exporting this equipment to Article 5 countries without informing the recipients of the negative consequences of CFC use.

In recent times, for example, large air-conditioning plants have been sold to hotels, old CFC refrigerators have been shipped to African countries and used cars with CFC-12 air-conditioning systems have been exported to Central America and the Caribbean. These 'dumping' practices will make Article 5 countries more dependent on CFC, and once the market prices of CFC increase, the equipment will become expensive to maintain.

There are several ways of reducing imports of CFC-using refrigeration and air-conditioning equipment:

- An outright ban, or quotas, on imports of CFC-using refrigeration and A/C equipment
- Increased duties on CFC-using equipment
- Reduced duties on alternative refrigeration equipment
- Subsidised local development and manufacture of alternative refrigeration equipment.

The most effective and sustainable solution is to bring about a smooth transition to non-CFC using equipment – avoiding, as far as possible, the costs of premature decommissioning of CFC-using equipment, and ensuring that supplies of CFC refrigerants are adequate to run existing equipment until the end of its economic life. The country should therefore, undertake detailed planning of its future needs for refrigeration equipment and CFC refrigerants.

The country should also avoid becoming dependent on the intermediate HCFC refrigerants, given that this type of refrigerant is to be phased out at a later stage. In the long term, the use of HFC refrigerants will also be controlled under the Kyoto Protocol.

In order to ban imports of CFC-using equipment effectively, customs officers must be able to distinguish between CFC-using and alternative refrigeration equipment. This requires adequate training and information for customs officers.

Publication and promotion of the phase-out schedule for CFCs will discourage potential purchasers of new CFC refrigeration and air-conditioning equipment.

A number of developed countries have levied taxes on imports and sales of CFCs in order to reduce their consumption. Tax levels vary widely from one country to another. Some countries introduced taxes at a relatively low level and then increased them to several times the original market prices of the substances.

The purpose of these taxes is to raise the price of CFC refrigerants, encouraging end-users to switch to alternative refrigerants, and to foster better practices and recycling of the refrigerants whenever possible. Furthermore, the tax revenue can be specifically used for the promotion of CFC recycling.

The following factors should be taken into account when levying taxes on CFC refrigerants:

- Taxable substances and tax level
- Availability of substitutes
- Information for end-users
- Risk of illegal imports
- Government enforcement capacity.

In most countries, taxes have been levied only for CFCs, including aerosol, foam and refrigeration applications. The tax level is designed to make the refrigerant several times more expensive than its pre-tax price.

Taxes and price regulation (economic disincentives)

Taxable substances and tax level

However, it is difficult to evaluate the real effect of taxes when they are accompanied by a general phase-out plan or ban on CFC use. The taxes have a relatively large effect on the retail price of products such as foams, aerosols and large refrigeration and air-conditioning facilities. They have less impact on the price of CFC-using mobile A/C or domestic refrigerators because of the relatively high prices of the refrigeration equipment and the small quantities of CFCs involved.

Several countries have also levied taxes on HCFCs in order to reduce their value as a substitute for CFC refrigerants.

The appropriate tax level should be balanced between several factors:

- The tax level should be high enough to make the switch to alternative non-CFC refrigerants attractive to consumers.
- The tax level should be high enough to make the recycling of CFC refrigerants attractive.
- The tax level should not be too high, since this makes illegal imports attractive. If this occurs, strict controls must be applied.

As these points counteract each other, individual assessments are needed for each country.

Availability of substitutes

Taxes aimed at substituting CFC refrigerants will not be successful unless reasonably priced alternative refrigerants and equipment is available. When drop-in substitution is possible, only the alternative refrigerant is needed, but otherwise reasonably priced alternative refrigeration equipment must be available as well.

If cost-efficient alternatives are not available, the users of refrigeration appliances will tend to run them until the end of their economic life and increasingly apply good practices and recycling. However, the way in which owners react to the tax also depends on the availability of appropriate information from refrigeration service companies, e.g. on the economic implications of the different options.

It is advisable to encourage refrigeration associations to distribute information on alternative refrigerants available on the international markets. This will, in turn, encourage the distributors to import them.

Information for end-users

Refrigeration service companies are usually not directly affected by the tax, because they simply pass it on to the end users. However, they should be interested in promoting alternative refrigerants and equipment in order to sustain their business in the long term. They should therefore familiarise themselves with the new technologies and pass their knowledge on to their customers.

Once end users are informed about alternative refrigerants and technology, they will purchase non-CFC solutions from their suppliers.

Higher prices of CFC refrigerants may foster illegal imports, which have been observed in several countries which have levied CFC taxes.

Risk of illegal imports

Illegal imports may undermine the move towards alternative refrigerants and refrigerant recycling, resulting in continued emission of CFC refrigerants to the atmosphere and encouraging users to ignore the phase-out plan for CFCs.

When a country imposes taxes on CFC refrigerants, administrative resources must be provided for the monitoring and control of the import and sale of the taxed substances. When the CFC refrigerants are imported by a limited number of dealers, this is relatively easy, but when numerous distributors are involved, the administrative work requires much more effort.

Government enforcement capacity

The use of alternative refrigerants and equipment can be promoted through subsidies, tax reductions and duty-free imports. Subsidies may support the development of new refrigeration technologies or the installation of available non-CFC technologies.

Subsidies and tax exemptions

Subsidies for the development of new technologies may enable the country and its industrial sectors to reduce dependency on foreign technology. However, the countries may have difficulties in raising the necessary funds. Some countries, such as Denmark, have subsidised the development of alternative technology with the revenue from the import tax on CFC refrigerants (*see Annex 4*).

Another way of eliminating the use of CFC refrigerants is to lift import taxes on alternative refrigerants and refrigeration appliances, including R&R equipment. This gives non-CFC technology a competitive edge over CFC-dependent technology. Tax exemptions for R&R equipment also make recycling more attractive. Such support measures may be financed through tax revenues from CFC refrigerants and technology.

Training and certification

Another way to reduce CFC emissions is to ensure that technicians are appropriately trained and that only certified technicians and companies are allowed to purchase and to handle CFC refrigerants. This can be achieved through a certification scheme involving training of specialised personnel in good practices and recycling, as well as control of the purchase of the necessary R&R equipment.

Such a certification scheme may influence the existing structure of the refrigeration servicing sector, especially if there is a large informal sector.

In Denmark (*Annex 4*), a certification system has been implemented under which only authorised companies and persons are allowed to recycle and purchase CFC refrigerants for refilling refrigeration appliances.

Public information The success of an R&R system depends on its acceptance by both the operators and the end users, and this means that they must be properly informed.

Operators should be made aware that CFC refrigerants can be recovered and recycled, and should receive appropriate training.

End users and the owners of refrigeration and air-conditioning facilities should be made aware of the advantages of recycling refrigerants. This target group can be informed both through the operators and by means of public information. It is important that the end users are aware of the environmental and economic benefits of recycling, as well as of the quality of the recycled refrigerant.

Annexes

- Annex 1** Experience from Ghana:
CFC refrigerant recycling for domestic, commercial
and mobile refrigeration and air-conditioning

- Annex 2** Experience from Guatemala:
CFC refrigerant recycling for domestic, commercial
and industrial refrigeration

- Annex 3** Experience from Malaysia:
CFC recycling for MAC sector

- Annex 4** Experience from Denmark:
CFC recycling in all sectors

- Annex 5:** List of approved R&R projects for refrigerants

- Annex 6:** Glossary & definitions

- Annex 7:** Further references

- Annex 8:** About the UNEP DTIE OzonAction Programme

- Annex 9:** Useful contact addresses

Annex 1: Experience from Ghana: CFC refrigerant recycling for domestic, commercial and mobile refrigeration and air-conditioning

1. Introduction and summary

Ghana is one of the first LVC countries to have successfully implemented a National CFC Refrigerant Management Programme, primarily consisting of:

- A refrigeration maintenance training programme
- Monitoring of current CFC refrigerant consumption
- Establishment of a R&R system.

The purpose of the National Programme, financed by the Multilateral Fund under the Montreal Protocol, is to promote good practices for CFC refrigerant management, including R&R among refrigeration and car service companies.

Training activities in good practices were initiated in 1993. The project for refrigerant recycling in domestic, commercial and mobile refrigeration and air conditioning got under way in 1995.

The programme is managed by the NOU within the national Environmental Protection Agency. The R&R system consists of 12 recycling centers located at 12 regional technical institutes and universities.

For the R&R project, a total of 14 recycling machines, together with cylinders, leak detectors etc., were distributed to the 12 centers. From these centers the refrigeration service companies can borrow the R&R equipment free-of-charge.

A total of 1750 managers, instructors and technicians from refrigeration service companies and institutes have been trained in good refrigerant management and recycling, resulting in a remarkable reduction in the use of CFC refrigerants, from about 32 tonnes in 1995 to about 15 tonnes in 1996. Most of the reduction in the use of CFCs is due to better refrigerant management, and only to a lesser extent to recycling.

Although some CFC refrigerant has been recycled, especially from major refrigeration plants, the general impression is that service companies are reluctant to recover and recycle the refrigerants because the economic incentives (lower costs for new CFCs) are limited and the companies have to borrow the recycling equipment from the centers each time they need it. Easier access to the recycling equipment could increase the amounts of CFC recovery and recycling.

The Government of Ghana has so far (1997) not adopted any legislation supporting the recovery and recycling of CFC refrigerants. However, draft legislation aimed at tightening the CFC phase-out (by controlling the imports of CFCs and other ODS) has been considered by the Government.

2. Organisation

The RMP and R&R projects are implemented by the National Ozone Unit, within the national EPA, and with technical assistance primarily given by the Accra Technical Training Center (ATTC) and two local consultants.

Within ATTC a National Refrigeration Demonstration Center (NRDC) has been established in order to organise and conduct training in good refrigerant management, to develop a facility for refrigerant R&R and to act as an information center within the field.

The National CFC Refrigerant Management Programme receives assistance from UNEP and UNDP.

3. Project design

The programme consists of the following steps:

- Establishment of project organisation, including establishment of refrigerant management training centers
- Establishment of CFC refrigerant recycling centers in the regional capitals (12 centers)
- Establishment of a national co-ordination center (NRDC) for the R&R system
- Appointment of consultants and suppliers of equipment
- Distribution of recycling equipment among the regional technical institutes (1 recycling machine for each of the 12 regional centers and one extra for two of the centers located in large cities)
- Training of 30 trainers from technical institutes
- Training of personnel from workshops (a total of 1750 managers and technicians), all members of the National Air Conditioning and Refrigeration Workshop Owners Association (NARWOA)
- Public awareness campaigns
- Follow-up information to workshops etc.
- Monitoring of the use of recycling machines, current imports and consumption of CFCs.
- Drafting legislation
- Monitoring of refrigeration workshops to ensure compliance with techniques acquired during the training courses.

The establishment of a national Refrigeration Institute has been initiated in order to stimulate co-operation within the commercial and industrial refrigeration sectors and to improve the exchange of information among centers around the world.

4. Technical set-up

The technical set-up of the R&R system is mostly a decentralised one, given that the recycling machines are distributed throughout the country and that CFC refrigerant recycling takes place on site.

The recycling machines are stationed at the centers, where the refrigeration service companies borrow them free of charge. The transport from and back to the centers is provided by the centers, but must be paid for by the service companies.

The recycling machines chosen for the project are automatic recycling machines, which

recover and recycle the refrigerant in two consecutive steps. This means that the recovered and recycled refrigerant will be recharged into the same refrigeration facility from which it was recovered.

The recovery procedure takes about 10 minutes per kg of refrigerant recycled, which accounts for most of the additional labour time required by the recycling operation. In most cases, the refrigerant left in the serviced refrigeration facilities can be recycled and purified to a satisfactory quality. In a few cases, such as compressor burnout, the refrigerant cannot be recycled. The non-recyclable CFC is vented to the air as there exist no facilities for disposal.

The recycling machines indicate automatically when the refrigerant has been purified to SAE/ULC quality standards.

5. Achievements and experience gained

By 1997, about 2 tonnes of CFC refrigerants had been recycled in connection with the national R&R programme – 1.2 tonnes in 1995 and 0.8 tonnes in 1996. In 1996 the amount was divided among the following types of refrigeration facilities:

- 90 kg of CFC-12 from commercial refrigeration and A/C (an average of 10 kg per operation)
- 600 kg of CFC-11 from chillers (an average of 50 kg per operation)
- 100 kg of CFC-12 from MAC (an average of about 0.5 kg per operation)
- 10 kg of CFC-12 from domestic refrigerators (an average of less than 0.1 kg per operation).

A few refrigeration service companies have bought refrigerant recycling equipment themselves. It is not known how much CFC these companies have recycled.

Based on import statistics, there has been a reduction in CFC refrigerant imports from about 32 tonnes in 1995 to about 15 tonnes in 1996. This reduction is primarily due to better management of the CFC refrigerants, and to a lesser extent to recycling of CFCs.

One reason for the reduced use of CFC refrigerants is the avoidance of several forms of malpractice, such as:

- Cleaning of the refrigeration system with CFC
- Leak testing with CFC
- Over-charging of the system with CFC refrigerants.

Avoidance of these practices has resulted in a two-fold, and in some instances three-fold reduction of the amount of refrigerants consumed. Given that the volume of illegal CFC imports in the same period has declined, these official figures seem to be reliable.

6. Economics of refrigerant R&R

Investments:

In the R&R project the refrigeration service companies borrow the R&R equipment from the centers. Hence, the companies do not need to invest in the equipment (which costs approximately US\$ 4,500 per recycling machine, including refillable cylinders and accessories).

The only investment made by the refrigeration service companies is the time spent on training, usually two or three days for the workshop manager or one technician. With labour

costs at between US\$5-10 per day, the investment for each workshop is between US\$15-30.

Operating Costs:

The operating costs of the companies for a recycling operation only include the labour costs: time for organising transport of the recycling machine, recovery of refrigerant and the cost of transport of the equipment. Maintenance and change of filters are the responsibility of the recycling centers and are covered in the project budget.

The market price of CFC-12 and -11 is about US\$4 per kg (1997 figures). With labour costs of between US\$0.5 - 1.2 per hour, this would seem to make recycling profitable.

Transport of the recycling machine normally costs between US\$2-5. This means that at least several kgs of CFCs must be recycled in order to make the operation profitable.

However, a number of factors make recycling less attractive:

- Recycling is not relevant in all workshop jobs.
- Whenever the service companies want to recycle refrigerants, they must collect the equipment from a center.
- Only a small amount of CFC can be recovered from small plants.
- In some cases, the owner of the refrigeration facility may claim the ownership of the recycled refrigerant.

If the refrigeration companies had to pay for renting the equipment, recycling would be even less attractive for them. Most of the companies cannot afford to invest in R&R equipment themselves, and, with interest rates for private loans as high as 45%, credit would be far too expensive.

7. Legislation

As mentioned above, the Government of Ghana had not – at the time of initiation of the R&R programme – adopted any legislation directly or indirectly supporting CFC refrigerant recycling. The EPA has drafted an Act of Parliament for strengthening the control of chemical imports, including ODS.

8. Attitude towards CFC recycling

Experience with the project shows that the attitude to better management of CFC refrigerants is positive, resulting in reduced consumption and emission of CFC to the atmosphere. The attitude towards recycling of CFC refrigerants is positive as well. However, the added administrative and economic load for the service companies discourages them from using R&R equipment.

9. Outstanding questions

It would be possible to recycle greater volumes of CFC refrigerant if more equipment were available and accessible to the workshops, and if the equipment could be bought at a much lower, subsidised price.

The problem of the disposal of non-recyclable CFCs still remains to be solved.

Annex 2: Experience from Guatemala: CFC refrigerant recycling for domestic, commercial and industrial refrigeration

1. Introduction and summary

Guatemala has successfully implemented a National CFC Refrigerant R&R Programme, primarily consisting of two recycling projects, one for the domestic, commercial and industrial refrigeration sectors and one for the mobile air-conditioning sector.

The purpose of the projects, financed by the Multilateral Fund, is to promote R&R among refrigeration and car service companies.

The project for refrigerant recycling in domestic, commercial and industrial refrigeration was launched in April 1997. In this project a number of training courses have been organised, and several R&R machines have been distributed to selected users. The project for MAC, financed as a bilateral project by US EPA, was about to start in mid 1997.

A total of 104 recovery and 4 recycling machines will be distributed for the domestic, commercial and industrial refrigeration project, and 24 recycling machines for the MAC project.

The Government of Guatemala had not – by 1997 - approved or implemented any legislation supporting the R&R of CFC refrigerants. The NOU within the Comisión Nacional de Medio Ambiente (CONAMA) has made extensive efforts to register all companies and institutions involved in the import, transport and use of CFC refrigerants. Legislation to regulate the use of ODS was recently prepared by CONAMA and submitted to the government, requiring importers to be registered and to submit annual reports on imports to the CONAMA.

2. Organisation

The R&R project has been implemented by the NOU with technical assistance from a local company, EXEA, and funded by the Multilateral Fund through UNDP.

The MAC project, which is supported by US EPA, will be implemented with assistance from the American consulting company ICF.

3. Project design

The project for domestic, commercial and industrial refrigeration consists of:

- Establishment of project organisation, including establishment of a Refrigeration Engineering Association, and a network for CFC recycling among local technical institutes
- Appointment of a consultant and suppliers of equipment
- Selection of participating refrigeration service workshops (104 out of about 350)
- Public awareness campaigns
- Training of trainers at technical institutes
- Training of technicians (1-2 technicians from each participating service company, trained in groups of 8-10 companies)
- Distribution of recycling equipment among the selected workshops (1 recovery machine

for small and medium-sized workshops and recycling machines for 4 large service companies)

- Organisation of the network: allocating the small workshops to the four recycling centers and establishing the logistics (transport, reporting and quality control)
- Follow-up information to workshops etc.
- Monitoring of the use of recycling machines and current imports and consumption
- Commissioning of machines to the workshops after two years of operation.

The design of the MAC project still lacks some details and is pending completion.

4. Technical set-up

The technical set-up for the R&R project within domestic, commercial and industrial refrigeration is a "semi-centralised" system in the sense that activities are divided into four regions, each with one recycling machine operating as a center for a number of recovery machines.

Two of the recycling machines are situated in the capital, Guatemala City, while a third one is placed in the northern harbour town of Puerto Barrios, and the fourth one in the major southern harbour town of Puerto Quetzal. This system will require transport of the recovered refrigerant to the recycling centers.

A total of 104 recovery and 4 recycling machines, each with two refillable cylinders and other accessories, will be distributed to a similar number of refrigeration workshops. The recovery machine has a vapour rate of 0.4 kg/min and a liquid rate of 1.8 kg/min (the average 60 kg/hour will depend on the amount recovered; large amounts could be faster and small amounts slower). The recycling machine chosen for the project can recycle up to 40 kg (8 hours operation) without the operator's supervision.

The recovery procedure takes 2–10 minutes per operation, which accounts for most of the additional working time necessary for the recycling operation. The cleaning of the recovered CFC takes about 6 hours for a full cylinder (5 kg per hour), but this can be done automatically outside working hours. The recycled CFC meets the SAE J1991 or ARI 700 quality standards.

5. Achievements and experience gained

It cannot yet be stated exactly how much CFC has been recycled as a result of the project because very few machines have been distributed.

However, one workshop repairing domestic refrigerators, and a workshop repairing commercial and industrial refrigeration facilities, have gained some experience.

The domestic refrigerator workshop, which is an in-house workshop for the major soft drink distributors, maintains some 35,000 refrigerators of its own. The workshop is equipped with a recovery machine, cylinders and other accessories. When servicing the refrigerators, the CFC is recovered and stored in refillable cylinders. The CFC is re-charged into the repaired refrigerators without further purification. In case of compressor burnout the CFC is stored in separate cylinders and is not reused. The CFC from worn-out refrigerators is recovered and reused whenever possible.

The commercial and industrial workshop, which services a number of large commercial and industrial refrigeration and air-conditioning systems, has been equipped with a recovery

machine and filter units as well as cylinders and other accessories. The company frequently services refrigeration facilities with 50-100 kg of CFC. Depending on the nature of the service, the refrigerant is refilled after the service or stored in refillable cylinders for subsequent purification or destruction. Once the recycling system is fully established, the recovered CFC will be sent to one of the recycling centers for purification.

6. Economics of recycling

The economic results of the CFC recycling project are considered to be positive for the participating companies, although the profit has not yet been estimated. The recovery procedures are not considered to be time-consuming because the machines are almost entirely automatic.

Investments:

The only investment by the companies is the time spent on a training course, lasting less than three days.

Operating Costs:

For domestic refrigerators the recovery procedure takes only a few minutes and is therefore not considered to add working time for the repair. For the large commercial and industrial refrigeration facilities, the time for the recovery of refrigerants depends on the amount of refrigerants. However, here also, the recovery procedure does not add appreciably to the time the procedure takes without recovery, since during recovery a number of other activities can be performed.

The cost of filters, repair and maintenance of the equipment etc. is also considered to be low.

In spite of the fact that new refrigerants are currently inexpensive (1997 prices: CFC-11: US\$4/kg, CFC-12: US\$5/kg, HCFC-22: US\$5.5/kg, HFC-134a: US\$19/kg), recovery is attractive to the service workshops due to its very low costs.

The labour cost is approximately 15 Q (US\$ 2.6) per hour, or 0.5–2.5 Q (US\$ 0.1-0.4) per operation, which makes the operation profitable for the workshops.

7. Legislation

Guatemala had by 1997 no legislation directly supporting R&R activities, but the ODS phase-out scheme for Article 5 countries has been adopted as national legislation. In addition to this, the NOU has established a registry for all refrigeration workshops in the country, according to the various categories. Furthermore, by 1997 all importers of ODS must be registered with CONAMA, and apply for an import permit for these substances. They also must prepare annual reports on the amounts imported and sold.

8. Attitude towards CFC recycling

The experience from the project shows that the attitude towards R&R varies widely from one workshop to the other. Some workshops consider the participation in the project a good opportunity to "do something for the environment", combined with the possibility of improving the service and making a small but real profit, while others show limited interest in the activity.

The larger, better-organised workshops that participated in the training courses are relatively positive, and seem to consider the activity attractive both from an economic and business point of view. However, it is not clear what their attitude would be if they had to pay the full price, or even a reduced price, for the equipment. The main obstacle to R&R seems to be the high cost of the equipment.

None of the workshops has any doubts about the quality of the recycled CFC. The workshops involved in the programme are convinced of the high quality of recycled CFC, and their only concern is for the refrigerants recovered after compressor burnout. In these cases the refrigerant is not recycled, but stored in separate cylinders.

9. Outstanding questions

It is still uncertain how much refrigerant can actually be recycled.

Experience shows that it is difficult to involve all refrigeration workshops in the refrigerant recycling activities, probably due to the lack of information, and the fear that the recycling operation creates additional costs.

Annex 3: Experience from Malaysia: CFC recycling for MAC sector

1. Introduction and summary

Malaysia has successfully implemented an R&R project in the mobile air-conditioning sector. The purpose of the project, financed by the Multilateral Fund, is to encourage car service companies to recycle CFC refrigerants. In total, 200 R&R machines have been distributed to the service workshops.

2. Organisation

The Department of Environment, within the Ministry of Science, Technology and Environment, implemented the project with technical assistance from a local consulting company. IBRD acted as the international implementing agency.

3. Project design

The project consists of:

- Project organisation
- Appointment of consultant and supplier of equipment
- Selection of participating workshops (200 out of 700-800)
- Training of technicians (1–2 from each selected workshop)
- Public awareness
- Distribution of recycling equipment among the selected workshops (1 set per workshop)
- Follow-up information to workshops etc.
- Monitoring of the use of recycling machines:
 - Quarterly report from workshops to DOE
 - Maintenance visits by consultant to workshops
 - Unscheduled visits by DOE to workshops
 - Final survey for the purpose of handing over the equipment
 - Retraining of technicians
 - Commissioning of machines to the workshops.

4. Technical set-up

The R&R system was designed as a "decentralised" system in the sense that the available R&R machines were distributed among selected workshops all over the country. The workshops recover and recycle the CFC refrigerants themselves. This means that it is not necessary to transport recovered CFC between the various workshops.

A total of 200 R&R machines, each with two refillable cylinders and accessories, were distributed to a similar number of workshops. The R&R machines chosen for the project are "semi-automatic" machines which operate in three steps:

- First, the refrigerant is recovered by vacuum from the air-conditioning system and stored in a refillable cylinder attached to the R&R machine.
- Then the air-conditioning system is charged with either new or recycled CFC from a separate cylinder.

- Once the first cylinder is full, the recovered refrigerant is purified through a filter and made ready for reuse.

The recovery procedure takes 2–10 minutes, which accounts for most of the additional labour time needed for the recycling operation. The cleaning of the recovered refrigerant takes about 6 hours for a full 50 lb cylinder, but this can be done automatically outside working hours.

The recycled CFC meets the SAE J1991 or ARI 700 quality standards, and in general the car owners have been satisfied with the recycling scheme, although some required the service companies to recharge with virgin CFC.

Automatic R&R machines that recover, clean and recharge the refrigerant in a single operation were rejected for this project, because of the poor quality of the recycled CFC they produce.

5. Achievements and experience gained

80% of the 200 R&R machines that were distributed are currently in use. The remainders are not being used for reasons such as mechanical defects, lack of skilled operators and lack of interest from the workshop owners.

It is not known exactly how much CFC has been recycled as a result of the project because no measurements have been made. The recycling machines are equipped with a clock, which measures the operation time, but it does not give exact information on how much CFC is recovered or recycled.

However, comparative estimates based on the purchase of new refrigerant before and after distribution of the recycling machines by the participating workshops show that the purchase of new refrigerant has dropped by approximately 20%. This would suggest that, as a result of the project, at least 20% of the 1997 consumption in the mobile air-conditioning sector has been recycled.

6. Economics of recycling

The average workshop charges its customers a total of 50 RM (US\$20) for servicing, which includes:

- 15 RM (US\$ 6) for the vacuum of the MAC system
- 15 RM (US\$ 6) for refilling the system with approximately 0.6 kg of CFC (0.5 kg virgin CFC); and
- 20 RM (US\$ 8) for servicing.

The average workshop costs are:

Investments:

- 500 RM (US\$ 200) as a fee for participating in the project, including delivery of a recycling machine which will become the property of the workshop after two years of proper

operation. The market price of the machine is around 10,000 RM (US\$ 4,000).

- Costs for attendance of a one or two-day training course.

Operating Costs:

- Labour costs for each recycling operation (2-10 minutes with an average of 5 minutes)
- Costs for changing of filters (costing 170 RM) every 30 hours of operation
- Repair and maintenance costs of the recycling machine (estimated at less than 400 RM – US\$160 – per year).
- Cost of electricity and lubrication oil (negligible).

Labour costs are approximately 3-6 RM (US\$ 1.5–3) per operation, which comes to 1,000–2,000 RM (US\$400–800) per month, which makes the activity profitable for the workshops.

7. Legislation

The control of service and installation of refrigeration and air-conditioning equipment using CFC refrigerants is primarily governed by the DOE Guidelines on Control Measures for the Protection of the Ozone Layer. CFC refrigerants from A/C and refrigeration units must be recovered and recycled, securely stored or returned to the distributor in connection with the service, maintenance and decommissioning. Codes of Good Practice should be followed for design and service. Suppliers and dealers of ODS must be registered, but there are no requirements for service workshops to be allowed to service or install refrigeration and A/C equipment, e.g. training or the use of certified of R&R equipment. By the end of 1997, an Environmental Quality Order was to be enforced, covering requirements for R&R of refrigerants.

In addition to this, an import tax on CFCs of 8% has been introduced, and the use of ODS alternatives has been promoted by means of import duty exemption.

Public awareness campaigns have been launched providing information on the environmental benefits of using recycled instead of virgin CFC refrigerants.

8. Attitude towards CFC recycling

The experience from the project shows that the attitude towards CFC recycling varies widely from one workshop to the other. Some workshop owners feel that the project gives them an opportunity to 'do something for the environment' while improving their service and making a profit, while others show only moderate interest in the activity.

Several workshops that were not selected for the project have bought CFC recycling machines on their own accord, while some of the participating workshops have bought a second machine. This indicates that at least some workshops are interested in providing refrigerant recycling service even when the equipment must be bought without subsidies.

9. Outstanding questions

It is still uncertain how much CFC refrigerant can effectively be recovered and recycled in the mobile air-conditioning sector. The refrigerant charge of MAC systems in need of servicing varies widely. On average it is less than half of the initial charge, which in Malaysia is

approximately 0.6 kg of CFC-12.

Experience shows that it is difficult to persuade some service workshops to participate in an R&R scheme, even though it may be profitable. And most workshops are unwilling to report on their activities which creates difficulties for the monitoring and evaluation of the project.

Annex 4: Experience from Denmark: CFC recycling in all sectors

1. Introduction and summary

Recycling of CFC refrigerants was introduced in Denmark soon after the first R&R machine was developed in the late 1970s. Refrigerant recycling has today become a standard procedure in the refrigeration sector, primarily due to the high cost of CFC refrigerants, a direct result of the strict Danish legislation aimed at ODS phase-out.

In 1994 the Danish Government introduced the first special tax on CFCs and halons and a phase-out schedule for banning ODS for specific applications. This phase-out plan was later intensified, with the banning of all imports and sales of virgin CFCs from 1 January 1995.

Refrigerant recycling activities are performed on commercial and industrial refrigeration systems as well as domestic refrigerators. This also includes mobile air-conditioning, although this sector is relatively insignificant in Denmark.

2. Organisation

The overall regulatory instruments and strategies for ODS phase-out in Denmark are formulated by the Danish EPA. In spite of the fact that Denmark, as a member of the European Union, is bound by EU legislation on ozone layer protection, it has added its own, more rigorous standards.

CFC recycling in Denmark falls into two types of activity:

- R&R from refrigeration and air-conditioning systems
- Collection and R&R from end-of-life refrigerators.

R&R from refrigeration and air-conditioning systems is administered by an independent organisation belonging to the Association of Refrigeration Service Companies, the KMO scheme, voluntarily established in agreement with the Danish EPA.

The collection of old refrigerators and R&R of the refrigerant is administered by municipalities, in compliance with a statutory order of the national Government.

3. The KMO Scheme

The KMO scheme was established in 1992 to support a smooth transition to non-CFC refrigerants, with special emphasis on refrigerant management.

Refrigeration service companies cannot buy CFC refrigerants unless at least one employee has received training in good practices in the handling of refrigerants and recycling. Before 1 January 1995 it was still legal to buy virgin CFC refrigerants for refrigeration equipment, but since that date only recycled CFC has been allowed on the market.

According to the agreement with the Environmental Agency, all refrigeration service jobs using CFCs must be reported to the KMO, which provides an overview of the use of both new and recycled CFC refrigerants.

Refrigeration service companies are free to recycle refrigerant without restrictions, but they must report on their activity to the KMO register. They must recover CFC refrigerant whenever possible, and the CFC which they do not reuse themselves must be delivered to wholesale companies in cylinders.

The service companies are paid US\$ 1.5 per kg of recyclable CFC delivered to the wholesale companies and US\$ 0.7 per kg of non-recyclable CFC. The service companies must pay an administrative fee of US\$ 2 per kg to the KMO for each kg of halogenated refrigerant (recycled CFCs, HCFCs and HFCs) they buy.

The wholesale companies are responsible for recycling or reclaiming the recovered refrigerant to an acceptable quality (ARI standard) and for delivering the non-recyclable refrigerant to a central incineration plant for the destruction of hazardous waste.

The price of CFC refrigerants has risen sharply due to phase-out, and currently stands at about US\$50 per kg – this makes it attractive for the service companies to recycle as much as possible, rather than delivering it to the wholesalers. Likewise, the wholesalers have an incentive to recycle, because they can sell the recycled CFC at a price close to the market rate.

4. Recovery of CFC from old refrigerators

All municipalities, in compliance with a Statutory Order of 1995, must take charge of the collection of old refrigerators and the recovery of the refrigerants. In practice, most of the municipalities, except for the large cities, have joined together in mutual schemes.

In most townships the waste management department collects old refrigerators upon request, transporting them to central recycling centers where the refrigerant is recovered and stored in cylinders. The recovered refrigerant is delivered to a reclaim center, which either cleans up the refrigerant or ensures its destruction. The costs of these schemes are covered by municipal income tax.

Parallel to this municipal scheme, household appliance stores, when selling a new refrigerator, collect the old one free of charge. A surcharge of approximately US\$40 is added to the price of new refrigerators to cover the dealers' costs of transporting the old refrigerators to the municipal collection centers. The dealers have to pay the collection centers approximately US\$20 for the disposal of the refrigerators.

It has been estimated that the costs of recovering CFC from refrigerators are between US\$ 100–300 per kg of CFC. However, some municipal governments have brought this cost down by making use of employment projects and various types of subsidised activities.

5. Achievements and experience gained

The tax on imported CFC refrigerants had no immediate effect on recycling activities, but it did contribute to a growing awareness of the ozone issue and the fact that there would soon be a shortage of CFC refrigerants.

The ban on imports of CFC refrigerants created a shortage and market prices increased significantly. They now range between US\$ 30–70 per kg.

The exact volume of CFC refrigerants recycled internally by the service companies is not known, but in 1996 some 30 tonnes of CFC refrigerants were returned to the wholesalers for recycling or destruction.

6. Economics of recycling

Most refrigeration service companies have invested in R&R equipment, and the high market prices of CFC obviously make this a profitable business.

7. Attitude towards CFC recycling

There is a generally positive attitude towards CFC recycling among the refrigeration service companies, the public and the owners of refrigeration facilities.

Annex 5: List of approved R&R projects for refrigerants

As of July 1999, 109 technical assistance and demonstration projects related to R&R of refrigerants had been approved by the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol.

Out of 109 approved projects, 25 more recent projects were approved in the framework of RMPs. In total, 50 projects (46%) are completed (COM) or closed (CLO), 50 projects (46%) are ongoing (ONG) and 9 projects (8%) are newly approved in 1999 (NEW).

The Executive Committee approved 73 projects (67%) for the implementing agencies UNDP, UNIDO and IBRD and 36 projects (33%) for bilateral implementation. Table 9 demonstrates the share for each agency and the implementation status and Table 10 contains the list of approved R&R projects as of July 1999.

The Access database "Inventory of Approved Projects" [20] contains more detailed information and is regularly up-dated by the Multilateral Fund Secretariat.

AGENCY	TOTAL NUMBER OF PROJECTS PER AGENCY	NEWLY APPROVED PROJECTS (% of agency total)	ONGOING PROJECTS (% of agency total)	COMPLETED OR CLOSED PROJECTS (% of agency total)
UNDP	44	4%	57%	39%
UNIDO	15	40%	7%	53%
IBRD	14		36%	64%
USA	19		32%	68%
Canada	5		100%	
Germany	5	20%	60%	20%
France	3		100%	
Australia	2		50%	50%
Denmark	1			100%
Finland	1		100%	
TOTAL	109	8%	46%	46%

Table 9: Share of R&R projects for each agency and implementation status as of July 1999

NO	COUNTRY	DATA BASE CODE	PROJECT TITLE	AGENCY	APPROVAL	STATUS
1	Kenya	n.a.	R&R project	Germany	Jul-99	NEW
2	Nepal	n.a.	RMP implementation: National programme for R&R of refrigerants	UNDP	Jul-99	NEW
3	Sudan	n.a.	RMP implementation: R&R project	UNIDO	Jul-99	NEW
4	Romania	n.a.	RMP implementation: R&R project	UNIDO	Jul-99	NEW
5	Macedonia	n.a.	RMP implementation: R&R project	UNIDO	Jul-99	NEW
6	Jordan	n.a.	RMP implementation: National R&R project	UNIDO	Jul-99	NEW
7	Honduras	n.a.	RMP implementation: National R&R project	UNIDO	Jul-99	NEW
8	Croatia	n.a.	RMP implementation: National R&R project	UNIDO	Jul-99	NEW
9	Niger	NER/REF/27/TAS/07	RMP implementation: National programme for R&R of refrigerants	UNDP	Mar-99	NEW
10	Antigua and Barbuda	ANT/REF/26/TAS/06	RMP implementation: National R&R project	Barbuda Canada	Nov-98	ONG
11	Botswana	BOT/REF/26/TAS/06	RMP implementation:	Germany	Nov-98	ONG
12	Global	GLO/REF/26/TAS/172	RMP implementation: 14 LVC countries in Eastern and Southern Africa	Germany	Nov-98	ONG
13	Swaziland	SWA/REF/26/TAS/05	RMP implementation	Germany	Nov-98	ONG
14	Burundi	BDI/REF/26/TAS/05	RMP implementation: National programme for R&R of refrigerants	UNDP	Nov-98	ONG
15	Gabon	GAB/REF/26/TAS/06	RMP implementation: National programme for R&R of refrigerants	UNDP	Nov-98	ONG
16	Nicaragua	NIC/REF/25/TAS/06	RMP implementation	Finland	Jul-98	ONG
17	Dominican Republic	DOM/REF/25/TAS/13	RMP implementation: National programme for R&R of refrigerants	UNDP	Jul-98	ONG
18	El Salvador	ELS/REF/25/TAS/09	RMP implementation:			
19	Moldova	MOL/REF/25/TAS/02	RMP implementation: National programme for R&R of refrigerants	UNDP	Jul-98	ONG
20	Saint Kitts and Nevis	STK/REF/24/TAS/04	RMP implementation	Canada	Mar-98	ONG
21	Cote d'Ivoire	IVC/REF/24/TAS/10	RMP implementation	France	Mar-98	ONG
22	Namibia	NAM/REF/24/TAS/05	R&R project: R&R of CFC-12 integrated with the introduction of hydrocarbon technology in the service sector	Germany	Mar-98	COM
23	Guyana	GUY/REF/23/TAS/08	RMP implementation: National R&R programme	Canada	Nov-97	ONG
24	Saint Lucia	STL/REF/23/TAS/04	RMP implementation	Canada	Nov-97	ONG
25	Lebanon	LEB/REF/23/TAS/21	R&R project: Implementation of an ODS R&R network	France	Nov-97	ONG
26	Morocco	MOR/REF/23/TAS/17	R&R project: Implementation of an ODS R&R network	France	Nov-97	ONG
27	Bahamas	BHA/REF/23/TAS/05	RMP implementation: National programme for R&R of refrigerant	UNDP	Nov-97	ONG

NO	COUNTRY	DATA BASE CODE	PROJECT TITLE	AGENCY	APPROVAL	STATUS
28	Georgia	GEO/REF/23/TAS/04	RMP implementation: R&R project: National programme for R&R of refrigerants	UNDP	Nov-97	ONG
29	Trinidad and Tobago	TRI/REF/23/TAS/09	RMP implementation: R&R project: National programme for R&R of refrigerant	UNDP	Nov-97	ONG
30	Jamaica	JAM/REF/23/DEM/07	MAC R&R project: MAC demonstration project	USA	Nov-97	ONG
31	Trinidad and Tobago	TRI/REF/23/DEM/08	MAC R&R project: MAC demonstration project	USA	Nov-97	ONG
32	Turkey	TUR/REF/23/DEM/32	MAC R&R project: MAC servicing demonstration project	USA	Nov-97	ONG
33	Venezuela	VEN/REF/22/TAS/55	R&R project: Implementation of a centralized reclamation plant for recovered refrigerants in the commercial refrigeration and air-conditioning sector	Canada	May-97	ONG
34	Bahrain	BAH/REF/22/TAS/04	R&R project: National programme for R&R of refrigerant	UNDP	May-97	ONG
35	Lesotho	LES/REF/22/TAS/04	R&R project: National programme for R&R of refrigerant	UNDP	May-97	ONG
36	Mozambique	MOZ/REF/22/TAS/06	R&R project: National programme for R&R of refrigerant	UNDP	May-97	ONG
37	Tanzania	URT/REF/22/TAS/08	R&R project: National programme for R&R of refrigerant	UNDP	May-97	ONG
38	Venezuela	VEN/REF/22/TAS/58	R&R project: Recovery and reclamation of refrigerants	UNDP	May-97	ONG
39	Benin	BEN/REF/22/TAS/04	R&R project: Refrigerant R&R scheme	UNIDO	May-97	COM
40	Burkina Faso	BKF/REF/22/TAS/05	R&R project: Refrigerant R&R scheme	UNIDO	May-97	COM
41	Gambia	GAM/REF/22/TAS/05	R&R project: Refrigerant R&R scheme	UNIDO	May-97	COM
42	Guinea	GUI/REF/22/TAS/05	R&R project: Refrigerant R&R scheme	UNIDO	May-97	COM
43	Philippines	PHI/REF/22/TAS/49	R&R project: National CFC R&R scheme	UNIDO	May-97	COM
44	Senegal	SEN/REF/22/TAS/08	R&R project: Refrigerant R&R scheme	UNIDO	May-97	COM
45	Vietnam	VIE/REF/20/DEM/14	R&R project: Demonstration project CFC recycling and emissions reduction in the commercial refrigeration sector	Australia	Oct-96	ONG
46	Bolivia	BOL/REF/20/TAS/04	R&R project: National programme for R&R of refrigerant	UNDP	Oct-96	ONG
47	Central African Republic	CAF/REF/20/TAS/05	R&R project: National programme for R&R of refrigerants	UNDP	Oct-96	ONG
48	Congo	PRC/REF/20/TAS/04	R&R project: National programme for R&R of refrigerants	UNDP	Oct-96	ONG
49	Sri Lanka	SRL/REF/20/TAS/08	R&R project: National programme for R&R of refrigerants	UNDP	Oct-96	ONG

NO	COUNTRY	DATA BASE CODE	PROJECT TITLE	AGENCY	APPROVAL	STATUS
50	Vietnam	VIE/REF/20/DEM/13	R&R project: Demonstration project in CFC recycling and emissions reduction in the commercial refrigeration sector	UNDP	Oct-96	ONG
51	Vietnam	VIE/REF/20/DEM/15	MAC R&R project: MAC servicing demonstration project	USA	Oct-96	ONG
52	Malawi	MLW/REF/19/TAS/05	R&R project: National programme for R&R of refrigerant	UNDP	May-96	COM
53	Uganda	UGA/REF/19/TAS/05	R&R project: National programme for R&R of refrigerant	UNDP	May-96	COM
54	Zambia	ZAM/REF/19/TAS/06	R&R project: National programme for R&R of refrigerant	UNDP	May-96	COM
55	Peru	PER/REF/19/TAS/17	R&R project: National programme for R&R of refrigerant	UNDP	May-96	ONG
56	Chile	CHI/REF/19/DEM/15	MAC R&R project: Demonstration mobile air-conditioning (MAC) and refrigerated transport (RT)	USA	May-96	COM
57	China	CPR/REF/19/DEM/163	MAC R&R project: Refrigeration mobile air-conditioning (MAC) servicing	USA	May-96	COM
58	Guatemala	GUA/REF/19/DEM/10	MAC R&R project: Mobile air-conditioning (MAC) and refrigerated transport (RT)	USA	May-96	COM
59	Costa Rica	COS/REF/19/DEM/09	MAC R&R project: Mobile air-conditioning (MAC) and refrigerated transport (RT)	USA	May-96	ONG
60	Malaysia	MAL/REF/18/TAS/77	R&R project: Reduction of the consumption of ODSs in the commercial air-conditioning sector via training, R&R of CFC-11 and CFC-12 in chillers at Mashrae	IBRD	Nov-95	ONG
61	Uruguay	URU/REF/18/TAS/19	R&R project: R&R of CFC-12 in maintenance workshops for industrial refrigeration equipment	IBRD	Nov-95	ONG
62	Dominican Republic	DOM/REF/18/TAS/06	R&R project: Demonstration project in commercial refrigeration (food storage, distribution and retailing)	UNDP	Nov-95	COM
63	Jamaica	JAM/REF/18/TAS/03	R&R project: National programme for R&R of refrigerant	UNDP	Nov-95	COM
64	Mexico	MEX/REF/18/TAS/43	R&R project: Recovery of CFC-12 servicing of domestic refrigeration at Vitromatic Comercial y Servicios Integrados	UNDP	Nov-95	COM
65	Region: LAC	LAC/REF/18/TAS/15	R&R project: Regional Latin America demonstration project in recovery of ODS in MACs: Phase I (Argentina, Colombia)	UNDP	Nov-95	COM

NO	COUNTRY	DATA BASE CODE	PROJECT TITLE	AGENCY	APPROVAL	STATUS
66	Global	GLO/REF/18/TAS/90	R&R project: Global MACs project: Phase 2	UNDP	Nov-95	ONG
67	Guatemala	GUA/REF/18/TAS/09	R&R project: National programme for R&R of refrigerant	UNDP	Nov-95	ONG
68	Panama	PAN/REF/18/TAS/06	R&R project: National programme for R&R of refrigerant	UNDP	Nov-95	ONG
69	Barbados	BAR/REF/18/TAS/04	R&R project: CFC-recovery, recycling and training in refrigeration	UNIDO	Nov-95	COM
70	Dominican Republic	DOM/REF/18/DEM/05	R&R project: Demonstration project in commercial refrigeration (food storage, distribution and retailing)	USA	Nov-95	COM
71	Philippines	PHI/REF/18/DEM/41	MAC R&R project: MACs servicing demonstration project	USA	Nov-95	ONG
72	Argentina	ARG/REF/17/TAS/24	R&R project: Provision of training in leak reduction, emission control and recycling and management of non-CFC refrigerants in domestic and commercial refrigeration and air-conditioning	Australia	Jul-95	COM
73	China	CPR/REF/17/TAS/130	R&R project: Establishment of a CFC recycling centre at Zhejiang Dongyang Chemical Factory	Denmark	Jul-95	COM
74	China	CPR/REF/17/DEM/131	R&R project: Demonstration project (refrigeration - large food stores)	UNDP	Jul-95	COM
75	Colombia	COL/REF/17/TAS/19	R&R project: National programme for R&R of refrigerant	UNDP	Jul-95	ONG
76	Mauritius	MAR/REF/17/TAS/07	R&R project: National CFC-12 R&R programme and demonstration of retrofit technology in commercial refrigeration	UNDP	Jul-95	ONG
78	Zimbabwe	ZIM/REF/17/TAS/04	R&R project: CFC refrigerant recovery and reclaim project	UNIDO	Jul-95	COM
79	Dominican Republic	DOM/REF/17/DEM/03	MAC R&R project: Demonstration project in MACs	USA	Jul-95	COM
80	China	CPR/REF/17/DEM/135	R&R project: Demonstration project (refrigeration - large food stores)	USA	Jul-95	COM
81	Argentina	ARG/REF/16/DEM/22	MAC R&R project: MAC servicing demonstration	USA	Mar-95	COM
82	China	CPR/REF/16/DEM/117	MAC R&R project: MAC servicing demonstration	USA	Mar-95	COM

NO	COUNTRY	DATA BASE CODE	PROJECT TITLE	AGENCY	APPROVAL	STATUS
83	Indonesia	IDS/REF/15/TAS/29	MAC R&R project: Reduction of CFC-12 emission during service of MAC by use of recycling equipment	IBRD	Dec-94	ONG
84	Venezuela	VEN/REF/15/TAS/32	MAC R&R project: Pilot project for MAC R&R of CFC-12 in MAC (Phase II)	UNDP	Dec-94	COM
85	Cuba	CUB/REF/15/TAS/04	R&R project: National programme for R&R of refrigerant	UNDP	Dec-94	COM
86	Colombia	COL/REF/15/DEM/13	MAC R&R project: MAC emissions reduction demonstration programme	USA	Dec-94	COM
87	Venezuela	VEN/REF/15/DEM/30	MAC R&R project: Demonstration project in the refrigeration sector	USA	Dec-94	COM
88	Mexico	MEX/REF/13/DEM/27	MAC R&R project: Demonstration project in MAC	USA	Jul-94	COM
89	Venezuela	VEN/REF/13/DEM/28	MAC R&R project: Demonstration project in MAC	USA	Jul-94	COM
90	Venezuela	VEN/REF/12/DEM/26	MAC R&R project: Pilot programme in MAC R&R of CFC-12 in MAC	UNDP	Mar-94	COM
91	Uruguay	URU/REF/12/TAS/04	R&R project: Conservation and demonstration programme for domestic and commercial refrigeration and installation of R&R equipment	UNDP	Mar-94	COM
92	China	CPR/REF/11/TAS/55	R&R project: Survey on policy and planning measures to promote recycling of CFC	UNDP	Nov-93	COM
93	India	IND/REF/10/TAS/05	R&R project: Feasibility study for the R&R of CFC refrigerants	UNIDO	Jun-93	ONG
94	Venezuela	VEN/REF/09/TAS/17	R&R project: Pilot programme in R&R of CFC-12 in domestic refrigeration	UNDP	Mar-93	COM
95	Ghana	GHA/REF/08/TAS/04	R&R project: Improved servicing and maintenance within the refrigeration sector	UNDP	Oct-92	COM
96	Costa Rica	COS/REF/08/TAS/04	R&R project: National programme for R&R of refrigerant	UNDP	Oct-92	ONG
97	Venezuela	VEN/REF/08/DEM/06	MAC R&R project: Technical assistance and demonstration project in CFC recycling in MAC	USA	Oct-92	COM
98	Jordan	JOR/REF/07/DEM/10	R&R project: R&R of CFC-12 in refrigeration equipment and maintenance procedures and recycling in halon systems	IBRD	Jun-92	CLO
99	Chile	CHI/REF/07/TAS/22	R&R project: R&R programme at Central De Servicios Tecnicos (CST)	IBRD	Jun-92	COM

NO	COUNTRY	DATA BASE CODE	PROJECT TITLE	AGENCY	APPROVAL	STATUS
100	Tunisia	TUN/REF/07/TAS/07	R&R project: Maintenance of domestic, commercial and industrial refrigeration systems	IBRD	Jun-92	COM
101	Turkey	TUR/REF/07/TAS/03	R&R project: R&R of CFC-12 at a refrigeration production plant	IBRD	Jun-92	COM
102	Turkey	TUR/REF/07/TAS/04	R&R project: Recovery and reclamation of CFC-12 from household refrigerators	IBRD	Jun-92	COM
103	Thailand	THA/REF/07/TAS/07	MAC R&R project: CFC recycling in MAC	IBRD	Jun-92	ONG
104	Brazil	BRA/REF/07/TAS/07	R&R project: CFC-12 collection, recycling and conservation programme for household refrigerator maintenance and repair shops	IBRD	Jun-92	ONG
105	Global	GLO/HAL/07/DEM/25	R&R project: Procurement of 40 halon recycling machines for demonstration	UNDP	Jun-92	COM
106	Malaysia	MAL/REF/06/TAS/05	MAC R&R project: Conservation, leakage control and recycling of CFC-12 and demonstration project in MAC sector	IBRD	Feb-92	COM
107	China	CPR/REF/06/TAS/04	MAC R&R project: Feasibility study on the application of HFC-134 a technology in MACs and CFC recycling	UNDP	Feb-92	COM
108	Mexico	MEX/REF/05/DEM/06	R&R project: Demonstration programme in CFC R&R of the Instituto Mexicano del Seguro Social (IMSS) refrigeration equipment	IBRD	Nov-91	COM
109	Mexico	MEX/REF/05/TAS/08	R&R project: CFC R&R of refrigeration equipment in Monterrey City (Climas Jiménez)	IBRD	Nov-91	COM
110	Mexico	MEX/REF/05/TAS/13	R&R project: CFC R&R programme through Quimobásicos, S.A.	IBRD	Nov-91	COM

Table 10: Refrigerant recovery & recycling projects approved by the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, as of July 1999.

Annex 6: Glossary & definitions

Article 5 country

Developing countries which are Party to the Montreal Protocol with an annual calculated level of consumption less than 0.3 kg per capita of the controlled substances in Annex A, and less than 0.2 kg per capita of the controlled substances in Annex B, on the date of entry into force of the Montreal Protocol, on any time thereafter. These countries are permitted a ten year grace period compared to the phase-out schedule in the Montreal Protocol for developed countries.

Blend

A blend is a mixture of two or more pure fluids. A ternary blend contains three fluids. Given the right composition, blends can achieve properties to fit almost any refrigeration purpose. For example, a mixture of flammable and non-flammable components can result in a non-flammable blend. Blends can be divided into three categories: azeotropic, non-azeotropic and near-azeotropic blends.

CFC

Chlorofluorocarbons - a family of organic chemicals composed of chlorine, fluorine and carbon atoms, usually characterised by high stability contributing to a high ODP. These fully halogenated substances are commonly used in refrigeration, foam blowing, aerosols, sterilants, solvent cleaning, and a variety of other applications. CFCs have the potential to destroy ozone in the atmosphere.

Chiller

System used for air-conditioning or process cooling based on a water cooling system and typically found in large buildings, such as hotels, office buildings, and hospitals.

Commercial refrigeration

Refrigeration equipment used at sites where food and/or beverages are warehoused, and all sites where they are sold to the public.

Domestic refrigeration

Refrigeration equipment for domestic use, usually with a small hermetically sealed compressor.

Drop-in replacement

The procedure when replacing CFC-refrigerants in existing refrigerating, air-conditioning and heat pump plants without doing any plant modification. However, drop-in are normally referred to as retrofitting because minor modifications are needed, such as change of lubricant, replacement of expansion device and desiccant material.

GWP

The relative contribution of certain substances (greenhouse gases), e.g. carbon dioxide, methane, CFCs, HCFCs and halons, to the global warming effect when the substances are released to the atmosphere by combustion of oil, gas, coal (CO₂), direct emission, leakage from refrigerating plants etc. The standard measure of GWP is relative to carbon dioxide (GWP can be given with 20, 100 or 500 years integration time horizon, but 100 years is most commonly used).

HCFC

Hydrochlorofluorocarbons - a family of chemicals related to CFCs, which contains hydrogen, chlorine, fluorine, and carbon atoms. HCFCs are partly halogenated and have much lower ODP than the CFCs. Examples of HCFC refrigerants HCFC-22 (CHClF₂) and HCFC-123 (CHCl₂F₃)

HFC

Hydrofluorocarbons - a family of chemicals related to CFCs, which contains one or more carbon atoms surrounded by fluorine and hydrogen atoms. Since no chlorine or bromine is present, HFCs do not deplete the ozone layer. HFCs are widely used as refrigerants. Examples of HFC refrigerants are HFC-134a (CF₃CH₂F) and HFC-152a (CHF₂CH₃).

LVC countries

Low-volume-ODS-consuming countries - defined by the Multilateral Fund's Executive Committee as Article 5 countries whose calculated level of ODS consumption is less than 360 tonnes annually.

ODP

Ozone depletion potential - a relative index indicating to which extent a chemical product may cause ozone depletion. The reference level of 1 is the potential of CFC-11 and CFC-12 to cause ozone depletion. If a product has an ozone depletion potential of 0.5, a given weight of the product in the atmosphere would, in time, deplete half the ozone that the same weight of CFC-11 would deplete. The ozone depletion potentials are calculated from mathematical models, which take into account factors such as the stability of the product, the rate of diffusion, the quantity of depleting atoms per molecule, and the effect of ultraviolet light and other radiation on the molecules. The substances implicated generally contain chlorine or bromine.

ODS

Ozone depleting substances - any substance with an ODP greater than 0 that can deplete the stratospheric ozone layer. Most of ODS are controlled under the Montreal Protocol and its amendments, and they include CFCs, HCFCs, halons, methyl bromide and carbon tetra chloride.

Recovery

To remove a refrigerant in any condition (vapour, liquid or mixed with other substances) from a system and to store it in an external container (ISO 11650 definition).

Reclaim

To process used refrigerant to the product specifications of new refrigerant. Chemical analysis of the refrigerant is required to determine that the appropriate specifications are met. The identification of contaminants and the required analysis must be specified in national or international standards for new product specifications (ISO 11650 definition).

Recycling

To reduce the contaminants in used refrigerants by separating oil, removing condensables and using devices such as filter dryers to reduce moisture, acidity and particulate matter (ISO 11650 definition).

Retrofitting

Conversion of a refrigeration system to an alternative refrigerant with a minimum change to its cooling performance. Unlike a replacement, only parts or components of the existing system may need to be replaced.

Annex 7: Further references

- [1] Case Studies - Refrigerant Recovery and Recycling, UNEP, 1994
- [2] Preliminary list of Manufacturers of Recycling, Recovery and Reclaim Equipment for Refrigerants, UNEP, 1994
- [3] Good Practices in Refrigeration - Training Manual, UNEP, 1994
- [4] Chillers and Refrigerant Manual - Training Manual, UNEP, 1994
- [5] Retrofitting with non-CFC substitutes, UNEP, Information Paper, 1994
- [6] Elements for Establishing Policies, Strategies and Institutional Framework for Ozone Layer Protection, UNEP, 1995
- [7] Regulations to Control Ozone-Depleting Substances, UNEP/SEI, 1996
- [8] Reducing CFC in Refrigeration: Strategic Options for Countries with Low CFC Consumption, ICF for USEPA and UNIDO, 1996
- [9] Report on UNEP's continued work on addressing the needs of Low Volume ODS Consuming Countries, UNEP, (UNEP/OzI.Pro/ExCom/20/60), 1996
- [10] Guidelines for Preparation of Refrigerant Management Plan, UNEP, 1997
- [11] Standards:
 - ISO 11650 Performance of Refrigerant Recovery/Recycling Equipment
 - ARI 740.98 Performance of Refrigerant Recovery/Recycling Equipment
 - ARI 700.93 Specifications for Fluorocarbon and Other Refrigerants
 - ARI 700.95 Standard on Recovered Refrigerants
 - SAE J1991 Standard of Purity for Use in Mobile Air Conditioning Systems
 - SABS 1583:1993 Refrigerant Recycle Equipment for the Minimisation of Environmental Pollution during the Servicing and Repair of Automotive Air-Conditioning Equipment, South African Bureau of Standards.
- [12] ODS Import/Export Licensing Systems - Policy Design and Setting up of Legislation, UNEP/SEI, 1998
- [13] Guidebook on Implementation of Codes of Good Practice - Refrigeration Sector, UNEP, 1998
- [14] Zero Leaks - Limiting Emissions of Refrigerants, Denis Clodic, ASHRAE, 1998
- [15] Designing a Program to Recover CFCs from Domestic Appliances, Environment Canada
- [16] Directory of Certified Refrigerant Recovery and Recycling Equipment, ARI, 1998
- [17] Handling and Reuse of Refrigerants in the United States, Industry Recycling Guide 2, Air-Conditioning and Refrigeration Institute, 1994
- [18] Policies, Procedures, Guidelines and Criteria, UNEP Ozone Secretariat, 1999
- [19] 13th IIR Informatory Note on Refrigerants: Standards for Flammable Refrigerants
- [20] Inventory of Approved Projects, Access database, Multilateral Fund Secretariat, 1999.

Annex 8: About UNEP DTIE and its OzonAction Programme

About the OzonAction Programme

Nations around the world are taking concrete actions to reduce and eliminate emissions of CFCs, halons, carbon tetrachloride, methyl chloroform, methyl bromide and HCFCs. When released into the atmosphere these substances damage the stratospheric ozone layer — a shield that protects life on Earth from the dangerous effects of solar ultraviolet radiation. Nearly every country in the world — currently 170 countries — has committed itself under the Montreal Protocol to phase out the use and production of ODS. Recognising that developing countries require special technical and financial assistance in order to meet their commitments under the Montreal Protocol, the Parties established the Multilateral Fund and requested UNEP, along with UNDP, UNIDO and the World Bank, to provide the necessary support. In addition, UNEP supports ozone protection activities in Countries with Economies in Transition (CEITs) as an implementing agency of the Global Environment Facility (GEF).

Since 1991, the UNEP DTIE OzonAction Programme has strengthened the capacity of governments (particularly National Ozone Units or “NOUs”) and industry in developing countries to make informed decisions about technology choices and to develop the policies required to implement the Montreal Protocol. By delivering the following services to developing countries tailored to their individual needs, the Programme has helped promote cost-effective ODS phase-out activities at the national and regional levels:

Information Exchange provides information tools and services to encourage and enable decision makers to make informed decisions on policies and investments required to phase out ODS. Since the 1991, the Programme has developed and disseminated to NOUs over 100 individual publications, videos, and databases that include public awareness materials, a quarterly newsletter, a web site, sector-specific technical publications for identifying and selecting alternative technologies and guidelines to help governments establish policies and regulations.

Training builds the capacity of policy makers, customs officials and local industry to implement national ODS phase-out activities. The Programme promotes the involvement of local experts from industry and academia in training workshops and brings together local stakeholders with experts from the global ozone protection community. UNEP conducts training at the regional level and also supports national training activities (including providing training manuals and other materials).

Networking provides a regular forum for officers in NOUs to meet to exchange experiences, develop skills, and share knowledge and ideas with counterparts from both developing and developed countries. Networking helps ensure that NOUs have the information, skills and contacts required for managing national ODS phase-out activities successfully. UNEP currently operates 4 regional and 3 sub-regional Networks involving more than 109 developing and 8 developed countries, which have resulted in member countries taking early steps to implement the Montreal Protocol.

Refrigerant Management Plans (RMPs) provide countries with an integrated, cost-effective strategy for ODS phase-out in the refrigeration and air conditioning sectors. RMPs have evolved

to meet the specific need to assist developing countries (especially those that consume low volumes of ODS) to overcome the numerous obstacles to phase out ODS in the critical refrigeration sector. UNEP DTIE is currently providing specific expertise, information and guidance to support the development of RMPs in 40 countries.

Country Programmes and Institutional Strengthening support the development and implementation of national ODS phase-out strategies especially for low-volume ODS-consuming countries. The Programme is currently assisting 91 countries to develop their Country Programmes and 76 countries to implement their Institutional-Strengthening projects.

For more information about these services please contact:

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About the UNEP Division of Technology, Industry and Economics

The mission of the UNEP Division of Technology, Industry and Economics is to help decision-makers in government, local authorities, and industry develop and adopt policies and practices that:

- are cleaner and safer;
- make efficient use of natural resources;
- ensure adequate management of chemicals;
- incorporate environmental costs;
- reduce pollution and risks for humans and the environment.

The UNEP Division of Technology, Industry and Economics located in Paris, is composed of one centre and four units:

The International Environmental Technology Centre (Osaka) promotes the adoption and use of environmentally sound technologies with a focus on the environmental management of cities and freshwater basins, in developing countries and countries in transition.

The Production and Consumption Unit (Paris) fosters the development of cleaner and safer production and consumption patterns that lead to increased efficiency in the use of natural resources and reductions in pollution.

The Chemicals Unit (Geneva) promotes sustainable development by catalysing global actions

and building national capacities for the sound management of chemicals and the improvement of chemical safety world-wide, with a priority on Persistent Organic Pollutants (POPs) and Prior Informed Consent (PIC, jointly with FAO)

The Energy and OzonAction Unit (Paris) supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition, and promotes good management practices and use of energy, with a focus on atmospheric impacts. The UNEP/RISØ Collaborating Centre on Energy and Environment supports the work of the Unit.

The Economics and Trade Unit (Geneva) promotes the use and application of assessment and incentive tools for environmental policy and helps improve the understanding of linkages between trade and environment and the role of financial institutions in promoting sustainable development.

UNEP DTIE activities focus on:

- raising awareness
- improving the transfer of information,
- building capacity,
- fostering technology co-operation,
- partnerships and transfer,
- improving understanding of environmental impacts of trade issues,
- promoting integration of environmental considerations into economic policies,
- and catalysing global chemical safety.

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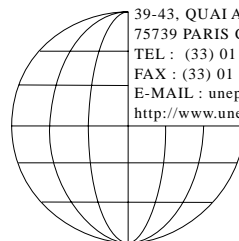
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GUIDELINES FOR RECOVERY & RECYCLING SYSTEMS REFRIGERATION SECTOR

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3. **Effectiveness**

This document is designed to assist ozone officers from national ozone units as well as representatives from refrigeration industry and trade associations in Article 5 countries to design and implement refrigerant recovery and recycling (R&R) systems. It aims to investigate the economical and technical feasibility and provides examples of successfully established recycling and recovery systems. Has this document been effective in meeting these objectives?

Please tick one box: **Fully** **Adequately** **Inadequately**

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- Guidance on how to design R&R systems
- Guidance on how to evaluate the economical and technical feasibility of R&R systems
- Guidance on how to implement R&R systems
- Guidance on how to establish the legislative framework
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