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FINAL REPORT
FOR
UNIDO PROJECT NO. MP-IND/93/163

ON

FEASIBILITY STUDY FOR RECOVERY & RECYCLING OF CFC REFRIGERANTS

(UNIDO CONTRACT NO. 94/037/VK)

M.94.629N/

JUNE, 1994

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I. INTRODUCTION

1.1 Background

The 'Feasibility Study for the Recovery & Recycling of CFC Refrigerants' (Project Ref No. MP/IND/93/163) was entrusted to Mantec Consultants Pvt Ltd, New Delhi vide UNIDO Contract No. 94/037/VK dated 28th February, 1994.

1.2 Project Objectives

The project aims at carrying out a study to, first, investigate the possibility of recovering CFCs from refrigerators, air-conditioners and mobile air-conditioners and if the result of this part is positive, then to check the individual and combined feasibility of the following :

* Strategies of recycling CFCs, such as centralised recycling versus distributed at individual enterprises.

* Possibilities of local manufacturing of recovery and recycling equipment.

* Possibility of reducing CFC consumption through better housekeeping. Training of repair and maintenance technicians.

1.3 The first interim report under sub-paragraph [B_2 (a)] of the Terms of Reference of contract, covering design of questionnaires and selection of sample enterprises, etc. was submitted by Mantec Consultants to UNIDO vide letter No. M.93.585 N/834 dated 28th February, 1994.

1.4 The second interim report, addressed to the work under sub-paragraph [B2 (b)] of the Terms of Reference of the contract and covered the following :

* Recovering CFCs from refrigerators, air-conditioners and mobile air-conditioners.

* Recycling CFCs (including checking the viability of collection networks, centralised versus distributed recycling, etc.).

* Local manufacturing of recovery and recycling equipment.

* Reducing CFC refrigerant consumption through better housekeeping and training of repair and maintenance technicians.

This report was submitted by Mantec consultants to UNIDO vide letter No. M.93.585 dated 31 March, 1994.

1.5 The final report has been prepared as per the Terms of Reference, reproduced in Annexure - 1.1. It also incorporates comments from UNIDO on Second Interim Report, vide their fax dated 12th May, 1994, discussions with Ministry of Environment and Forest, Government of India and subsequently discussed with Mr Cahit Gurkok, Acting Head, Engineering and Metallurgical Industries Branch UNIDO on 3rd June, 1994.

1.6 Chapter-II describes the methodology used.

1.7 Chapter-III refers to the survey analysis of refrigerator industry and the service stations in the organised/informal sector with particular reference to the potential for recovery and recycling and other methods for reducing CFC consumption such as good housekeeping, etc.

1.8 Chapter-IV and Chapter-V similarly deal with these issues for the mobile air-conditioner and air-conditioner sub-sectors respectively.

1.9 Chapter-VI analyses the feasibility of local manufacture of recovery and recycling equipment.

1.10 Chapter-VII assesses the feasibility of recycling of CFCs including collection networks and centralised versus distributed recycling.

1.11 Chapter-VIII summarises the findings of the study and brings out conclusions.

1.12 The list of reports & publications referred in the preparation of the report are given in Annexure 1.2 as Bibliography.

II. METHODOLOGY

2.1 As per the Terms of Reference, two cities had to be selected for field survey, data collection and analysis. Delhi and Bombay were chosen for this purpose by the project team as these two metropolitan cities have the largest concentrations of refrigerators, air-conditioners and mobile air-conditioners-car, bus etc. Five out of eight refrigerator manufacturers in the country have their manufacturing facilities/central offices/company service stations located in these two cities. Two of the manufacturing enterprises which have been covered in the survey namely Kelvinator at Delhi and Godrej at Bombay account for 85% of the annual domestic production of Refrigerators.

In case of car air conditioners all the three manufacturers covering 100% of the capacity available in the country are located in these two cities. Their major service stations are also located in Delhi and Bombay.

Similarly, in the case of room air conditioners, seven out of nine manufacturers are located in Delhi and Bombay, and they account for 70% of air conditioners manufactured in the country. These two cities also have a very high standard of living and use a large percentage of refrigerating and air conditioning equipment.

All these factors prompted the project team to select Delhi and Bombay as the 2 cities to be surveyed to get a realistic appraisal of the CFC that can be recovered and/or recycled.

2.2 The sample size of 95 included all manufacturers in the 2 cities, their own service centres as well as a cross section of servicing enterprises.

The sample covers enterprises not only in the organised sector but also in the informal sector. The analysis of the sample survey covering the major part of this industry will therefore provide a reasonably accurate appraisal.

2.3 Representative enterprises have been identified covering the three sub-sectors, namely, refrigerators, air-conditioners and mobile air-conditioners in both organised and informal sectors.

The distribution of enterprises is as follows :

	Delhi	Bombay
Refrigerators:		
Refrigerator Manufacturing Enterprises	2	3
Servicing Enterprises of Manufacturers	3	4
Servicing Enterprises in informal sector	5	2
Room Air Conditioners:		
Room A/C Manufacturing Enterprises		
- Organised sector	2	5
- Informal sector Servicing Enterprises	3	2
Room A/C Servicing Enterprises		
- Organised Sector	2	3
- Informal sector	9	8

Package Air-conditioners:

Package A/C Manufacturing Enterprises		
- Organised sector	2	3
- Informal sector	1	-
Package A/C Servicing Enterprises		
- Organised sector	2	1
- Informal sector	1	5

Car Air-conditioners:

Car A/C Manufacturing Enterprises	2	1
Car A/C Servicing Enterprises		
- Organised sector	4	-
- Informal Sector	4	9

Bus/Van Air-conditioners:

Bus/Van A/C Manufacturing Enterprises	1	-
Bus/Van Servicing Enterprises		
- Organised Sector	-	2
- Informal Sector	1	3
Total	44	51

58 enterprises have been covered in all, but as some of the units are involved in manufacture/servicing of more than one product, the total number of sample enterprises has become 95. The list of enterprises/service stations covered during the field survey in Delhi and Bombay is given at Appendix 2.1.

2.4 Different field survey questionnaires have been designed for manufacturers and for service stations (Appendices 2.2 and 2.3) to collect the base line data through visits and one-to-one interaction with the technical personnel.

2.5 The sub-sector-wise coverage of manufacturing enterprises in Delhi and Bombay is shown in the form of bar charts at Fig. 2.1 and Fig. 2.2 respectively. Similarly, the sub-sector-wise coverage of servicing enterprises in Delhi and Bombay is shown at Fig. 2.3 and Fig. 2.4 respectively. The overall sub-sector coverage (% distribution) in Delhi and Bombay as part of the field survey for manufacturing and servicing enterprises is shown in the form of pie-charts at Fig. 2.5 and Fig. 2.6 respectively.

2.6 In subsequent chapters III, IV and V, the details of each enterprise are presented and analysed.

COVERAGE OF MANUFACTURING ENTERPRISES DELHI

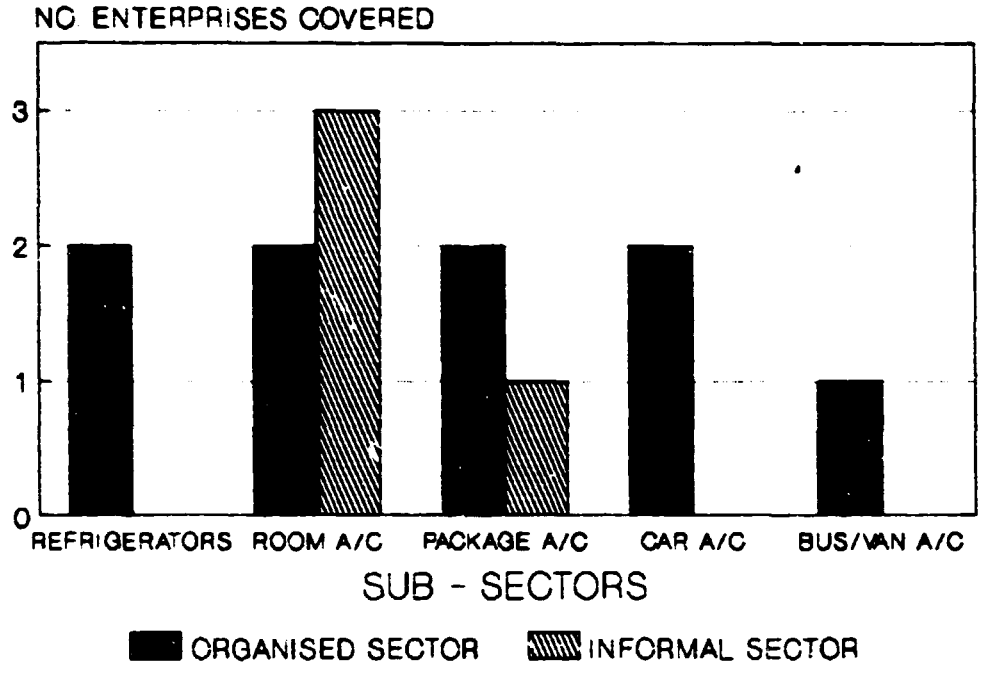

FIGURE - 2.1

COVERAGE OF MANUFACTURING ENTERPRISES BOMBAY

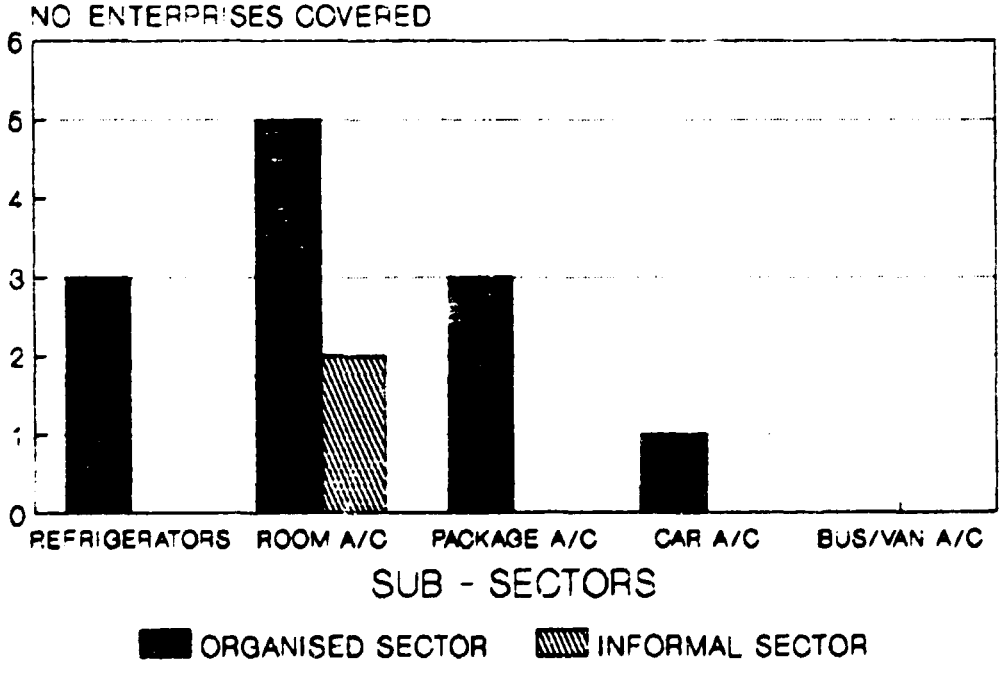

FIGURE - 2.2

COVERAGE OF SERVICING ENTERPRISES DELHI

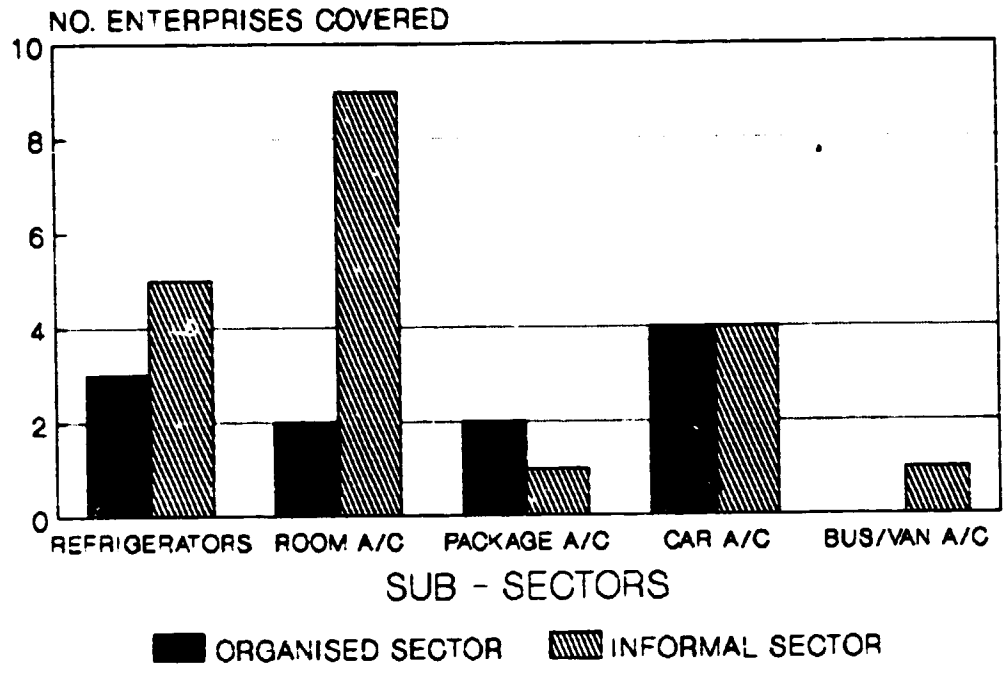

FIGURE - 2 3

COVERAGE OF SERVICING ENTERPRISES BOMBAY

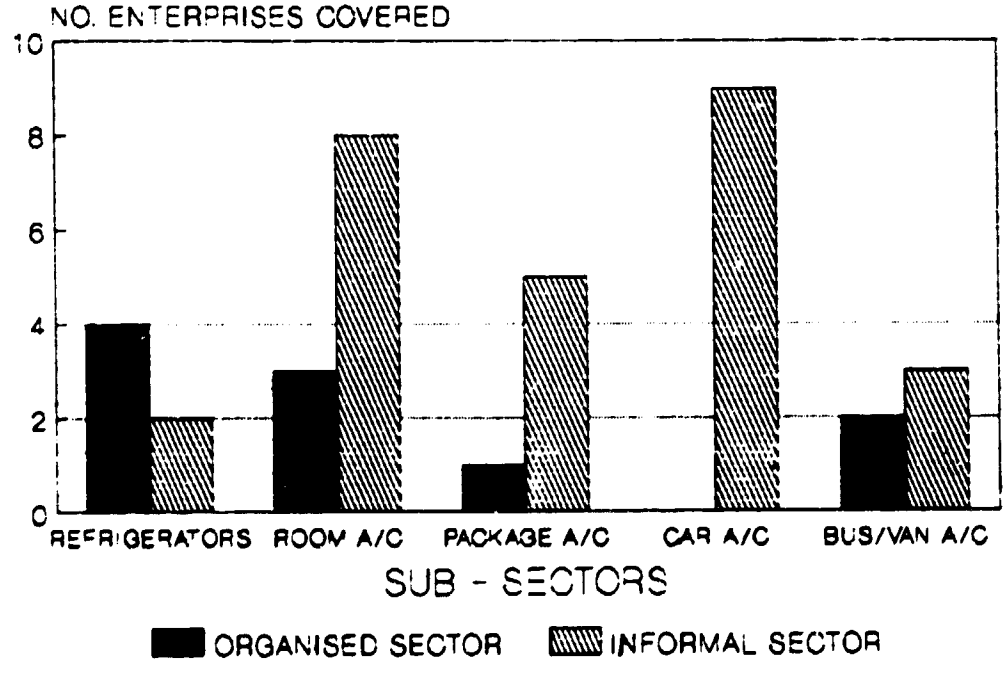

FIGURE - 2.4

SUBSECTOR COVERAGE IN DELHI & BOMBAY MANUFACTURING ENTERPRISES

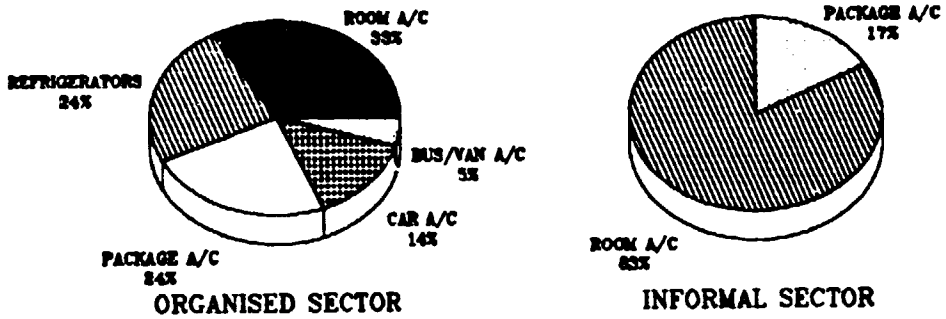

FIGURE - 2.5

SUBSECTOR COVERAGE IN DELHI & BOMBAY SERVICING ENTERPRISES

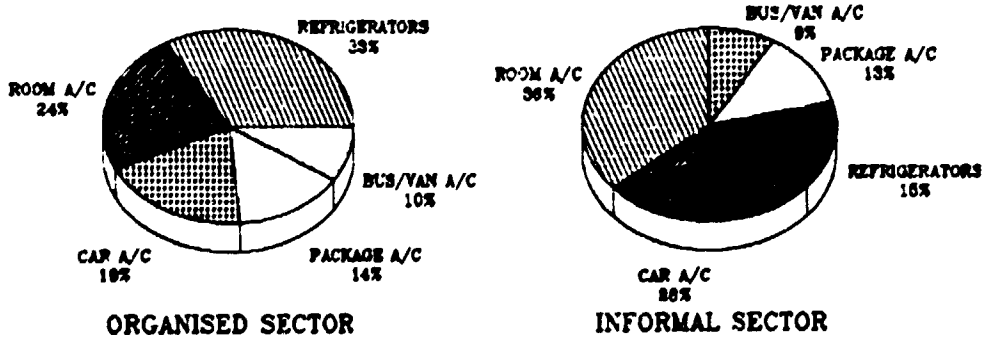

FIGURE - 2.6

III. SURVEY ANALYSIS - REFRIGERATORS

3.1 General

There are 8 manufacturers of refrigerators in India, namely, Kelvinator of India Ltd, Fedders Lloyd Corporation Ltd, Godrej GE Appliances Ltd, Videocon Appliances Ltd, Hyderabad Allwyn Ltd, BPL Limited, Voltas Ltd and Maharaja Appliances Ltd. The first two manufacturers are at Delhi while Godrej has its plant at Bombay. Voltas has one plant at Bombay and one at Warora. The survey conducted covers the manufacturers and their service stations at Delhi and Bombay.

3.2 Manufacturers and Their Authorised Service Stations

3.2.1 Kelvinator of India Ltd

Kelvinator of India is one of the leading manufacturers of refrigerators and deep freezers and accounts for approximately 43% of the market share. They manufacture refrigerators of 65, 90, 165, 286 and 310 ltrs capacity. In addition to the above, the company manufactures its own compressors. The installed capacity for refrigerators is 0.7 million Nos and for compressors is 0.9 million Nos per annum. The production figures were 0.399 million Nos, 0.344 million Nos and 0.6 million Nos approximately during the years 1991-92, 92-93 and 93-94 resepctively. The company has three manufacturing lines for refrigerators and the annual consumption of CFC-12 is 70,000 Kg. Each manufacturing line has a charging station and one of them is an automatic charging station. A halogen leak detector is used for leak checking before packing.

The charging rejections account for 3% of the production and these are mainly due to leaks, particle and moisture chokes and inefficient compressors. Of

this, 1.5% accounts for chokes and inefficient compressors. These refrigerators are reworked on a reworking line, but as they do not have any recovery equipment at present, the refrigerant is emitted out during re-work. Flushing is done with dry compressed air.

In case of chokes and inefficient compressors, as the gas is intact, it is possible to ' recover the refrigerant from the compressor. In case of minor leaks also, possibility exists for recovery of a major part of the refrigerant. Assuming 2% recovery on the whole, the recoverable CFC - 12 is estimated at 1400 kg/year.

3.2.2 Expo Machinery Ltd, a sister concern of Kelvinator of India, markets and services the refrigerators from 4 regional offices and 18 branch offices with service stations at each location. In addition, they have atleast 100 dealer service stations all over India. They have major service stations at Delhi and Bombay. At major service stations, panel type of charging stations are available whereas at other locations, 'Kelvinator-designed' portable charging stations exist. Flushing is done with nitrogen. The main failures in the field are either due to leaks or compressor failures. Leaks mainly occur due to bad road conditions and loading and unloading. In this case, the gas mostly leaks away. In case of minor leaks and chokes, the complaints come much later mostly as insufficient cooling. The other type of failures are compressor failures, which are about 5% over the 7 year warranty period. Each year, there are compressor returns from out of total population in the field and they work out around 4% based on that year's production. Compressor failures mostly occur due to wide voltage fluctuations. Together they account for around 6% of the year's production. In case of complaints, the refrigerators are brought to service stations and repaired and recharged. If the compressor has failed during warranty period, it is replaced by a

new compressor and the failed compressor is sent to the factory for repair.

In case of compressor failures, the refrigerant is intact though contaminated. This can be recovered if a proper equipment is available. The recoverable quantity all over the country would be 3240 kg based on 0.6 million production @ 135 grams charge and 4% failure. At Delhi and Bombay service stations, on an average 2000 refrigerators are repaired each year. This gives a recovery potential of around 150 Kg in each of the company service stations at these places. There is no recovery equipment available in any of the service stations.

3.2.3 Fedders Lloyd Corporation Ltd

Fedders Lloyd has an installed capacity of 15,000 refrigerators/year and their production was around 8000 Nos during 1993-94. The annual consumption of CFC -12 was 1.29 MT and that of CFC-11 for foam was 7.5 MT. The average CFC-12 charge was 0.127 Kg per refrigerator. The recoverable refrigerant quantity will be only around 20 Kg per year. They have facilities for automatic charging and electronic leak detection.

3.2.4 Airserco Pvt Ltd which is the authorised service station of Fedders Lloyd in Delhi provides servicing/charging to around 4 refrigerators per day on an average and in only 10% of the cases, the refrigerant is released into the atmosphere. The estimated recoverable CFC-12 is 24 Kg per year.

3.2.5 Godrej-GE Appliances

Godrej-GE Appliances is one of the leading manufacturers of refrigerators and account for about 43% of the market share. They manufacture refrigerators of 100, 165, 240, 300 and 390 ltrs capacity. Godrej also manufactures the compressors for

captive use. In 1993-94, they have produced 0.6 million refrigerators approximately in 3 manufacturing lines. An additional manufacturing line is being added. The estimated CFC-12 consumption is 85,000 Kg of which about 5% is the wastage on account of rework etc. The refrigerant can be recovered from refrigerators with chokes or minor leaks. This accounts for about 2% of production, i.e.,1700 Kg/year. They have no recovery & recycling equipment in the plant.

3.2.6 Godrej-GE Appliances services/charges in their service station around 120 refrigerators per day in a year (for entire Bombay). This works out to 36000 refrigerators serviced/charged in a year with a recoverable CFC-12 of 3600 Kg per year. They have their own ware-houses and service stations in other parts of the country also.

3.2.7 <u>Videocon Appliances Ltd</u>

Videocon Appliances Ltd manufacture 165, 85 and 239 ltrs capacity refrigerators. Their production in 1993-94 was around 20,800 Nos. The estimated recoverable CFC-12 is 62 Kg/year.

3.2.8 Videocon International Ltd service station in Bombay services/charges around 5 refrigerators per day on an average in a year. The annual services handled is around 1500 refrigerators and the recoverable CFC-12 is 180 Kg per year.

3.2.9 <u>Voltas Limited</u>

Voltas Ltd manufactures around 1,90,000 Nos of refrigerators per year (165 & 310 ltrs) at their Warora plant. The annual recoverable CFC-12 refrigerant has been estimated at 570 Kg.

3.2.10 Voltas Ltd in Bombay services around 50 refrigerators per day in entire Bombay on an average (i.e., 15000

Nos/year) and the estimated recoverable CFC-12 quantity is 1500 Kg per year.

3.2.11 **Hyderabad Allwyn Ltd**

Hyderabad Allwyn Ltd service station in Delhi provides service/charging for 165, 300 and 380 ,ltrs capacity refrigerators. The manufacturing facility of the company is in Hyderabad. Allwyn has 5 regional service centres, 20 area service stations and 5000 authorised service contracts spread throughout the country. The Delhi service station handles on an average around 2,400 refrigerators per year requiring service/charging, out of which around 1,200 Nos involve venting of CFC-12 into the atmosphere every year. The estimated recoverable CFC-12 quantity is 240 Kg per year. They do not have any automatic charging station.

3.2.12 **Blue Star Ltd**

Blue Star Ltd provides service/charging to around 300 refrigerators per year and the estimated recoverable CFC-12 quantity is a nominal 30 Kg per year.

3.3 **Service Stations in the Informal Sector**

3.3.1 Refrigerator in India is a life-time purchase and accounts for 2-3 months salary of an average purchaser. It is, therefore, more often than not, repaired rather than replaced. During the warranty period which varies between 5-7 years depending upon the manufacturer, the user gets his refrigerator serviced invariably from the authorised service station of original manufacturer. After the warranty period is over, he invariably turns to the service mechanic in the informal sector because of differential cost of servicing. There are two ways in which this service technician operates: In case of leaks or chokes, he takes with him a 1 Kg CFC-12 cylinder, tools and brazing equipment and a small compressor (which he uses for rough vacuumising prior to charging) to the customer's residence. In this

case, the gas is vented out by breaking the process tube. After repairing leaks, leak checking (with soap bubbles) and flushing is also done with the refrigerant gas. Thereafter it is charged and sealed. On an average 1 Kg of gas lasts for 4 to 5 re-chargings. In case of compressor failures, he has to bring the refrigerator to the service station. Here also the gas is vented out in the process of taking out the compressor from the system. The field survey covered 7 service stations in the informal sector which are discussed below:

3.3.2 Aramco Refrigeration Co. in Delhi services only 50 refrigerators/year in all and the number of cases in which the refrigerant is to be vented out is not significant enough (5 Kg/year) to warrant installation of recovery and recycling equipment.

3.3.3 In the case of Inter Cool, Indian Traders & Agents and Capital Refrigeration Corporation, all based in Delhi, the number of refrigerator servicing/charging handled is around 15 Nos/year, 50 Nos/year and 150 Nos/year respectively. The recoverable CFC-12 thus is only 1.4 Kg, 5 Kg and 15 Kg respectively in a year. In the case of Ramesh Tan & Co, this number goes to around 100 refrigerators per year. In addition to the low volumes of refrigerators required to be serviced by individual service stations, the uncertainity of maintaining a given level of service maintenance support in terms of minimum numbers every year has been stated to be the main impediment for informal service stations in procuring recovery & recycling equipment.

3.3.4 Pioneer Refrigeration Engg. Co. in Bombay services around 300 refrigerators per year and the recoverable quantity of R-12 is of the order of 30 Kg per year.

3.3.5 Nelson Enterprises in Bombay provides service to 10 refrigerators per day on an average. This means 3000 Nos serviced/charged per year and the estimated recoverable CFC-12 is about 300 Kg per year.

3.4 Scenario for refrigerators and the need for recovery and recycling as a strategy for CFC phase-out

3.4.1 In India, refrigerators being manufactured range in capacities from 65 litres to 380 litres but the 165 litres capacity is the most popular accounting for 90% of the market sales in 1990. The refrigerator life expectancy varies between 15-20 years. The population of refrigerators in 1991 was around 8.3 million Nos. About 1.4 million refrigerators were manufactured in 1993-94. The refrigerant charge for a refrigerator varies from 75 grams to 200 grams depending upon the capacity of the refrigerator. However, for the most popular 165 litres model, the refrigerant charge is typically 135 grams. Allowing a leakage of maximum of 5 grams during charging, a consumption norm of 140 grams for refrigerators may be taken. Recharging of refrigerators is done either because of rejections in manufacture or because of leaks developed at joints during operation in field or compressor failures. During warranty period, refrigerators are referred to original manufacturers or their service stations for recharging whenever necessary. In general, during post-warranty period, the repair shops in the informal sector are approached where facilities do not exist for accurate charging or proper welding of leaked joints. A recharge value of 200 grams for the 165 ltr refrigerator is common. CFC-12 consumption in refrigerators in 1991 was 200 MT for initial charge and 110 MT for recharge.

3.4.2 The National Task Force report of Government of India has projected a growth of population of refrigerators to a level of 98 million Nos. by 2010. Figures of consumption of the refrigerant CFC-12 are also indicated for an unconstrained scenario (Table 3.1).

Table 3.1

Forecast of Production and Population of Refrigerators

	1990	1996	2005	2007	2010
Production(in million Nos)	1.24	2.86	8.08	9.77	13.01
Population(in million Nos)	7.10	17.95	58.40	72.29	98.08
Requirement of CFC-12(MT)	268.0	637.0	1969.20	2431.8	3301.0
- Initial charge (MT)	174.0	401.0	1132.2	1367.8	1821.0
- Recharging (MT)	94.0	236.0	838.0	1064.0	1480.0

Recharging includes (i) recharge during manufacturing and warranty period of five years (ii) recharging of 10% of population of previous fifth year. Recharging demand depends on the population and the figures indicate that the recharging demand in 2010 is 1480 MT and, unless steps are taken to reduce the same on an urgent basis, phase-out of CFC-12 will not be realised. Demand on account of initial charge can be brought to zero through adoption of non-CFC technologies and for this, efforts are being made. But as long as use of CFC refrigerants continues, population of refrigerators based on CFC-12 refrigerant continue to increase resulting in an increased recharging demand. The recharging demand can be reduced by the companies changing over to non-CFC technologies at the earliest so that the population of CFC-12 refrigerators in field is limited and to whom the other measures such as better manufacturing and service practices supported by recovery and recycling can be applied.

3.5 Potential for Recovering CFCs from Refrigerators

3.5.1 From the market survey conducted at Bombay and Delhi (see Figure 3.1 and 3.2) of the manufacturing and servicing enterprises, it can be seen that, of the 5 manufacturers covered during the survey, 3 manufacturers have recoverable CFC-12 of more than 500 Kgs/year at the present level of production volumes and clearly offer potential for recovery and recycling equipment. It should be possible to have a recovery/recycling equipment along side the re-work lines. In the case of servicing enterprises, out of the sample surveyed, there are 6 service stations who have a recoverable CFC-12 level exceeding 150 Kg/year. But this refrigerant may be heavily contaminated because of compressor failures. In such cases, there will be a need for evolving mechanisms for collection and transfer to reclaiming stations. It may be observed that the potential for CFC refrigerant recovery from house hold refrigerators and in the informal sector enterprises can be through plastic bags as is being done in certain other countries of the World.

3.6 Reducing CFC Consumption Through Better Housekeeping and Training of Repair and Maintenance Technicians

3.6.1 Automatic charging stations, improved brazing techniques and training for technicians have reduced the field failures in advanced countries to 500 ppm level in production. The present ppm level seems to be between 4000 to 6000 ppm in India for even reputed manufacturers. There is a greater need for such training for the technicians in the unorganised sector. Also if venting is prohibited, it would automatically establish the need for recovery and recycling equipment on the rework lines.

In manufacture, the aspects of training could include proper dehydration, brazing techniques, defluxing, leak testing and analysis of rejections prior to breaking the process tubes to decide the cases where gas can be recovered.

Refer Para 3.5.1

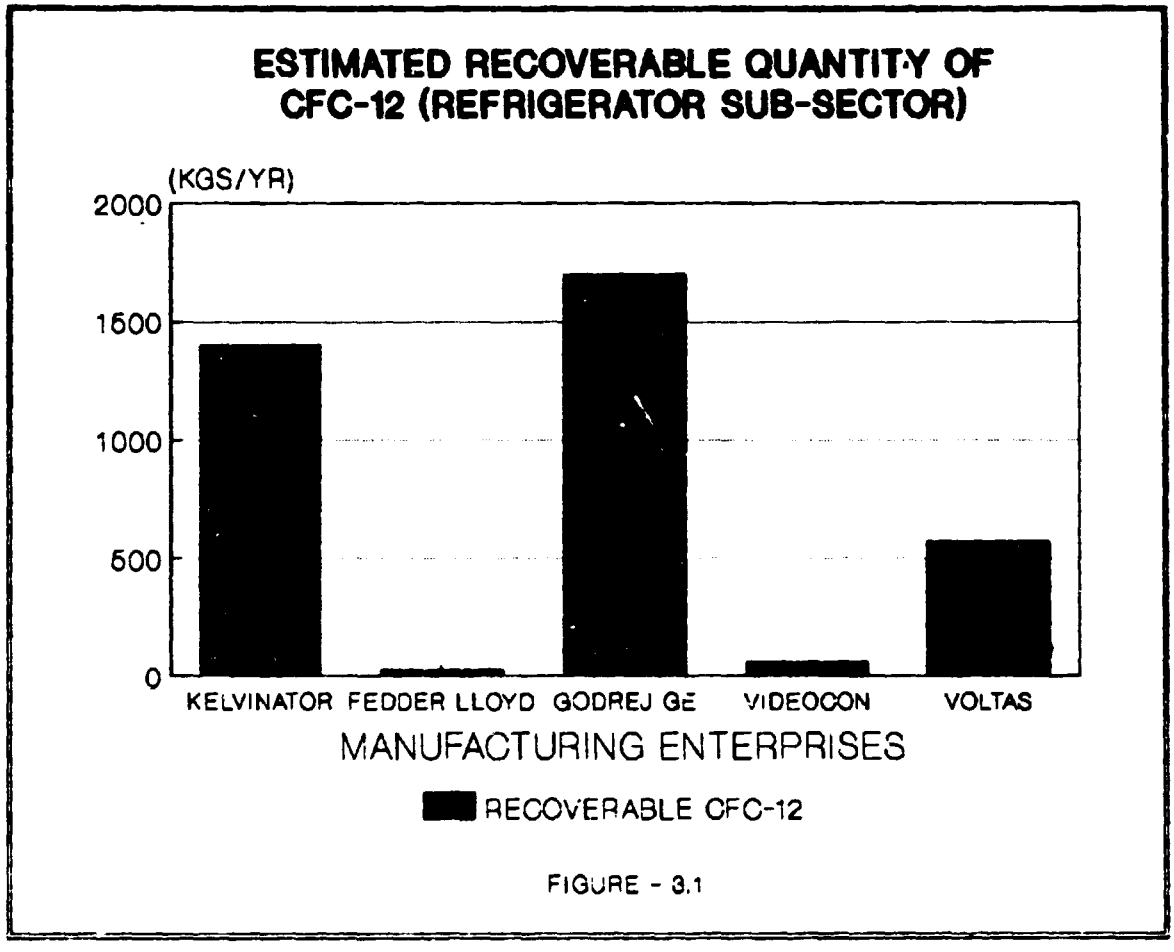

FIGURE - 3.1

Note: The estimated recoverable quantity of CFC-12 in case of Fedders Lloyd and Videocon is low because of their recent entry and their low volumes of production.

Refer Para 3.5.1

ESTIMATED RECOVERABLE QUANTITY OF CFC-12 (REFRIGERATOR SUB-SECTOR)

SERVICING ENTERPRISES

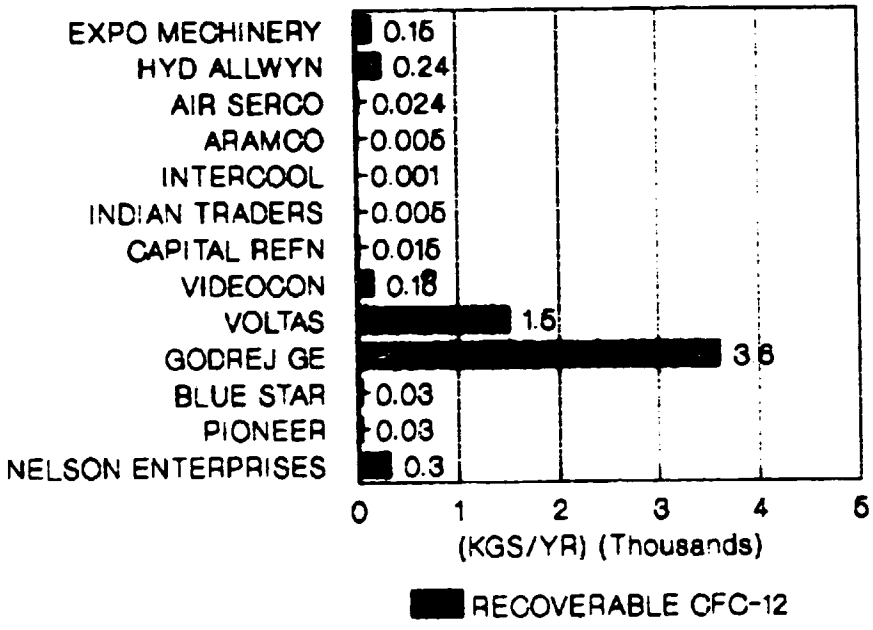

FIGURE - 3.2

Note: The estimated recoverable quantity of CFC-12 in case of Voltas and Godrej GE is high because of large number of refrigerators being serviced by these enterprises in Bombay.

The technicians should be aware and appreciate the relation between improper processing and the emission of CFC into the atmosphere and the dangers it can pose.

With so many organisations applying for ISO certification, a number of these aspects also leading to better housekeeping will hopefully be taken care of. The problem still remains with the training of technicians in the informal sector where facilities for processing are insufficient and technicians keep changing from one place to another because of poor salaries. Accredition of service stations for repair based on training of technicians is suggested. To do this, however, codes of good manufacturing and service practices suitable to Indian conditions have to be formulated by the Bureau of Indian Standards as a first step.

An infrastructure to train the technicians and also to demonstrate better manufacturing and service practices is to be created and this can be only in a public sector or with an association.

IV. SURVEY ANALYSIS - MOBILE AIR CONDITIONERS

4.1 General

Mobile air conditioners include car air, conditioners, bus/van air conditioners and train airconditioners. These air conditioners are manufactured in the organised sector and are supplied as OEMs to car manufacturers, bus/van builders and coach factories without charging the refrigerant. The refrigerant is charged after they are fitted into cars, bus/vans and railway coaches at their manufacturing locations.

CFC-12 is the refrigerant used in the car A/Cs, while in bus/van A/Cs and train A/Cs, there are also models developed based on HCFC-22.

Manufacturers of car air conditioners also run authorised service stations for their clients. There are service centres in the informal sector also.

4.2 Car Air Conditioners - Manufacturers & Their Authorised Service Stations

There are 3 manufacturers of car airconditioners in India, namely, Subros Ltd, Sanden Vikas (India) Ltd and Indus Airconditioning Pvt Ltd. The first two manufacturers are at Delhi and Faridabad (Haryana State) respectively. Indus Airconditioning Pvt Ltd has its manufacturing facility at Bombay. The field survey covers 3 car airconditioner manufacturers, 4 service stations in organised sector and 13 service stations in informal sector.

4.2.1 Subros Limited, New Delhi

Subros Ltd has technical cum financial collaboration with Nippondenso of Japan and financial collaboration with Suzuki, Japan. They manufacture car air

conditioners including the compressors (0.8T) for cars (800 CC, 1000 CC) & Gypsy manufactured by Maruti Udyog Ltd, the largest Indian car manufacturer. The entire requirement of Maruti Udyog Ltd for car air-conditioners is being met from Subros Ltd. The production of car air-conditioners by Subros Ltd was around 23,000 Nos. in 1991-92, 30,000 Nos. in 1992-93 and 43,000 Nos. in 1993-94. Over the last ten years, Subros has manufactured 1,22,000 units. The installed capacity of their unit is 48,000 Nos. per year.

Subros Ltd also manufactures car air conditioners with compressors (1.3T) for supplies to Premier Automobiles Ltd (Model 118NE), Hindustan Motors Ltd (Ambassador), Mahindra & Mahindra Ltd (Armada) and Tata Engineering and Locomotive Company Ltd (models Tata Sierra and Tata Estate).

The present designs of car air conditioners and compressors for car A/Cs are based on the use of CFC-12 as the refrigerant. Since the refrigerant is charged only at the premises of the car manufacturers, the CFC consumption at Subros is only 2T per year. This is on two accounts:

- Checking for minor leaks by injecting a small quantity (45 gms) of CFC-12 and using halogen leak detector.

- Random sample testing of compressors and car A/Cs for performance and reliability.

CFC-12 used for both the purposes can be recovered (recovery potential estimated at 1500 Kg), but Subros has no recovery and recycling equipment.

Subros has in near future plans to redesign compressors and air conditioners to be suitable for HFC 134a and for this Multilateral Fund of Montreal Protocol has approved a grant of US $ 1.7 Million.

4.2.2 Service Station of Subros Ltd

Subros Limited at NOIDA, U.P. is is the authorised service station for car A/Cs of Maruti Udyog Ltd for whom Subros Ltd is the OEM supplier.

During 1993-94, 968 car A/Cs were recharged consuming 860 Kg of CFC-12. In almost 50% of these, the refrigerant was more or less intact. In the remaining it was partially available because of leaks. The recoverable gas is thus estimated at 400 Kg/per year.

4.2.3 Sanden Vikas (India) Ltd

Sanden Vikas has a collaboration with Sanden, Japan for the manufacture of car air conditioners. They do not manufacture the compressors but import them instead from Sanden. The installed capacity is 25,000 Nos per year and the production was 6000, 8000 and 10000 Nos in 1991-92, 1992-93 and 1993-94 respectively. The company is an OEM supplier to Maruti Udyog Ltd, Hindusthan Motors, Mahindra & Mahindra and Premier Automobiles Ltd. Over the last ten years Sanden has produced 60,000 Nos. At the manufacturing facility of Sanden Vikas (India) Ltd, the estimated annual recoverable CFC-12 is around 400 Kg. There is no recovery equipment in the factory.

4.2.4 Service Station of Sanden Vikas (India) Ltd

At the service station of Sanden Vikas (India) Ltd, the annual consumption of CFC-12, on an average, during summer (April to September) is around 73 kg (1 cylinder) per 10 days for charging & topping. The available data shows that on an average the recoverable CFC-12 released into the atmosphere is 650 Kg per annum. The initial charging is not done at the factory but carried out at the service stations. The car air-conditioners being serviced involve complaints of choking of filter & thermo expansion valve due to moisture, dust etc. Compressor burnout cases are referred to the factory at Faridabad.

4.2.5 **Indus Airconditioning Pvt Ltd, Bombay**

Indus Air-conditioning Pvt Ltd has technical-cum-financial collaboration with Theco, Taiwan and are sourcing the compressors for car air-conditioners from their principals. As the air-conditioners are fitted to the cars in their production facility, the initial charging is also done at the same place. The production of car air-conditioners by Indus Air-conditioning Pvt Ltd was 10,000, 12,000 and 15,000 Nos. in 1991-92, 1992-93 and 1993-94 respectively. The installed capacity of this unit is 27,000 Nos. per year. Over the last 10 years, this company has produced around 60,000 car airconditioners. The total estimated recoverable CFC-12 per year at their production facility is around 600 Kg. They have no recovery and recycling equipment available in the factory.

4.2.6 **Maruti Authorised Car Service Stations**

Sikand & Co and Hemkunt Service Station, both located in Delhi are authorised car service stations for Maruti. Problems with the car air conditioners in Maruti cars received for servicing are referred to the service station of Subros Ltd. The annual recoverable CFC-12 at Sikand is around 8 Kg while it is 52 Kg at Hemkunt Service Station.

4.3 **Car A/C Service Stations in the Informal Sector**

4.3.1 The field survey covered 4 service stations in Delhi and 9 service stations in Bombay in the informal sector. While 7 of these service/repair car airconditioners exclusively, the others take on jobs related to refrigerators/room airconditioners/package airconditioners/bus/van airconditioners also. In the latter case, they deal with two refrigerants - CFC-12 and HCFC-22.

In all the service stations, it was noticed that:

a) The gas is emitted out as a matter of convenience during repair/maintenance.

b) The gas has leaked out completely due to cracking/bursting of hoses or pipes.

c) The gas has partially leaked out from shaft seals but as these seals have to be replaced, the remaining gas is also let out.

d) The compressor has failed but with the sealed systems intact, requiring compressor replacement. In this case also, the gas is vented out.

In cases (a), (c) and (d), possibility exists for recovering the refrigerant gas from the systems before undertaking the repair.

4.3.2 The repairing facilities at these stations also need much to be desired in the following respects:

- Non-availability of compressed dry air or nitrogen. Only normal compressed air lines are available.

- Level of skills of workmen, majority of whom have no formal training in processing the systems or the final brazing.

- Lack of proper facilities for processing - tools, manifolds, regulators, couplers etc.

- Possibility of mix-up in the use of refrigerants (CFC-12 and HCFC-22) in recycling.

4.3.3 Table 4.1 gives the details of each enterprise, alongwith estimated annual quantity of recoverable CFC-12 refrigerant.

Table 4.1

Details of Recoverable CFC-12 at Servicing Enterprises in the Informal Sector

Enterprise	Average No of car A/Cs serviced/ repaired per year	Recoverable refrigerant quantity (Kg)
Breezeways	600	240
Intercool	40	16
Aramco	60	24
Quick Refrigeration*	400	400
Sarayu	1800	900
Pioneer	1500	600
Keep it Cool Centre	900	360
Auto Cool	2100	840
United Auto Airconditioning	1500	600
Hans Air-conditioning	1200	480
Reeta & Co	1200	480
Top Beat Electronics	1500	600
Jai Auto Service	900	360

* This enterprise is providing switchover of car A/C to heating in winter and cooling in summer. In this case, the entire refrigerant is being vented into the atmosphere and can be recovered.

It is to be noted that the usage of car air conditioners in Bombay is longer (for around 6-8 months) compared to Delhi (around 4 months) due to temperature as well as higher humidity. Further the sample enterprises selected show a higher number of per day servicing/charging in Bombay compared to Delhi. The sample units in this segment are thus not similar. In some of the above cases, the refrigerant wastage has been estimated by the consultants.

4.4 Bus/Van Air-conditioners

There are 3 manufacturers in the organised sector for bus/van airconditioners in India, who build the systems with imported/indigenously manufactured compressors. Few units in the organised sector also assemble these systems. CFC-12 is the refrigerant used. During the survey in Delhi and Bombay, one manufacturer and 2 service stations in the organised sector and 4 service stations in the informal sector were covered.

Details of production/servicing and the estimated recoverable CFC are given in Table 4.2 below:

Table-4.2

Details of Recoverable Refrigerant at Manufacturing/ Servicing Enterprises in the Organised/Informal Sectors

Manufacturer/ Service Enterprise	Nature of Business	Numbers manufactured/ serviced/yr	Recoverable CFC per year (Kg)
Organised Sector:			
Shiv Shakti Engineering Co	Manufacturer	37	-
Blue Star	Marketing/ Servicing	-	-

Voltas Ltd	Servicing	1500	4500
Informal Sector			
Aramco	Servicing	5	-
Auto Cool	Servicing	30	90
Reeta & Co.	Servicing	30	90
Top Beat Electronics	Servicing	30	90

The deficiencies in processing and systems of service stations in the informal sector are essentially the same as those described in para 4.3.2. Possibility for using a recovery/recycling machine is seen only in the service station of Voltas Ltd in organised sector.

4.5 Train Air-conditioners

150-200 airconditioned coaches are manufactured by Integral Coach Factory at Madras and Kapurthala each year, based on compressors manufactured in the organised sector. CFC-12 is the refrigerant used and the initial charge is 36 Kg.

These coaches are serviced at their Railway Repair Workshops located in various parts of the country. In general, minor leaks are tolerated and the required quantity of refrigerant is topped-up. In case of major leaks, all the refrigerant escapes into the atmosphere.

It should be possible to have a recovery/recycling station at each such repair workshop and also at coach manufacturing units to minimise the emissions by timely maintenance and repair.

4.6 Scenario for Mobile Airconditioners and the Need for Recovery and Recycling as a Strategy for CFC Phase-out

4.6.1 Car Air-conditioners:

The total estimated air-conditioners fitted to automobiles in the country during 1993-94 (including vehicles manufactured for export) was of the order of 140,000 Nos. The total population of car air-conditioners in the country is estimated to be around 350,000 Nos at present and in an unconstrained scenario is projected to grow to a level of 4.1 million Nos by 2010 covering both OEM supplies and retrofitting as shown below (Table 4.3) assuming an average life time of 10 years :

TABLE - 4.3

Forecast of Production and Population of Car Air-conditioners

	1990	1996	2005	2007	2010
Production of car air-conditioners (in thousand Nos.)	99.0	175.0	413.5	500.0	666.0
Population (in million Nos.)	0.304	1.064	2.683	3.182	4.136
CFC-12 requirement (MT)	169	473	1174	1400	1831
- Initial charging (MT)	69	122	289	350	466
- Recharging (MT)	100	351	885	1050	1365

33% of population is assumed to be recharged every year. The average CFC-12 required as initial charge is 700 grams and for recharge, 1000 grams is assumed.

4.6.2 Bus Van Air-conditioners

Bus and Van air-conditioners are manufactured by very few units in the organised sector and in the informal sector. Considering a growth rate of 15%, the production, population and CFC-12 demand, as projected by National Task Force is given below (Table 4.4).

TABLE - 4.4

Forecast of Production and Population of Bus/Van Air-conditioners

	1990	1996	2005	2007	2010
Production of Bus/ Van air-conditioners (in thousand Nos)	0.35	0.81	2.85	3.80	5.73
Population (in thousand Nos)	2.77	6.00	16.40	20.80	30.20
CFC-12 requirement (MT)	20.12	44.10	126.50	163.00	238.30
- Initial Charge(MT)	3.50	8.10	28.50	38.00	57.30
- Recharging (MT)	16.62	36.00	98.00	125.00	181.00

An average life time of 10 years and 50% units for recharge every year has been assumed. The high recharging rate is because of near continuous use of the buses and uneven road conditions. Since each bus/van air-conditioners would have 7-8 T capacity, the initial charge of CFC-12 may be taken as 10 Kg and for recharging, 12 Kg.

4.6.3 Train Air-Conditioners

The forecast of production, population and CFC-12 demand, as projected by National Task Force is given below (Table 4.5).

Table - 4.5

Forecast of Production, Population and Demand of CFC-12 for Train Air-conditioners

	1990	1996	2005	2007	2010
Production of Train air-conditioners (in thousand Nos)	0.10	0.10	0.20	0.20	0.20
Population (in thousand Nos)	0.80	1.40	2.80	3.20	3.75
CFC-12 requirement (MT)	29.2	48.4	96.8	104.6	127.2
- Initial Charge(MT)	3.6	3.6	7.2	2.2	7.2
- Recharging (MT)	25.6	44.8	89.6	102.4	120.0

4.6.4 As can be seen from above, the recharging demand of CFC-12 in 2010 in an unconstrained scenario will be 294% of the 1996 base year consumption. Alongwith transfer to non CFC technologies, good manufacturing and service practices, recovery and recycling will have to be implemented as a strategy to keep consumption to minimum.

4.7 Potential for Recovering CFCs in the Mobile Air-conditioning Sector

The results of survey indicate (refer Figure 4.1 and 4.2) that at each car air-conditioner manufacturer's premises where charging is done, more than 400 Kg/year of refrigerant can be recovered. Further, in case of car air-conditioner servicing enterprises, out of 13 service stations in the informal sector and 4 service stations in the organised sector covered during the field survey, 13 service stations have recoverable CFC-12 exceeding 240 Kg/year where recovery/recycling

ESTIMATED RECOVERABLE QUANTITY OF CFC-12 (CAR A/C SUB-SECTOR)

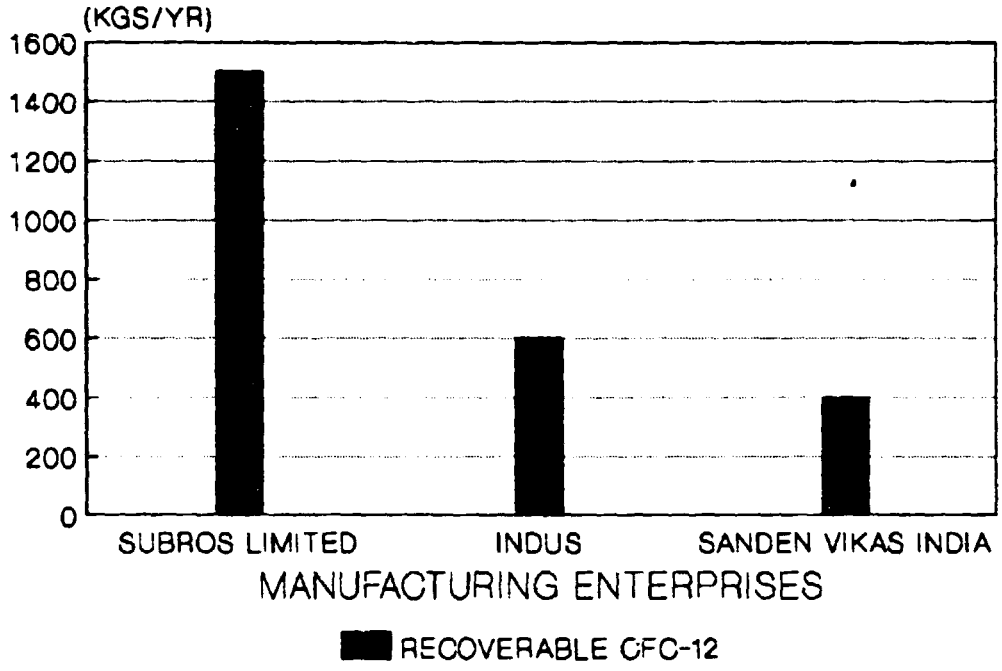

FIGURE - 4.1

ESTIMATED RECOVERABLE QUANTITY OF CFC-12 (CAR A/C SUB-SECTOR)

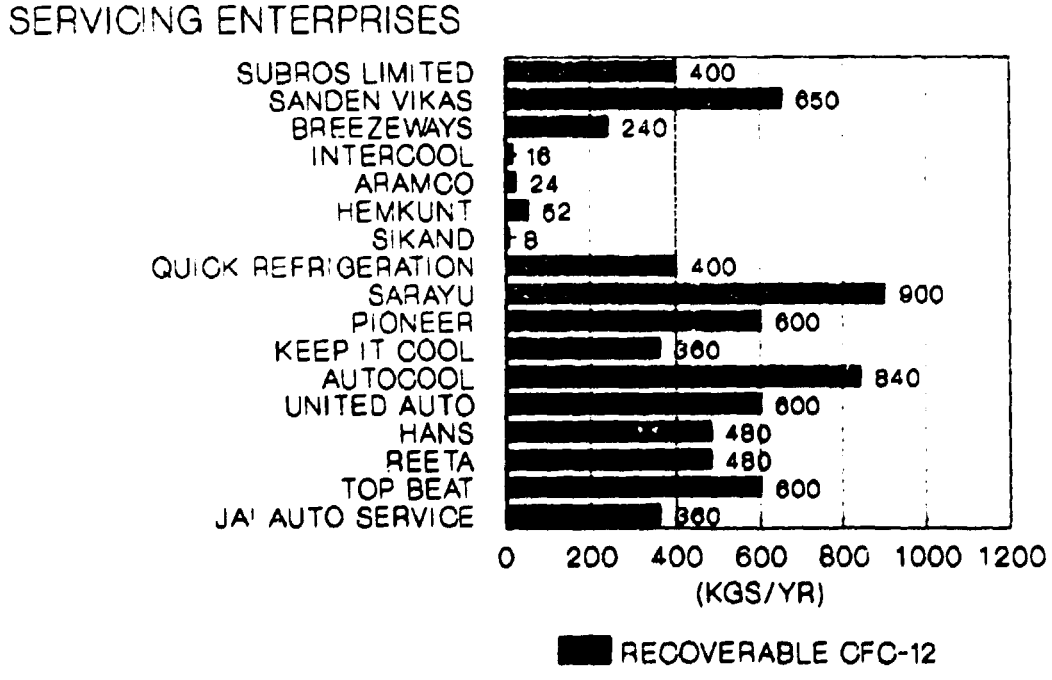

FIGURE - 4.2

equipment can be used. When the recoverable refrigerant is small, recycling may have to be centralised.

Recovery and recycling units can be recommended for the following cases :

a) As an adjunct to the rework lines of manufacturers who charge the A/Cs.

b) Authorised service stations of car air-conditioner manufacturers

c) Service stations in the informal sector where the recovery potential is atleast around 250 Kg/year.

d) Integral coach factories at Kapurthala and Madras.

e) Train maintenance repair workshops in various parts of the country.

4.8 Reducing CFC Consumption Through Better Housekeeping and Training of Repair and Maintenance Technicians

4.8.1 In the overall effort aimed at reducing CFC consumption,better housekeeping practices both in manufacturing as well as servicing and training of repair and maintenance technicians can play a significant role in reducing CFC-12 consumption in this sub-sector. Some of the measures necessary to reduce the CFC consumption include the following :

* Evolving codes of manufacturing and service practices. Adoption of codes of practice by manufacturers and service stations will need to include obligations to prevent leakage and to recover CFCs to the extent possible. This will also require that recovery equipment is purchased, installed, used and the recovered gas is recycled.

* Providing technical inputs to repair and maintenance technicians through appropriate

training. This may involve short-term training modules/seminars/workshops and need to involve the Ministry of Environment & Forests, Industry Associations, etc. The training may also be imparted in a distributed fashion and must include demonstration of the benefits of refrigerant recovery and recycling equipment to evoke serious interest and adoption of the practice. Special attention must be paid to servicing enterprises in the informal sector, where the availability of skilled/technical manpower is limited and significant repair/servicing activity takes place in the refrigerator, air-conditioner and mobile air-conditioner sub-sectors.

* Certification/accredition of service enterprises.

* Organising public awareness programmes

* Intervention in the pricing of 'recovered' CFCs.

* Overall coordination and monitoring with industry, service enterprises and multilateral agencies.

4.8.2 While legislation would be among the major means for reduced CFC consumption in India, the financial incentives are expected to evoke stronger response. Some of the financial support measures envisaged for introduction of recovery and recycling equipment include :

a) Making imported equipment and spares for the recovery and recycling exempt from customs duty.

b) Providing grants/subsidies on the equipment.

c) Increasing the price of CFCs by imposing higher fiscal duties so as to raise the price of recovered CFCs.

d) Partial funding of expenses for training and promotion.

e) Establishing demonstration stations for recovery, recycling refrigerants and their performance in re-use.

It is also necessary to strengthen the environmental agencies in the country for implementing and monitoring of the CFC recovery and recycling programmes.

V. SURVEY ANALYSIS - AIR CONDITIONERS

5.1 General

Comfort air-conditioning depends on two types of air-conditioners - room air-conditioners (RAC) and package air-conditioners (PAC).

For room airconditioners, there are 7 manufacturers in the organised sector and they offer service at their service stations. A large population of room air-conditioners are assembled in the informal sector also. Similarly, repair and service is offered by enterprises in the informal sector.

Package air-conditioners are mainly made by manufacturers in the organised sector. The customers usually enter into a service contract with the manufacturer for maintenance. Alternatively, they have their own maintenance crew.

Both RACs and PACs use HCFC-22 - not an immediate controlled substance under Montreal Protocol and also not a CFC. One manufacturer uses CFC-12 as the refrigerant in the smaller 0.7 T capacity RAC.

5.2 Room Air-conditioner Manufacturers in the Organised Sector & Their Authorised Service Stations

The field survey covers 7 manufacturers in the organised sector and 5 manufacturers in the informal sector. Similarly, 5 service stations in the organised sector and 17 service stations in the informal sector have been covered.

5.2.1 Fedders Lloyd Corporation Ltd

Fedders Lloyd Corporation Ltd in Delhi manufactures room air-conditioners, package air-conditioners and air conditioners for railway coaches (installed capacity

12000 Nos/year). The air conditioners for railway coaches (7T) are being supplied to Railway Coach Factories and maintenance workshops. They have no foreign collaboration. Their production of air-conditioners (all types) was 7000 Nos in 1993-94. The consumption of HCFC-22 was 7.5 MT in 1993-94. They use leak detector and have electronic charging facility. The total recoverable refrigerant is estimated at 750 Kg per year for room air-conditioners during manufacturing @ 10% of total refrigerant consumption due to leakage and other factors. The unit does not have recovery & recycling equipment.

5.2.2 **Airserco Pvt Ltd**

This is a sister concern of Fedders Lloyd and their authorised service station is in Delhi for refrigerators, room and package air-conditioners. They use about 1300 Kg of HCFC-22 per year at the service centre in Delhi in addition to certain quantity of CFC-12. The HCFC-22 which can be recovered from room air-conditioners is 130 Kg per year.

5.2.3 **Air-conditioning Corporation Ltd**

Air-conditioning Corporation Ltd manufactures 1/2 T, 1 T, 1.5 T and 2 T window type air-conditioners. Their Works is located at Calcutta and their installed capacity has been reported to be 5000 Nos/year of window air-conditioners and 2000 Nos/year of split air-conditioners. They have no foreign collaboration. They also do not have recovery and recycling equipment at their factory. The initial charge of HCFC-22 is 500 gms for 0.5 T (recently introduced), 900 gms for 1 T, 1000 gms for 1.5 T, 1350 gms for 2 T window air-conditioners. The estimated annual recoverable HCFC-22 is 670 Kg.

5.2.4 The authorised service station of Air-conditioning Corporation Ltd in Delhi handles around 1-2 room air conditioners per week with servicing problems on an average in a year. The annual recoverable refrigerant emitted is estimated to be around 12 Kg.

5.2.5 **Blue Star Limited**

Blue Star Ltd in Bombay have foreign technical collaboration with York International, USA and Mitsubishi, Japan and manufactures room air conditioners of 1T, 1.5T, 2T and 3T (installed capacity 8000 Nos/year). Their production in 1993-94 was of the order of 5000 Nos. They have stated that around 20% of total HCFC-22 consumed is vented out during manufacturing. The estimated annual recoverable HCFC-22 is around 600 Kg.

5.2.6 Blue Star authorised service station in Bombay provides servicing/charging of 2 room air-conditioners per day on an average. Based on an average 10% of the cases are on account of choking/compressor failures requiring re-charging, the annual recoverable refrigerant is around 70 Kg.

5.2.7 **Shriram Refrigeration Industries**

This organisation, covered during the field survey in Bombay, has foreign technical collaboration with Tecumseh, U.S.A. for manufacture of compressors. The HCFC-22 consumption figures/wastage were not made available. Their installed capacity for compressors is 100,000 Nos. They have recently introduced into the market 0.5 T and 0.75 T room air-conditioners. They have indicated plans for switching over to a technology for non-CFC compressor development.

5.2.8 **Videocon Appliances Ltd**

Videocon Appliances Ltd in Bombay have technical tie-up with Matsushita, Japan. Their annual installed capacity is 60,000 room air-conditioners (1T and 1.5T). Actual production in 1993-94 was 7,500 Nos.. The estimated annual recoverable HCFC-22 is around 900 Kg. They have facilities for automatic gas charging and halogen leak detection.

5.2.9 Videocon International Ltd

This is the authorised service station of Videocon Appliances in Bombay and services/charges around 2 room air-conditioners per day on average. They have facilities for halogen leak detection and have stated that a marginal quantity of HCFC-22 is 'wasted during flushing. The annual recoverable HCFC-22 is estimated to be 70 Kg on account of choking and compressor problems.

5.2.10 Voltas Limited (Appliances Business Group)

Voltas Ltd in Bombay have no foreign collaboration for technology. Their installed capacity is 22,500 room air-conditioners/year (1 to 3T capacities). The HCFC-22 consumption was reported as 0.85 Kg for 1.5T and 1.70 Kg for 3T. Their production in 1993-94 was 23,000 Nos. The estimated annual recoverable CFC-12 and HCFC-22 (as they use both types of refrigerants with CFC-12 primarily being used in air-conditioners of less than 1 T capacity) is 2760 Kg.

5.2.11 Voltas Limited (Air-conditioning Business Group)

The authorised service station of Voltas in Bombay services room air-conditioners, package air-conditioners in large numbers and has reported an average annual HCFC-22 consumption of 60,000 Kg. In this station, the leak detector is occasionally used while soap bubble test is common. They have one recovery and recycling machine on trial. This unit was imported from 'Robin Air'. Around 15% of the refrigerant consumption for both room & package air-conditioners is reported to be vented out (6000 Kg) every year which can be recovered.

5.2.12 Amtrex Ambience Ltd

Amtrex in Bombay manufacture 1T,1.5T,2T,3T room air-conditioners and have an installed capacity of 5000 Nos./year. Their production was 2,500 Nos. in 1993-94. The annual recoverable HCFC-22 is around 300 Kg.

5.3 Room Airconditioner Manufacturers and Their Service Stations in the Informal Sector

5.3.1 Thandak Aircon

Thandak Aircon in Delhi assembles 1.5 T window air conditioners (production 100-150 Nos/year) on job-order basis, under its own brand. They also provide after sales service for their own make as well as other makes of room air conditioners. The flushing is done with dry Nitrogen and dip test is used for leak detection. They have indicated that the main reasons for refrigerant leakage are due to compressor failure or choking and the estimated annual recoverable HCFC-22 in manufacturing is around 25 Kg.

5.3.2 Temperature Control

Temperature Control in Delhi is assembling room air conditioners and package air conditioners under the band name 'T-DOT'. Reliable data on their production and refrigerant leakage is not made available. They also provide servicing to room airconditioners as well as package airconditioners. The basic facilities availalble for servicing/charging of CFC refrigerant include charging line (locally fabricated), vacuum pump and gauge manifold, punching set, gas welding set, etc. The adequacy of charge is normally noted by back pressure. There is no precise measurement of charge.

5.3.3 Coolway India Airconditioning Pvt Ltd

This organisation in Delhi assembles room airconditioners under their own brand name and also provide servicing of their make. Their annual production of room airconditioners is around 700 Nos. The estimated recoverable refrigerant in manufacturing is around 85 Kg/year.

5.3.4 Coolways India Airconditioning Pvt Ltd in Delhi could recover around 50 Kg of their total annual consumption of about 560 Kg of HCFC-22 required in servicing, topping and recharging room air-conditioners.

5.3.5 J B Enterprises & Modern Motor Co. in Bombay are assembling around 75 and 35 air-conditioners per year respectively in the informal sector (1T, 1.5T & 2T). The annual recoverable refrigerant is marginal and is estimated at 9 Kg and 4 Kg respectively.

5.4 Room Airconditioner Service Stations in the Informal Sector

5.4.1 In all the service stations covered during the field survey, it was noticed that:

a) The gas is being emitted out as a matter of convenience in repair.

b) Proper leak detection facilities are not available.

c) The level of skills of workmen in processing the systems and brazing are poor.

d) Whenever the compressor motor was rewound during repairs, HCFC-22 refrigerant was mixed with CFC-12 in proportions varying from 80%-20% to 70%-30% and charged. This was expected to help in cooling the compressor, while at the same tine giving the benefit of cost (CFC-12 is cheaper than HCFC-22).

5.4.2 Table-5.1 gives the details of the servicing enterprises in the informal sector covered during the field survey alongwith the estimated quantity of recoverable HCFC-22 in a year:

Table-5.1

Details of Recoverable Refrigerant in the Servicing Enterprises in the Informal Sector

Enterprise	Estimated Recoverable Refrigerant (Kg/Year)
Quick Refrigeration	175

Uni-Air Refrigeration	300
Aramco Refrigeration	50
Intercool	50
Indian Traders & Agents	60
Capital Refrigeration	60
Sanvik	25
Clair Airconditioning	120
Nelson Enterprises	300
Classic Airconditioning	145

5.4.3 In Breezeways, Ramesh Tan & Co, Pioneer Refrigeration Engg. Co, Modern Airconditioning Co, Hans Airconditioning and Mehta Cool Tech Co which are also covered during the survey, the recoverable quantity of HCFC-22 is very small.

5.5 Package Airconditioner Manufacturers in the Organised Sector & Their Authorised Service Stations

5.5.1 The field survey covers 5 manufacturers in the organised sector and 1 manufacturer in the informal sector. Similarly, 3 service stations in the organised sector and 6 service stations in the informal sector have been covered.

5.5.2 Fedders Lloyd Corporation Ltd

This organisation in Delhi manufactures packaged air conditioners in the range of 1T to 3T. Break-up of refrigerant wastage in this segment during manufacturing was not made available.

5.5.3 Airserco Pvt Ltd which is the authorised service station of Fedders Lloyd in Delhi services around 600

package air conditioners per year out of which about 60 Nos involve release of refrigerant into the atmosphere. The quantity of recoverable refrigerant is estimated to be 450 Kg per year.

5.5.4 **Air Conditioning Corporation Ltd**

This organisation with their plant located in Calcutta has an installed capacity of around 1000 package air-conditioners per year. These are manufactured in their works at Calcutta and the 1993-94 production figure is not available. Their sales in Delhi was only about 15 Nos. The range includes 4T and 7.5T. Refrigerant leakage figures were not made available.

5.5.5 Air Conditioning Corporation Ltd authorised service station in Delhi services 4T and 7.5T package air-conditioners of their own make. The Delhi service station handles only 15 units per year. The recoverable refrigerant quantity is not significant.

5.5.6 **Voltas Ltd**

Voltas Ltd in Bombay manufactures package air-conditioners in technical collaboration with Carrier Corporation, U.S.A. (5T, 7.5T, 10T & 14T) . Their production was around 1650 Nos in 1993-94. The initial charge varies from 7.5 Kg to 20 Kg. The units are pressure tested and vacuum tested before charging. The estimated annual HCFC-22 consumption at their manufacturing facility has been estimated to be 12000 Kg @ 7.5 Kg as initial charge on an average since majority of package air-conditioners would have this charge. The estimated annual recoverable HCFC-22 is around 1200 Kg.

5.5.7 Voltas Ltd authorised service station in Bombay services/charges approximately 30 package air-conditioners per day during season (say 6 months). Assuming 10% of refrigerant is vented out vis-a-vis the total HCFC-22 consumption of around 30,000 Kg in this

segment, the recoverable refrigerant quantity can be around 3000 Kg per year.

5.5.8 **Blue Star Ltd**

Blue Star Ltd in Bombay manufactures around 1500 packaged air conditioners per year. Estimated refrigerant wastage through venting has been stated to be as high as 15% (i.e., 1690 Kg) at the manufacturing premises.

5.5.9 **Shriram Refrigeration Industries**

This organisation covered during the field survey in Bombay have not disclosed their production, refrigerant consumption and wastage in this segment.

5.6 **Manufacturers of Package A/C and Service Stations in Informal Sector:**

5.6.1 Temperature Control in Delhi which is a manufacturer of packaged airconditioners in the informal sector and the recoverable refrigerant is small due to low production volume.

5.6.2 Temperature Control provides servicing of 10-15 package air-conditioners per year (range 5T & 7.5T) of their own make. On an average, the package air conditioners serviced involve refrigerant release of around 15 Kg per year which can be recovered.

5.6.3 Pioneer Refrigeration, Sanvik, Clair Airconditioning, and Nelson Enterprises in Bombay which service package airconditioners have a small quantity of recoverable refrigerant per year.

5.6.4 In case of Classic Airconditioning in Bombay, the annual recoverable HCFC-22 quantity is estimated at 1125 Kg.

5.7 Scenario for Room Airconditioners and Package Airconditioners and the need for recovery and recycling

5.7.1 Room Airconditioners

Major room air-conditioner manufacturers in India include Air-conditioning Corporation Ltd, Fedders Lloyd Corporation Pvt Ltd, Carrier Aircon Ltd, Electronics Ltd, Voltas Limited, Amtrex Ambience Ltd, Shriram Refrigeration Industries, Blue Star and Videocon Appliances. The standard models are 1, 1.2, 1.5, 2 and 3 T of window and split types. Most of the room air-conditioners use HCFC-22 but CFC-12 is also used in some of the units. It is estimated that the present production is around 150,000 units per year (50,000 units in the organised sector and 100,000 units in the informal sector). The room air-conditioners are made in both the organised and informal sector in India with major share contributed by informal sector. The compressors for room air-conditioners are supplied by Kirloskar Copeland, Shriram Compressors etc.

5.7.2 The population of room air-conditioners in an unconstrained scenario is projected to grow to a level of 3.4 million Nos. by the year 2010 as shown below (Table 5.2) assuming an average life time of 10 years.

TABLE 5.2

Forecast of Production and Populaltion of Room Air-conditioners

	1990	1996	2005	2007	2010
Production (in thousand Nos)	120	161	250	275	319
Population (in million Nos)	1.2	2.015	2.970	3.152	3.460
Requirement of HCFC-22 (MT)	350	560	833	892	991

- Initial charge (MT)	92	126	192	212	245
- Recharging (MT)	258	434	641	680	746
Requirement of CFC-12 (MT)	105	166	249	266	297
- Initial charge (MT)	28	36	58	63	74
- Recharging (MT)	77	130	191	203	223

a) Recharging is assumed for 20% of the population every year as the failure of room air-conditioner compressors is more frequent compared to refrigerators.

b) HCFC-22 charge for 1.5 T room air-conditioner is 1000 gms and this is assumed as the weighted average for the total production. For recharging. 1400 gms is taken.

c) 77% of production is assumed to use HCFC-22 and balance 23%, CFC-12.

5.7.3 <u>Package Airconditioners</u>

Bulk of the production of package air-conditioners in India is accounted for by Fedders Lloyd, Shriram Refrigeration Industries, Blue star Ltd, Carrier Air-con and Voltas Ltd in the organised sector. Technology has been imported by majority of them. The range of capacities vary from 3 to 15 T. The package air-conditioners use hermetic and semi-hermetic compressors and primarily HCFC-22 is the refrigerant. About 5000 units are estimated to be produced annually.

5.7.4 The population of package air conditioners (capacities ranging from 3-10T) in an unconstrained scenario is projected to grow to a level of 216,000 Nos by 2010 as given below (Table 5.3) assuming a growth rate of 12% per year :

TABLE - 5.3

Forecast of Production and Populaltion of Package Air-conditioners

	1990	1996	2000	2007	2010
Production (in thousand Nos)	4.4	9.0	24.0	30.0	42.0
Population (in million Nos)	21	44	122	154	216
Requirement of HCFC-22 (MT)	67	136	374	477	662
- Initial charge (MT)	45	89	247	311	436
- Recharging (MT)	22	47	127	161	226

5.7.5 HCFC-22 is not a controlled substance like CFCs. But it is atleast 1.5 times costlier than CFC-12 and the potential for recovery is immense. This, by itself, should justify the need for recovery and recycling equipment.

Efforts are in progress to control HCFCs also because they have some ODP (0.05) although not as high as with CFCs and Halons. In U.S.A, even in terms of the latest amendments proposed for Montreal Protocol, controls will become effective from 2004 onwards. It may be therefore necessary to introduce the recovery and recycling systems as early as possible.

5.8 Potential for Recovering CFCs and HCFCs from Air-conditioners

5.8.1 Figure 5.1 and 5.2 indicate the estimated recoverable quantity of HCFC-22 by manufacturing and servicing enterprises respectively, covered by the field survey. It may be noted out that in the case of manufacturing enterprises, 6 units, all in the organised sector, have recoverable HCFC-22 of a level exceeding 300 Kg per year. In case of all the 5 manufacturing enterprises

ESTIMATED RECOVERABLE QUANTITY OF HCFC-22 (ROOM A/C SUB-SECTOR)

MANUFACTURING ENTERPRISES

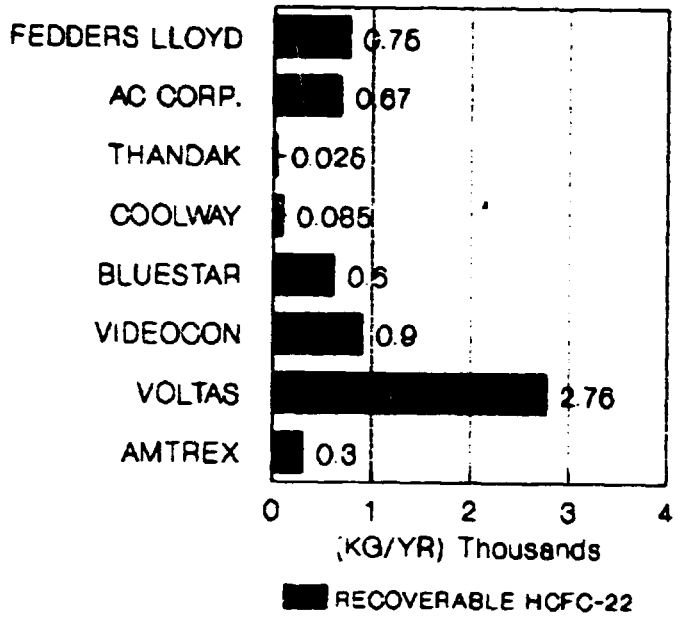

FIGURE - 5.1

ESTIMATED RECOVERABLE QUANTITY OF HCFC-22 (ROOM A/C SUB-SECTOR)

SERVICING ENTERPRISES

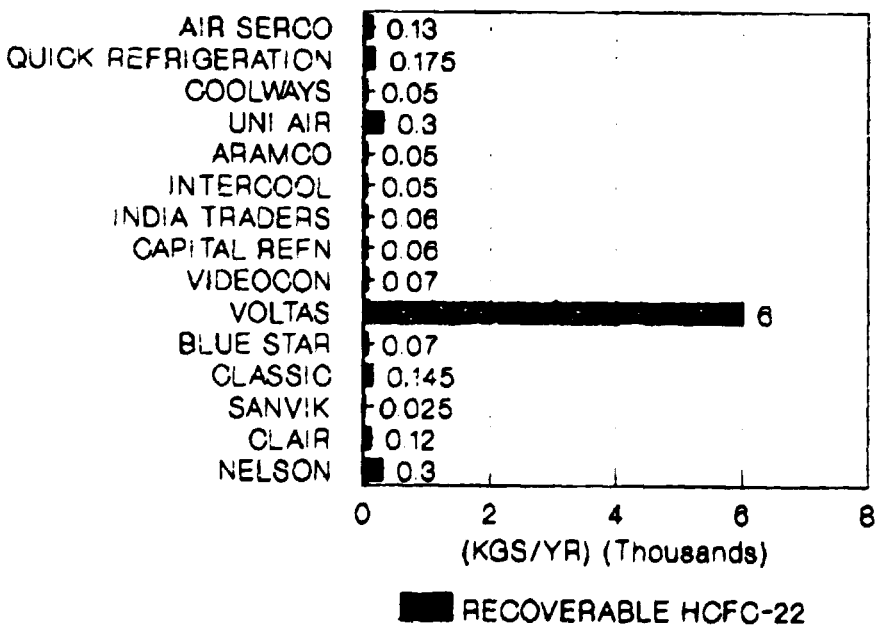

FIGURE - 5.2

Note: The estimated recoverable quantity of HCFC-22 in case of Voltas Ltd is high because of large number of air conditioners being serviced by them in Bombay.

in the informal sector covered during the field survey, the recoverable HCFC-22 is less than 85 Kg. Further, out of 5 authorised service stations of manufacturers and 16 service stations in the informal sector covered during the field survey, one authorised service station repairs air conditioners on a very large scale, and has a recoverable HCFC-22 of 6000 Kg. 14 service stations have recoverable HCFC-22 in the range of 50 Kg - 300 Kg/year while 6 service stations have small quantity of recoverable HCFC-22 annually.

5.8.2 The fact that some of these enterprises are attempting to recover the refrigerant indicates that they will be responsive to accept a proper recovery and recycling station if available at an affordable price.

5.8.3 Mixing of CFC-12 with HCFC-22 at the time of recharging by mechanics in the informal sector highlights the need for extending the recovery and recycling principle to HCFC-22 based systems also, although HCFC-22 is not covered under Montreal Protocol because of its small ozone depleting potential of 0.05 compared 1.0 of CFC-12. If not anything else, the economic benefits that would accrue in saving the costly HCFC-22 would in itself induce these service stations to install recovery/recycling stations. The economic viability however has to be established and for those whose potential for recovery is lower, alternative solution like a centralised recycling station should be offered.

5.9 <u>Reducing CFC Consumption Through Better Housekeeping and Training of Repair and Maintenance Technicians</u>

5.9.1 Although HCFC-22 is not a CFC, housekeeping and training measures as already described in para 4.8.1 apply here also. If not for reduction of consumption, it will be good for improving the productivity and reducing the costs.

VI. FEASIBILITY OF LOCAL MANUFACTURE OF RECOVERY AND RECYCLING EQUIPMENT

6.1 This chapter discusses the feasibility of local manufacture of recovery & recycling equipment in India based on broad estimates of market potential assessed as a result of field survey carried out in Delhi and Bombay.

6.2 Significance of Recovery & Recycling

There are two basic reasons for conserving CFCs and HCFCs refrigerants. The first is the environmental concern about CFC emissions and the fact that refrigerant conservation will reduce emissions substantially. The second is the economic consideration that, as CFC production is proposed to be phased out, CFC refrigerant supplies will dwindle and it will become increasingly difficult and expensive to maintain existing equipment and systems in operation. Substantial reduction of CFC emissions can be realised through (a) minimising the requirements of refrigerant through suitable equipment re-design (b) by adopting better manufacturing and servicing practices thereby minimising loss of refrigerant due to leakage and (c) through recovery and recycling of refrigerant. The importance of recovery and recycling is borne out from the fact that the recharging demand of refrigerants CFC-12 and HCFC-22, due to leakages, venting and scrapping in refrigerator, room air-conditioners and mobile air-conditioner sectors covered under the study, formed about 51% of the CFC consumption in 1990. With this as the backdrop, Fig-6.1 shows the awareness levels of adverse effects of CFCs in the servicing enterprises covered in Delhi and Bombay.

6.2.1 Awareness of Adverse effects of CFCs among Servicing Enterprises and willingness to install Recovery & Recycling Equipment

In the sample survey study, out of the total 39

servicing enterprises undertaking repair/maintenance of refrigerators, mobile air conditioners and air conditioners, only 15% are not aware that leakage of CFC refrigerants in atmosphere causes environmental problems. The use of CFC refrigerants world wide is to be discontinued latest by the year 2010 is known to all the parties covered by the survey and only 38% are aware that this phase out is as per commitment under Montreal Protocol. 66% of the enterprises are aware that the availability of CFC will gradually reduce in the next ten years in the country. 61% are aware that CFC refrigerants are being recovered and recycled in advanced countries and only 46% are aware that equipment are available for recovery and recycling of refrigerants in advanced countries. Figure 6.1 depicts the awareness levels about the adverse effects of CFCs, in the servicing as well as manufacturing enterprises covered in the survey at Delhi & Bombay.

During market survey, it was found that most of the manufacturers and servicing enterprises evinced keen interest in the recovery and recycling equipment. These enterprises have also shown willingness to install the equipment at their premises.

6.3 Typical Configurations of Recovery & Recycling Equipment

Recovery and recycling equipment is typically available in the following configurations :-

(i) Dedicated to either R-12, R-22, R-500 or R-502. These units are available in 1/4 HP.

(ii) Multi-refrigerant units which are available in 1/4, 1/2, or 3/4 HP.

(iii) Dedicated to R134a. These machines are available in 1/3 HP.

(iv) Equipment for Recovery and Recycling, Recovery only or Recycling only.

Refer to Para 6.2.1

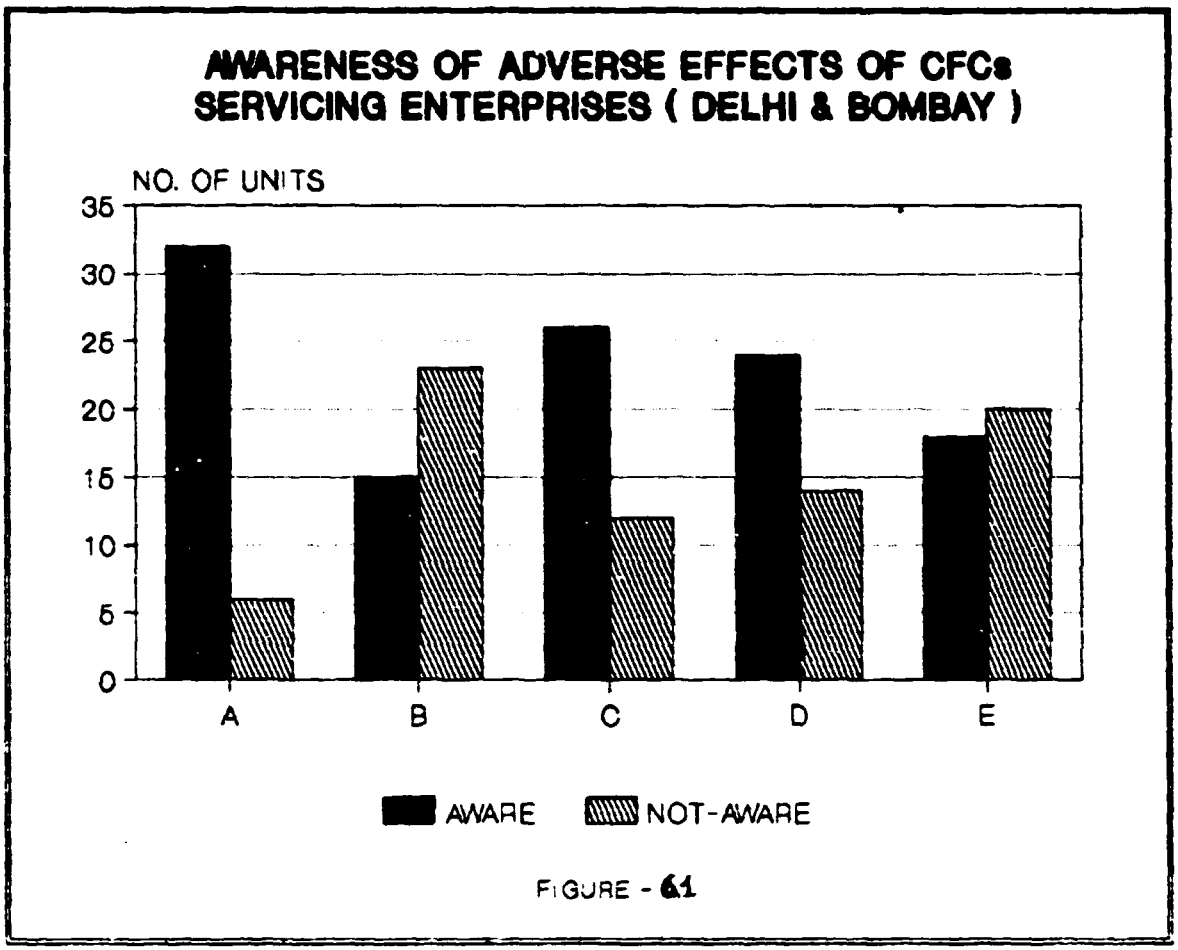

FIGURE - 6.1

A - LEAKAGE OF CFC REFRIGERANTS IN ATMOSPHERE CAUSES ENVIRONMENTAL PROBLEMS.

B - WORLDWIDE USE OF CFC REFRIGERANTS IS TO BE DISCONTINUED BY YEAR 2010 UNDER MONTREAL PROTOCOL

C - AVAILABILITY OF CFCs WILL GO DOWN IN NEXT TEN YEARS DEPENDING UPON DEVELOPMENT OF ALTERNATIVE REFRIGERANTS

D - IN DEVELOPED COUNTRIES, CFC REFRIGERANTS ARE RECOVERED AND RECYCLED.

E - EQUIPMENTS ARE AVAILABLE FOR RECOVERY AND RECYCLING OF REFRIGERANTS.

Machines designated as 'multi-refrigerant' are designed so that one can easily switch from one refrigerant to another without any emission into the atmosphere. This takes about 5 minutes. Separate cylinders and discharge hoses must be used for each refrigerant.

All models can be used to recover liquid using the displacement method with a buffer cylinder.

The recovery and recycling equipment or equipment for recovery only or recycling only are presently not being manufactured in India. The consultants have analysed the specifications of different recovery and recycling equipment available abroad and have selected EP-3 machine (technical specification of which are enclosed at Appendix 6.1) of Environmental Products Amalgamated Pty Ltd, Australia as a suitable model.

6.4 Rate of Recovery

6.4.1 The rate of recovery will vary according to the temperature and pressure within the system, the ambient temperature and other variables. However, as a guide, it is possible to recover approximately 25 kg per hour with 1/3 HP machines and approximately 50 kg per hour with the 3/4 HP machines. Using the buffer method of liquid displacement, where the high side of the recovery machine is directed to a dual valve buffer cylinder and the vapour withdrawn, it is possible to recover up to 200 kg per hour.

6.4.2 It is not yet possible to have a combination machine for both CFC refrigerants and non-CFC refrigerants (such as HFC-134a) at an economic price. These refrigerants must be kept separate.

6.5 Level of Manufacturing Technology

The level of technology required to manufacture recovery and recycling equipment is not highly sophisticated. It involves sheet metal fabrication and powder coating, steel welding, copper brazing and electrical fitting and testing.

6.6 **Sources of supply of sub-assemblies/components**

6.6.1 The price of EP3 machine with all accessories including 2 Nos of cylinders, manifold, gauge & hose set, 2 Nos of anti-blow back valves,gauge bracket will be US $ 2000 each.

6.6.2 The price is FOB Melbourne, Australia or Houston, U.S.A and applies to 100 machines. The freight is additional and is approximately US $ 2800 for a 20 foot container for 100 machines. The CIF value would work out to US $ 2028 per machine.

6.7 **Major Sub-assemblies/Components**

6.7.1 The major sub-assemblies and components for model EP-3 along with possible sources of supply are indicated below :

TABLE - 6.1

MAJOR SUB-ASSEMBLIES AND COMPONENTS FOR A RECOVERY AND RECYCLING EQUIPMENT (MODEL EP-3 MACHINE)

Sub-assemblies/Components	Sources of Supply
Sheet metal fabrication	Local
Powder coating	Local
Compressor-hermetically sealed,piston type 1/3- 1/2hp	Danfoss
Compressor service valve	Danfoss
Condensor	Local
Electrical wiring harness	Local
Electrical relays,switches, hour meter	Siemens

Sub-assemblies/Components	Sources of Supply
Pressure switches high/low	Danfoss
Oil recovery device made from 40mm steel or copper tube	Local
Brass fittings, capillary tube, copper tube	Local
Filter/accumulator assembly	Technology Supplier
Main filter molecular sieve	Technology Supplier
Storage cylinders (22kg,dual valve recycling cylinder)	Local
Manifold gauges,hoses, anti-blowback valves	Local

6.7.2 It is expected that over a period of time, it will be possible to make or buy in India all components except the filter/accumulator assembly and main filter which are proprietory parts and which would need to be sourced from abroad. It may be convenient to initially source major parts from the technology supplier until Indian sources are developed.

6.8 Estimates of Cost of Equipment

6.8.1 The cost of sub-assemblies/components from factory build list of technology supplier are as follows for model EP-3 machine :

TABLE - 6.2

REFRIGERANT RECOVERY & RECYCLING EQUIPMENT (RP3 MACHINE) - COST OF COMPONENTS

ITEM	FOB COST IN US $	CIF COST IN US $	ESTIMATED COST INDIGENOUS (RS)	ESTIMATED COST IMPORTED (RS EQUIV)
Danfoss compressor/condenser outfit FR8.5B	191.35	200.90	-	200.90
Danfoss TX valve TEF R12	26.70	28.00	-	28.00
Danfoss D/P pressure control hi/lo KP 15	27.40	28.75	810	-
Danfoss check valve NRV6	13.45	14.10	-	14.10
Danfoss sight glass SGI 1/4"	9.60	10.10	-	10.10
Danfoss orifice 0/0	5.85	6.10	-	6.10
Chassis, cover and body - ext.sourced fabrication	160.95	169.00	2745	-
Powder coating chassis, cover and body-ext.sourced	35.35	37.10	600	-
Carton and pallet	8.90	9.30	150	
Consumable items e.g. welding gases, silver solder, electricity etc.	9.60	10.10	260	-
Rubber wheels 2 X 2" X 6"	4.85	5.10	80	-
Siemens electrical switches 3SB12, buttons,globes	14.60	15.30	-	15.30
Hour counter - Siemens	13.20	13.85	-	13.85
Microswitch Omron 1991 RE	1.85	1.90	-	1.90
Screen print fascia	2.05	2.15	55	-
Electrical lead and plug 4 metres	1.70	1.75	45	-
Wire loom assembly	4.40	4.60	120	-
Brass fittings, nuts & bolts, minor items	60.50	63.50	1650	-

Main filter core	20.00	21.00	-	21.00
Filter/accumulator assembly, bolt-in	150.00	157.50	-	157.50
Dual valve recycling cylinder	77.00	80.85	1300	-
Manifold gauges and hoses	73.70	77.35	1250	-
	913.00	958.30	9065	468.75

Exchange rate taken @ US $ = Rs 31/

Estimated total cost = Rs 23,595/-
(imported & indigenous components)

6.8.2 The cost of direct labour for assembly as per experience abroad averages at about 5 hours per EP3 machine. The royalty has been taken to be @ US $ 100 per EP3 machine.

6.9 <u>Estimates of Cost of Indigenous Equipment (EP-3 Machine)</u>

6.9.1 The estimates of cost of refrigerant recovery & recycling machine when locally manufactured are worked out as below :

	I yr	II yr	III yr	IV yr	V yr
Phased Manufacturing Programme(Production in Nos)	2000	2500	3000	3500	4000

Imported EP-3 machine cost with cylinder as of 1994 = US $ 2000 = Rs 62,000/-
@ 1 US $ = Rs 31/-

Estimated cost of major sub-assemblies/components for EP-3 machine. RS 24275/-

Add - Direct labour charge for 10 hours @ Rs 15/hour (5 hours is the normal time abroad)	Rs 150/-
- Other overheads (including factory overheads, admn overheads & financial overheads/machine @ 300% of direct labour.	Rs 450/-
- Incidence of depreciation on estimated capital investment of Rs 1.5 million on tooling to be imported @ 33% per annum	Rs 200/-
- Provision for contingencies @ 5%	Rs 1250/-
- Ex-factory cost of EP-3 machine	Rs 26,325/-
- Royalty @ 100 US$ per machine	Rs 3100/-
- Cost incidence due to Indian taxes on royalty @ 20%	Rs 620/-
- Sales overheads @ 10% on ex-factory cost per machine	Rs 2630/-
- Sales price/EP-3 machine	Rs 40,000/-

6.9.2 Based on the sales price of Rs 40,000/EP-3 machine, the total sales turnover at full production capacity of 4000 machines in 5th year, will be Rs 160 million with a profit after depreciation of Rs 30 million (approx).

6.9.3 The above is based on assumed production programme during first five years. The above estimates will change based on the actual procurement prices for sub-assemblies/components from indigenous sources.

6.9.4 Import duty is not taken in to account on proprietary components which will need to be imported as Government can be approached for its exemption. Import duty on tooling has also not been considered.

6.10 **Market Potential**

6.10.1 In the car air-conditioning sector, on a very conservative basis, it is considered that there are atleast 7-8 major car air-conditioner service stations in class A cities (Delhi, Bombay, Calcutta, Madras, Bangalore & Hyderabad) each offering a potential for one refrigerant recovery and recycling machine initially. Similarly there are 2-3 major service stations in another 15 state capitals offering potential for one machine at each service station. Further, there are atleast 1-2 major service stations in each of some 100 class B cities in different states offering potential for one machine at each service station. This means a total initial potential of about 300 refrigerant recovery and recycling machines (Model EP-3).

6.10.2 Room air-conditioners require about 1.2 kg of HCFC-22 per A/C. With increasing population of room air-conditioners, the possibility for introducing recovery & recycling equipment is sizable as the quantity of refrigerant involved per room air-conditioner is high. In fact, based on the information gathered from the survey, it was found that there are possibly 250 service stations of room air-conditioners, on average, in each of the class A cities i.e Delhi, Bombay, Calcutta, Madras, Bangalore and Hyderabad. If it is assumed that each of these stations service room A/Cs with compressor/choking problems twice per week on an average, then the total such room A/Cs per year serviced by each station would be about 100 Nos (involving potential HCFC-22 recovery of 120 kg per year). In other words, there is a potential for 1,500 EP-3 machines in the class A cities alone for catering to the service needs of room A/Cs. If 100 service stations are assumed to exist in each of another 15 state capitals servicing room A/Cs with

compressor problems twice a week and 50 service stations each in about 100 class B cities, the total demand potential for EP-3 machines in class A, B & C cities initially will be 8000 Nos (1500+1500+5000).

6.11 Export Market

6.11.1 In addition to the Indian market, the Indian plant can cater to the large export market due to low input costs based on indigenous sub-assemblies/components and lower cost of labour. Due attention may therefore have to be paid for development of indigeous vendors for major components /sub-assemblies where possible right before the initial stages of production. Possibilities of export through OEM supplies or through direct exports for catering to the international market requirements may be explored in this context. In view of legislative requirements in advanced countries, there is a large potential for refrigerant recovery and recycling equipment overseas.

The escalating cost of CFCs makes it attractive for the Indian venture to orient its production to export markets either directly or with the assistance of collaborators. In developing countries (Article 5 countries of the Montreal Protocol), the car air-conditioners population is about 25 million. This represents about 10% of world car air-conditioning capacity. The number of new air-conditioned cars manufactured annually in Article 5 countries is estimated at 2.5 million. The total CFC consumption in this sector in Article 5 countries is estimated by UNEP at 26,000 tons with 3,000 tons for OEM and 23,000 tons for servicing. Developing countries also thus offer significant market potential for export of refrigerant recovery and recycling equipment from India.

6.12 Based on the review of the feedback received from the market survey as well as the pre-feasibility analysis on the manufacture, the venture would be unique in the following respects :

a) The product introduces the new concept of refrigerant recovery and recycling in India

b) There are no existing manufacturers in the country for this range of equipment and hence the first entrant can achieve a sizable market share quickly and become established.

c) Marketing can be started prior to establishment of manufacturing operations to tap the ready market.

d) The project falls in the high priority area of preservation of environment and is also of social and national relevance.

e) This is the opportune time for introduction of the recovery and recycling equipment in the country which is compatible with the implementation of Montreal Protocol by Government of India.

It is necessary to encourage the industries in pollution control business to locally manufacture recovery and recycling equipment. Exemption of excise

duty and other fiscal benefits may have to be provided in addition to subsidizing the equipment with assistance from Multilateral Fund of Montreal Protocol so that service stations, workshops & manufacturers can buy and utilise the equipment.

VII. FEASIBILITY OF RECYCLING CFC REFRIGERANTS

7.1 General

7.1.1 The effective collection/recovery and recycling of refrigerants from refrigerators, mobile air-conditioners and room air-conditioners requires different approaches in view of the varied nature of each sector.

7.1.2 For instance, the refrigerators are manufactured in large numbers but are also widely dispersed in the country. Again, refrigerators are serviced in authorised service stations during warranty period and by servicing enterprises in the informal sector after warranty period. In many cases, the recovery, rectification and recharging is done at the residence of the customer by the mechanic in the informal sector. Refrigerator is brought to the service station in case of compressor failure.

7.1.3 Fortunately, in the case of car air-conditioners, it is the customer who goes to the service station. The same applies to bus/van A/Cs. Train A/C coaches are invariably serviced at the repair workshops. In these cases, collection/recovery of the gas is not a problem.

7.1.4 In case of room air-conditioners and package A/Cs, which are covered by service contract, they are taken to the service stations. Where the room air-conditioners are not covered by the service contract and are beyond the period of warranty, it is taken or picked up by the technician in the informal sector. But these service stations/centres/garages are so widely dispersed that each station may not have enough recoverable refrigerant to justify the viability of a recovery/recycling system. The refrigerant may have to be delivered at a centralised facility for recharging based on a suitable incentive system.

7.1.5 Other aspects of recovered refrigerant is the state of purity which depends upon the life of the unit, the type of failure and/or whether it has been recharged earlier by service stations in the organised/informal sector.

7.2 Quantities of Recoverable & Recyclable CFC Refrigerants for Economic Viability of Recovery & Recycling Stations

Recovery and Recycling Equipment of several international manufacturers were considered and evaluated in a previous study on " Techno-Economic Assessment of the Financial Viability of the Collection and Safe Disposal of Refrigerant Gases and Related materials in Africa", carried out by Mantec Consultants Pvt Ltd for UNIDO, Vienna (Project No. US/RAF/90/173), and it was found that the equipment of Environmental Products Amalgamated Pty Ltd, Australia are most cost-effective. Therefore. economic viabilities have been worked out based on product prices of EPA, Australia.

The break-even quantity of refrigerants to be processed for recovery and recycling is indicated at Table 7.1. Calculations and assumptions for working break-even quantities for CFC-12 and HCFC-22 refrigerants are given in Appendix-7.1. It may be mentioned that for recovery & recycling equipment prices of processed refrigerants have been taken as same as those of virgin gases, whereas, for recovery only equipement these have been taken at 60% of the virgin gas prices.

Table-7.1

BREAK-EVEN QUANTITY OF RECOVERABLE REFRIGERANTS

		CFC-12	HCFC-22
Landed cost of imported recovery & recycling equipment excl. import duty	Rs 63,000	209 Kg	175 Kg

Landed cost of imported recovery only equipment excl. import duty	Rs 30,400	124 Kg	80 Kg

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7.3 **Assessment of the Potential for Distributed Recovery/ Recycling and Centralised Recycling Stations for the Sampled Enterprises**

The potential for the distributed recovery and recycling and centralised recycling stations for the sample enterprises is assessed on the basis of the following :

a) The minimum machine capacity of the 'Recovery only' or 'Recovery and Recycling only' types of machines is 25 Kg per hour. The machines have therefore a capability to recover/recycle CFC refrigerants of 60,000 Kg per year on single shift, 300 working days per year basis. This is far higher than the recoverable refrigerant value of any one of the enterprises covered by the sample survey. But as the Break-even quantity is only 124 Kg and 80 Kg for CFC - 12 and HCFC - 22 respectively as per table - 7.1, one recovery station will stand justified if the annual recoverable refrigerant quantity is more than these values.

b) Similarly, a recovery and recycling station stands justified if the annual recoverable refrigerant quantity is more than 209 Kg of CFC - 12 or 175 Kg of HCFC - 22.

c) Therefore, for all enterprises having more than above refrigerant quantities, a recovery and recycling station is suggested.

d) In enterprises where the annual recoverable refrigerant is less than 124 Kg of CFC - 12 or 80 Kg of HCFC - 22, even a recovery station is not

justified. For all such enterprises alternative arrangements must be made for recovering the refrigerant and depositing the same in a central recycling station.

Table 7.2 gives the potential number of recovery and recycling, recovery only, recycling only machines that can be installed in these sample enterprises.

TABLE 7.2

POTENTIAL NUMBER OF RECOVERY AND RECYCLING MACHINES THAT CAN BE INSTALLED AT MANUFACTURERS & SERVICING ENTERPRISES COVERED IN SURVEY

S. No.	Name of the enterprise	Manufacture: (M)/Service Station (S)	Sub-sector: Refrigerator	Car A/C	Bus A/C	RAC	PAC	Recoverable refrigerant (Kg /year) CFC-12	HCFC-22	Potential No. of machines which can be installed: Recovery & recycling	Recovery only	Recycle only
1.	Kelvinator of India Ltd	M (O)	_/					1400		1	-	-
2.	Expo Machinery Ltd	S (O)	_/					150		-	1	-
3.	Fedders Lloyd Corpn. Ltd	M (O)	_/			_/	_/	20	750	1	-	-
4.	Airserco Pvt Ltd	S (O)	_/			_/	_/	24	580	1	-	-
5.	Godrej-GE Appliances	M (O)	_/					1700		1	-	-

S. No.	Name of the enterprise	Manufacture: (M)/Service: Station (S)	Sub-sector: Refrigerator	Car A/C	Bus A/C	RAC	PAC	Recoverable refrigerant (Kg /year) CFC-12	HCFC-22	Potential No. of machines which can be installed: Recovery & recycling	Recovery only	Recycle only
6.	Godrej-GE Appliances	S (O)	✓					3600		1	-	-
7.	Videocon Appliances Ltd	M (O)				✓		62	900	1	-	-
8.	Videocon International Ltd	S (O)				✓		180	70	-	1	-
9.	Voltas Ltd (Refrigerators Unit)	M (O)	✓					570		1	-	-
10	Voltas Ltd (Air Conditioners Unit)	M (O)			✓	✓	✓		8460	1	-	-
11.	Voltas Ltd	S (O)	✓			✓	✓	1500	9000	2**	-	-
12.	Hyderabad Allwyn Ltd	S (O)	✓					240		1	-	-
13.	Blue Star Ltd	S (O)	✓					30		-	-	-
14.	Aramco Refrigeration Co	S (I)	✓	✓	✓			29	50	-	-	-
15.	Intercool	S (I)	✓	✓				17		-	-	-
16.	Indian Traders & Agents	S (I)	✓			✓		5	60	-	-	-
17.	Capital Refrigeration Corpn.	S (I)	✓			✓		15	60	-	-	-

S. No.	Name of the enterprise	Manufacture: (M)/Service: Station (S)	Sub-sector: Refrigerator	Car: A/C	Bus: A/C	RAC	PAC	Recoverable refrigerant (Kg /year): CFC-12	HCFC-22	Potential No. of machines which can be installed: Recovery & recycling	Recovery only	Recycle only
18.	Ramesh Tan & Co	S (I)	_/			_/		10	Negligible	-	-	-
19.	Pioneer Refrigeration Engg.Cop	S (I)	_/			_/	_/	630	do	1	-	-
20.	Nelson Enterprises	S (I)	_/			_/	_/	300	300	2**	-	-
21.	Subros Ltd	M (O)		_/				1500		1	-	-
22.	Subros Ltd	S (O)		_/				400		1	-	-
23.	Sanden Vikas (India) Ltd	M (O)		_/				400		1	-	-
24.	Sanden Vikas (India) Ltd	S (O)		_/				650		1	-	-
25.	Indus Air Conditioning (P) Ltd	M & S (O)		_/				600		1	-	-
26.	Sikand & Co	S (O)		_/				8		-	-	-
27.	Hemkunt	S (O)		_/				52		-	-	-
28.	Breezeways	S (I)		_/		_/		240	Negligible	1	-	-
29.	Quick Refrigeration	S (I)		_/		_/		400	175	2**	-	-
30	Shiv Shakti Engg Co	S (O)			_/				Data not available	-	-	-
31.	Sarayu	S (I)		_/				400		1	-	-
32.	Keepit Cool Centre	S (I)		_/				360		1	-	-

S. No.	Name of the enterprise	Manufacture: (M)/Service: Station (S)	Sub-sector					Recoverable refrigerant (Kg /year)		Potential No. of machines which can be installed		
			Refrigerator	Car: A/C	Bus A/C	RAC A/C	PAC	CFC-12	HCFC-22	Recovery & recycling	Recovery only	Recycle only
33.	Auto Cool	S (I)		✓	✓			840	90	1	1	-
34.	United Auto Air Conditioning	S (I)		✓				600		1	-	-
35.	Hans Air Conditioning	S (I)		✓		✓		480	Negligible	1	-	-
36.	Reeta & Co	S (I)		✓	✓			680	90	1	1	-
37.	Top beat Electronics	S (I)		✓	✓			600	90	1	1	-
38.	Jai Auto Service	S (I)		✓				360		1	-	-
39.	Shiv Shakti Engg.Co	M (O)			✓			Negligible		-	-	-
40.	Blue Star	S (O)			✓	✓		do	70	-	-	-
41.	Air Conditioning Corpn Ltd.	M (O)			✓	✓			670	1	-	-
42.	Air Conditioning Corpn.Ltd	M (O)				✓	✓		12	-	-	-
43.	Blue Star	M (O)				✓	✓		2290	1	-	-
44.	Shriram Refrigeration Industries	M (O)				✓			Data Not available	-	-	-
45.	Antrex Ambience Ltd.	M (O)				✓			300	1	-	-
46.	Thandak Aircon.	M (I)				✓	✓		25	-	-	-
47.	Temperature Control	M (I)				✓	✓		Data not available	-	-	-

S. No.	Name of the enterprise	Manufacture: (M)/Service: Station (S)	Sub-sector					Recoverable refrigerant (Kg /year)		Potential No. of machines which: can be installed		
			Refrigerator	Car: A/C	Bus A/C	RAC A/C	PAC	CFC-12	HCFC-22	Recovery & recycling	Recovery only	Recycle only
48.	Temperature Control	S (I)				✓	✓		15	-	-	-
49.	Coolways India Air Conditioning Pvt Ltd	M (I)				✓			85	-	1	-
50.	Coolways India Air Conditioning Pvt Ltd	S (I)				✓			50	-	-	-
51.	J B Enterprises	S (I)				✓			9	-	-	-
52.	Modern Motor Co	S (I)				✓			4	-	-	-
53.	Uni-Air Refrigeration	S (I)				✓			300	1	-	-
54.	Intercool	S (I)				✓			50	-	-	-
55.	Sanvik	S (I)				✓	✓		25	-	-	-
56.	Clair Air Conditioning	S (I)				✓	✓		120	-	1	-
57.	Classic Air Conditioning	S (I)				✓	✓		1270	1	-	-
58.	Mehta Cool Techco	S (I)					✓		Negligible	-	-	-
	Total									35	7	-

* (O) - Organised Sector

* (I) - Informal Sector

** Two separate machines for CFC - 12 & HCFC - 22 have been shown. However in these cases a single multi-refrigerant machine may also be used for recovery of both CFC - 12 & HCFC - 22.

From Table-7.2 above it may be seen that out of 58 enterprises in Delhi and Bombay covered in the organised and informal sectors, potential exists for 35 recovery and recycling machines and 7 recovery only type of machines. There are 22 enterprises out of 58 sampled units (38%) which do not have minimum economically viable annual refrigerant quantity for recovery/recycling. In cases where the refrigerant is recovered only or where the quantity of refrigerant recoverable does not justify a recovery/recycling machine, the refrigerant may have to be taken to a centralised recycling station.

7.4 Assessment of the Possibility for Distributed Recovery/Recycling and Centralised Recycling Stations for the Country

7.4.1 In the refrigerator sector, there are atleast 8 manufacturers each with around 10-12 major service stations distributed throughout the country. Recovery and recycling stations will stand justified not only at their manufacturing locations but also at their major service stations. The immediate potential for recovery and recycling machines at the refrigerator manufacturing locations and their major service stations (in the organised sector) is estimated to be 104 Nos. With a population of 8 million refrigerators in the field, there are atleast 5000 service stations in the informal sector out of which atleast 10% i.e. 500 service stations are likely to have recoverable refrigerant in excess of 130 Kg/year and justify installation of a recovery only type of machine. When the recoverable refrigerant quantity is small, a scheme of incentives needs to be built for collection of refrigerant in small bags at the customer location and small cylinders at the service stations for eventual deposition of the same at a centralised recycling station. With 5 centralised recycling stations in each of 6 class A cities (Delhi, Bombay, Calcutta, Madras, Bangalore & Hyderabad), one centralised recycling station in each of another 15 state capitals and 100 class B cities, the total estimated potential for centralised recycling stations will be around 150 Nos.

7.4.2 In the car air-conditioning sector, on a very conservative basis, it is considered that there are atleast 7-8 major car air-conditioner service stations in all the 6 class A cities, each service station offering a potential for one refrigerant recovery and recycling machine initially. Similarly, there are 2-3 major service stations in another 15 state capitals offering potential for one machine at each service station. Further, there are atleast 1-2 major service stations in each of some 100 class B cities in different states offering potential for one machine at each service station. This means a total initial potential of about 300 refrigerant recovery and recycling machines.

Further, there are atleast 2000 service stations in the country in the informal sector undertaking repair of mobile air-conditioners out of which, as a broad estimate, around 600 service stations could use recovery only type of machine at their premises. In case of balance service stations, the refrigerant may have to be transported to centralised recycling stations.

7.4.3 Room air-conditioners require about 1.2 Kg of HCFC-22 per A/C. With increasing population of room air-conditioners, the possibility for introducing recovery and recycling equipment is sizable as the quantity of refrigerant involved per room air-conditioner is high. In fact, based on the information gathered from the survey, it was found that there are around 250 service stations of room air-conditioners, on average, in each of the class A cities i.e. Delhi, Bombay, Calcutta, Madras, Bangalore and Hyderabad. If it is assumed that each of these stations service room A/Cs with compressor/choking problems on two air conditioners per week on an average, then the total such room A/Cs per year serviced by each station would be about 100 Nos (involving potential HCFC-22 recovery of 120 Kg per year). In other words, there is a potential for 1,500 refrigerant recovery and recycling machines in the class A cities alone for catering to the service needs of room A/Cs. If 100 service stations are assumed to exist in each of another 15 state capitals servicing

room A/Cs with compressor problems twice a week and 50 service stations each in about 100 class B cities, the total demand potential for refrigerant recovery and recycling machines in class A, B & C cities initially will be 8000 Nos (1500+1500+5000).

Further, there are least 1000 service stations in the country in the informal sector undertaking repair of room air-conditioners out of which, as a broad estimate, around 500 service stations could use recovery only type of machine at their premises. In case of balance service stations, the refrigerant may have to be transported to centralised recycling stations.

7.4.4 Since some of the servicing stations undertake repair of refrigerators, mobile air-conditioners and room/package air-conditioners in combination, a multi-refrigerant recovery/recycling machine may be needed at the premises of such service stations.

Table-7.3

Assessment of the Potential for Refrigerant Recovery & Recycling

Sector	Recovery & Recycling Machines	Recovery only Machines	Centralised Recycling Machines
Refrigerator Sector	104	500	150
Mobile A/C Sector	300	600	
Room A/C Sector	8000	500	
Total	8404	1600	150

7.5 Location of the Centralised Recycling Stations

7.5.1 The centralised recycling stations should be located in

such a manner as to make them easily accessible. It may be possible for a major service station with a large recoverable refrigerant to install a centralised recycling station as a business venture. It may also be possible for the centralised recycling stations to be located at some of the authorised service stations of the manufacturers of refrigerators, mobile A/Cs and air-conditioners. Further, the regional offices of CFC manufacturers may be encouraged to put up recycling stations at their premises as they are in the best position to decide on the manner of purification/reclamation.

7.5.2 Where a centralised recycling station is present, it is possible that refrigerants of different contamination levels are received.

7.6 <u>Infrastructural Support for Effective Recovery & Recycling in the Country</u>

7.6.1 The infrastructural support required for effective recovery and recycling in the country is of three types, which are discussed below.

7.6.2 <u>Technical Infrastructral Support</u>

Technical infrastructural support is required for the following:

a) Changes in the design of the appliances/equipment.

As Venting of refrigerant is to be prohibited, design changes are required in the refrigerating and air-conditioning appliance/equipment to facilitate easy recovery of the refrigerant in case of leakage or a problem. These include provision for recovery tubes and quick couplers or valves on the appliances/equipment. This will also call for a standardisation of these tubes, valves and coupler to be used for the purpose.

b) Demonstration Stations for recovery and recycling refrigerants & training of mechanics.

It will be necessary to establish demonstration stations for recovery and recycling of refrigerants to illustrate the capabilities and operation of recovery and recycling machines, to generate awareness and to evoke serious interest in the adoption of refrigerant recovery and recycling practices. It is also necessary to provide technical training to the mechanics, specially in the informal sector, on the operation, maintenance and efficient recovery of refrigerant from the appliances/equipment or collection devices. This may involve short-term training modules/ seminars/ workshops for certification/accredition and need to involve the Ministry of Environment & Forests, Industry Associations such as All-India Air-conditioning and Refrigeration Association (AIACRA).

c) Training in better manufacturing & servicing practices.

Better manufacturing will result in virtual elimination of CFC emissions during manufacture and also reduce frequency of failures in the field. Better service practices will eliminate venting of the sealed systems. Better brazing to eliminate leaks and proper charging will bring down the rate of failures after servicing to a minimum.

d) Formulation of standards for recycled refrigerants and recovery & recycling Equipment.

There are no standards/specifications available in India for recycled refrigerants. Till these are ready it will be difficult to ask manufacturers and servicing stations to use recycled refrigerant in place of new refrigerant.

Considerable work in this direction has already been done in advanced countries. For example, in U.S.A., the Environmental Protection Agency (EPA) ad-hoc group established a specification that recycled CFC-12, removed from and intended to be

returned to a mobile air-conditioner contain not more than the following amounts of specified contaminants:

Moisture	15 ppm by weight
Refrigerant Oil	4000 ppm by weight
Non Condensable Gases	330 ppm

Subsequently, SAE issued standards on service practices for refrigerant contaminant, recycling equipment and refrigerant purity. SAE J 1991, a refrigerant purity specification, applies to recycled CFC-12 recovered from mobile air-conditioners. It also states that refrigerant received from other sources should comply with ARI standard 700-88. Underwriters Laboratories Inc has also issued a safety standard/UL 1963/ on recovery and recycling units and administers a certification programme on compliance with UL 1963 and SAE J 1990.

It will be necessary to formulate similar standards in India, taking into account Indian conditions.

7.6.3 Legal Infrastructural Support

a) Prohibition on venting CFC refrigerants.

Legislation prohibiting venting is the first step to force manufacturers and service stations to adopt methods/techniques to recover the gas from the appliances in cases of a problem in manufacture/service. This has been done in USA through US clean air act 1990. A similar legislation suitable for Indian conditions will have to be enacted and enforced through the Pollution Control Directorate.

b) It will also be necessary to make it mandatory to use recovery and recycling machine if the annual recoverable CFC refrigerant quantity is more than

209 Kg and a 'recovery only' type of machine if the annual recoverable refrigerant quantity is more than 124 Kg.

The U.S Clean Air Act of 1990 imposed recycling requirements on service facilities that repair more than 100 vehicles per year effective January 1, 1992 and on all service facilities effective January 1. 1993. India also needs to promulgate a similar legislation to prohibit venting of CFC refrigerants.

7.6.4 Financial Infrastructural Support

Financial Infrastructural support is required to encourage recovery and recycling. This include

a) Exemption from customs duty of imported equipment and spares for the recovery and recycling.

b) Provision of grants/subsidies on the recovery/ recycling machines to encourage a wide spread use of refrigerant recovery and recycling units. The subsidy may be 50% of the cost of imported equipment when supplied to manufacturer/Service Stations in the organised as well as in the informal sector. Provision of subsidy can be made contingent on effective use of the equipment for recovery, recycling and re-use which is subject to verification by Pollution Control Inspectors.

c) Graduated taxation on CFCs both to minimise CFC use and wastage and also to encourage use of recycled refrigerants in its place.

d) Funding for Demonstration Stations, Training of mechanics on better manufacturing and servicing practices and also on collection, recovery and recycling techniques and equipment.

e) Subsidy to the centralised recycling stations for the purchase of mobile vans for collection of refrigerants from manufacturers and service stations in the organised and informal sectors.

f) Incentives to manufacturers and service stations for collection and deposition of refrigerants at centralised recycling stations when the quantities are small.

g) Exempting fiscal duties and customs duty on imported components/parts for local manufacture of recovery/recycling equipment.

7.7 Suggested Projects

Based on the survey and findings, the following projects are required to establish the infrastructural support for effective recovery and recycling of CFC refrigerants in India.

7.7.1 Indigenous manufacture of Recovery, Recycling and Recovery and Recycling equipment for refrigerants.

In the refrigeration and air conditioning industry an annual growth of 10 to 15% on an average is forecast per year. With this growth the population of the refrigeration and air conditioning equipment will also increase and the servicing and recovering needs will also increase inspite of better manufacturing and servicing methods.

For this purpose, a project for indigenous manufacture of 'Recovery only', 'Recovery and Recycling only' equipment of an established design like that of Environmental Products Amalgamated Pty Ltd, Australia, as discussed in chapter-VI & Chapter-VII, in this report, is suggested.

Initially the units could be imported and simultaneously facilities for indigenous manufacture could be started.

Recovery and recycling machine makes economic sense even if CFCs are phased out at some point of time and non-CFC refrigerants are to be used.

7.7.2 Centre for demonstration and training on recovery and recycling units.

Organised sector always has the means and resources to train their employees on new equipment and technologies. But for the informal sector, however, there is a strong need to create awareness about recovery and recycling and to train their workers to use the same. For this purpose, it is necessary to establish a training centre for recovery and recycling under the aegis of an Industry Association. The centre shall cover the following :

a) Demonstration equipment for recovery and recycling for various types of refrigeration and air-conditioning equipment.

b) Training the mechanics in the use of recovery and recycling equipment.

c) Training the mechanics in better manufacturing and service practices and housekeeping.

d) Accreditation of service mechanics as indicated in (b) and (c) above.

With the above, the mechanics will get equipped for better servicing practices for refrigerators and air-conditioners.

VIII. SUMMARY OF FINDINGS AND CONCLUSIONS

8.1 The feasibility study for recovery and recycling of CFC refrigerants aims at investigating the possibilities of recovering CFCs from refrigerators, air-conditioners and mobile air-conditioners. The study also examines the possibility of :

i) Centralised versus distributed recycling of CFCs.

ii) Local manufacturing of recovery and recycling equipment.

iii) Reducing CFC consumption through better house-keeping and training.

The field survey covered representative units from the above sub-sectors and included manufacturers, their authorised service stations as well as service stations in the informal sector. In all 58 enterprises were covered in Delhi and Bombay. The data was collected through personal visits and discussions with the technical staff of the enterprises based on the questionnaires designed for this purpose. The data collected from the field survey has been analysed and the sub-sector-wise findings are discussed below.

8.2 Refrigerator Sub-Sector

8.2.1 In case of manufacturers, the charging rejections account for 3% of the production and they are mainly due to leaks, particle and moisture chokes and inefficient compressors. Of this, 1.5% accounts for chokes and inefficient compressors. These refrigerators are reworked on a reworking line, but as the manufacturers do not have any recovery equipment at present, the refrigerant is emitted out during rework. As the refrigerant is intact before venting, it is possible to recover the same from the compressors if recovery stations are available. In case of minor leaks also, possibility exists for recovery of a major part

of the refrigerant. Thus, on an average, 2% of the refrigerant consumption on the whole can be recovered by the manufacturers with the use of dedicated recovery stations.

8.2.2 Of the 5 manufacturers covered during the survey, 3 manufacturers have recoverable CFC-12 of more than 500 Kgs per year at the present level of production volumes and clearly offer potential for recovery and recycling equipment.

8.2.3 In the case of service stations covered during the survey, there were 6 service stations who have a recoverable CFC-12 level exceeding 150 Kg per year. But this refrigerant may be heavily contaminated because of compressor failures. In such cases, there will be a need for evolving mechanism for collection and transfer to recycling/reclaiming stations.

8.2.4 In cases involving servicing at customer location either by the authorized service stations of manufacturers or by the informal servicing enterprises, CFC-12 can be recovered in plastic bags at customer location for transfer to central recycling stations. The cost of plastic bags etc may have to be subsidised by the Multilateral Fund of Montreal Protocol.

8.3 <u>Mobile Air-conditioner Sub-Sector</u>

8.3.1 In the car air-conditioner sub-sector, the field survey revealed that at each of the three manufacturers premises where charging is done, more than 400 Kg/year of refrigerant can be recovered per year. At the service stations, it was noticed that the CFC-12 can be recovered in cases where :

a) The gas is emitted out as a matter of convenience during repair/maintenance.

b) The gas has partially leaked out from shaft seals but as these seals have to be replaced, the remaining gas is also let out.

c) The compressor has failed but with the sealed systems intact, requiring compressor replacement after venting out the gas.

8.3.2 Further, in case of car air-conditioner servicing enterprises, out of 4 service stations in the organised sector and 13 service stations in the informal sector covered during the field survey, 13 service stations have recoverable CFC-12 exceeding 240 Kg/year where recovery and recycling equipment can be used. When the recoverable refrigerant is in small quantities or when servicing is done at customer's location, recycling may have to be centralised.

8.3.3 In the bus/van air conditioner sub-sector, one manufacturer, one enterprise marketing the systems and one service station in the organised sector were covered during the field survey, in addition to 4 service stations in the informal sector. The recoverable CFC-12 is noted to be around 4500 kg in the case of service station in the organised sector offering potential for recovery and recycling, while all the service stations in the informal sector have less than 90 kg of recoverable CFC-12.

8.4 Air Conditioner Sub-Sector

8.4.1 In air-conditioner sub-sector, HCFC-22 is the refrigerant and the field survey revealed that of the six air-conditioner manufacturers in the organised sector who provided the necessary data during the field survey, all have a recoverable HCFC-22 of a level exceeding 300 Kg/year.

8.4.2 In case of all the 5 manufacturing enterprises in the informal sector covered during the field survey, the recoverable HCFC-22 is less than 85 Kg. Further out of 5 authorised service stations of manufacturers and 16 service stations in the informal sector covered during field survey, one authorized service station repairs air-conditioners on a very large scale and has a recoverable HCFC-22 of 6000 Kg. 14 service stations

have recoverable HCFC-22 potential in the range of 50 Kg - 300 kg/year while 6 service stations have small quantity of recoverable HCFC-22 annually.

8.4.3 In package air-conditioner sub-sector, 5 manufacturers and 3 service stations in the organised sector and one manufacturer and 6 service stations in the informal sector were covered during the field survey. The estimated annual recoverable HCFC-22 in case of two manufacturers in the organised sector exceeds 1200 Kg. In the case of one authorised service station, the recoverable HCFC-22 is 3000 Kg/year while in case of another, it is 450 Kg/year. In the informal sector, only one service station has a recoverable HCFC-22 of 1125 Kg/year while the rest have very small recoverable quantities.

8.4.4 Mixing of CFC-12 with HCFC-22 in the proportion varying from 30% - 70% to 20% - 80% at the time of recharging by mechanics in the informal sector highlights the need for training the mechanics on good servicing practices. As HCFC-22 is also being brought into 'controlled substance' category albeit with a longer time schedule for phase out, the principle of recovery and recycling should be extended to this sector also. If not anything else, the economic benefits that would accrue in saving the costly HCFC-22 would in itself induce these service stations to install recovery/recycling equipment. When the recoverable refrigerant is small in servicing enterprises in the informal service sector or when recovery is done at customers location, recycling may have to be centralised.

8.5 <u>Awareness of adverse effects of CFCs among servicing enterprises and willingness to install recovery and recycling equipment</u>

In chapter-6, para 6.2.1 the details of awareness of adverse effects of CFCs among servicing enterprises and their willingness to install recovery and recycling equipment has been indicated. It was found that reasonably high percentage of servicing enterprises in informal sector covered by the survey are aware that

a) Leakage of CFC refrigerants in atmosphere causes environment problems.

b) Worldwide use of CFC refrigerants is to be discontinued by year 2010 under Montreal Protocol.

c) Availability of CFCs will go down in next 10 years depending upon the development of alternative refrigerants.

d) In developed countries, CFC refrigerants are recovered and recycled.

e) Equipment are available for recovery and recycling of refrigerants.

8.6 Feasibility of Local Manufacture of Recovery and Recycling Equipment

8.6.1 Refrigerant recovery and its reuse may become a key factor in keeping technically sound CFC systems functioning for their full life time even if virgin CFC is not available. Recovery of environmentally harmful refrigerants has become mandatory in certain countries. India will also benefit by introducing a legislation to that effect.

8.6.2 In the car air-conditioning sub-sector, on a very conservative basis, an initial demand potential of 300 refrigerant recovery and recycling machines is estimated in the country while in case of room air-conditioners, the initial demand potential is estimated at 8000 Nos. It should be possible to manufacture indigenously the recovery & recycling equipment at a price of Rs 40,000 to the customer as against the price equivalent to Rs 63,000 for the imported equipment. The Multilateral Fund of Montreal Protocol may need to subsidise the cost of recovery and recycling equipment so that the end users can find the purchase of the equipment attractive in terms of return on investment.

8.7 Breakeven Quantities for CFC & HCFC Refrigerants

8.7.1 The breakeven quantities of refrigerants have been worked out for CFC 12 & HCFC 22 for recovery only and recovery and recycling equipment. In the case of recovery and recycling equipment the breakeven quantities have been calculated taking the prevailing market prices of CFC-12 & HCFC-22, which are Rs. 140 and Rs. 200 per kg respectively. For recovery only equipment the refrigerant prices have been taken as 60% of the prevailing market prices i.e. Rs. 84 and Rs.120 per kg respectively for CFC-12 & HCFC-22. The breakeven quantities have been worked out as under:

	CFC-12	HCFC-22
Recovery only equipment	124Kg	80Kg
Recovery & recycling equipment	209Kg	175Kg

The potential number of recovery only and recovery & recycling machines that can be installed in the enterprises are 7 and 35 respectively.

8.7.2 Assessment has been made for total number of recovery and recycling machines, recovery only machines and Centralised recycling machines. The total demand for these works out to 8404,1600 and 150 respectively.

8.8 Suggested follow-up projects and Conclusions

The following follow-up projects have been suggested.

1. Indigenous manufacture of Recovery & Recycling equipment.

2. Centre for demonstration and training for recovery and recycling units.

8.9 Infrastructural support

Technical, legal and financial infrastructural supports have been considered necessary for introduction of recovery and recycling as under :

- changes in design of appliances/equipment

- prohibition on venting CFC refrigerants

- customs duty exemption for imported recovery and recycling equipment and spares

- provision of subsidy/grant for equipment users

- graduated taxation of CFCs

The above measures would facilitate introduction of efficient system of recovery and recycling of refrigerants and make manufacture and use of recovery & recycling equipment in India financially viable.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

TERMS OF REFERENCE FOR SUBCONTRACT

MF/IND/93/163
Feasibility study for the recovery and recycling of CFC refrigerants

A. AIM OF THE PROJECT

This project aims at carrying out a study to, first, investigate the feasibility of recovering CFC's from refrigerators, air-conditioners and mobile air-conditioners, and if the result of this part is positive, then to check the individual and combined feasibility of the following::

- Strategies of recycling CFC's, such as centralized recycling versus distributed at individual enterprises.
- Possibilities of local manufacturing of recovery and recycling equipment.
- Possibility of reducing CFC consumption through better housekeeping: Training of repair and maintenance technicians.

Project will have three phases:

❶ Preparatory phase: recruitment of consultant(s) and consulting firm(s); design of work programme; design of questionnaire for workshop survey and consumption data collection; etc.

❷ Data collection and analysis phase: data collection in two selected cities.

❸ Preparation of final report and project proposals: based on the outcome of ❶ and ❷, preparation of follow-up project proposals.

A.2 Background

Please refer to the India Country Programme[1].

B. RESPONSIBILITIES OF THE CONTRACTOR

B.1 Statement of the work

The work of the CONTRACTOR will cover the following project phases:

a) Sampling process:

a-i] Identification of two cities with concentrations of ODS refrigerant users such as refrigerator, air-conditioner and mobile air-conditioner manufacturers and service stations will be made by the CONTRACTOR under the supervision of the Ministry of Environment and Forest.

a-ii] Identification of representative sets of small-, medium and (if applicable) large-scale enterprises among refrigerator, air-conditioner and mobile air-conditioner manufacturers and service stations will be made by the CONTRACTOR.

b) Data collection and analysis:

b-i] CONTRACTOR will design a questionnaire to collect the baseline data through visiting and working with every selected enterprise individually. The questionnaire will consider, among others:

- Quantity and description of products manufactured and/or services provided.
- Technologies and equipment used in the manufacturing and/or servicing.
- ODS refrigerant use: Type(s), amount, price, suppliers.

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[1] Country Programme: Phaseout of ozone depleting substances under the Montreal Protocol, Government of India, New Delhi, September 1993.

- Quantity and cost of other inputs related to ODS refrigerant use: Labour, electricity, water, etc.
- Enterprise's ability and willingness to recover and recycle ODS refrigerants.

b-ii] CONTRACTOR will analyze the data in order to check the individual and combined feasibility of the following:

- Recovering CFC's from refrigerators, air-conditioners and mobile air-conditioners.
- Recycling CFC's (including checking the viability of collection networks, centralized versus distributed recycling, etc.).
- Local manufacturing of recovery and recycling equipment.
- Reducing CFC refrigerant consumption through better housekeeping. Training of repair and maintenance technicians.

c) Preparation of final report and project proposals:

c-i] Preparing a final report covering the activities and outcome of all above-mentioned phases.

c-ii] Based on the outcome of above, preparation of follow-up project proposals using the formats acceptable to Executive Committee of the Multilateral Fund. A team consisting of the CONTRACTOR, the staff of UNIDO and international experts to be recruited by UNIDO will formulate these projects.

B.2 Reports

The CONTRACTOR will be required to make the following reports to UNIDO, in English:

a) **First Interim Report**: At the end of designing the questionnaire and selection of sample enterprises.

b) **Second Interim Report:** Representing collected, compiled and analyzed data on selected enterprises, that is, the feasibility checks.

c) **Formulated follow-up projects.** (UNIDO will provide additional inputs through its staff and/or international consultants to produce this output).

B.3 Work Plan

A simplified time schedule of major project activities is given below. The detailed and binding work plan shall be proposed by the CONTRACTOR and will be negotiated with UNIDO. The final form of the work plan shall be a part of the CONTRACT.

Timing of major project activities

	1994			
	JAN	FEB	MAR	APR
Signing of the subcontract	■			
Selection of cities and enterprises	■	■		
Data collection and analysis		■	■	
Project formulation				■

C. RESPONSIBILITIES OF THE GOVERNMENT

UNIDO has entered into this CONTRACT with the CONTRACTOR on the basis that the GOVERNMENT (in this case represented by the Ministry of Environment and Forest) will provide guidance and assistance to the project whenever necessary.

D. RESPONSIBILITIES OF UNIDO

UNIDO shall make progress payments to the CONTRACTOR, upon successful and timely completion of agreed pre-identified stages of the CONTRACT activities, subject to the conditions to be specified in the CONTRACT and based on submission and acceptance of relevant reports as listed in Section B.2 hereof.

BIBLIOGRAPHY

1) Reducing the consumption of Ozone Depleting Substances in India, Phase-2 : Complying with the Montreal Protocol, Touche Ross & Co, June 1990.

2) Refrigeration & Air-conditioning - Study and Recommendations by Sub-committee of Task Force on national strategy for phasing-out of ozone depleting substances, December 1991.

3) Techno-economic assessment of the financial viability of the collection and safe disposal of refrigerant gases and related materials in Africa, Mantec Consultants Pvt Ltd, August 1992.

4) Country Programme - Phase-out of Ozone Depleting Substances under the Montreal Protocol, Government of India, September 1993.

Appendix - 2.1

LIST OF ENTERPRISES COVERED DURING THE FIELD SURVEY IN DELHI AND BOMBAY

Manufacturing Enterprises - Delhi

1. Mr P K Mishra
   Jt. Manager (R&D)
   Kelvinator of India Ltd
   28, New Industrial Town
   Faridabad - 121 001

   Tel : 8232285, 8232381
   8233382, 8234013

   Fax : 91-11-8233383(FRD)
   91-11-3311183(ND)

   Tlx : 0343-220 KIND IN
   0343-266 KIND IN

2. Mr Bhupinder Godara
   Manager (R&D)
   Fedders Lloyd Corporation Ltd
   Industrial Area
   Kalkaji
   New Delhi - 110 019

   Tel : 6430775, 6436334
   6469513

   Fax : 91-11-6430771

   Tlx : 31-71207 FEDD IN

3. Mr N C Agrawal
   Sr. Manager (Production)
   Subros Ltd
   C 51, Noida Phase II
   Dist. Ghaziabad
   Uttar Pradesh

   Tel : 89-62226/7/8

   Fax : 89-62783

4. Mr D K Dhawan
   Air Conditioning Corp Ltd
   D1, Green Park
   New Delhi - 110 016

   Tel : 667402, 668420

5. Mr Dhananjai Pandya
   Thandak Aircon
   167, Sarai Juliena
   Okhla Road
   New Delhi - 110 025

   Tel : 633153, 6823964

6. Mr Ashok Gomber
   Business Executive
   Temperature Control
   D 152, Flatted Factories Complex
   Okhla, New Delhi - 110 020

   Tel : 6836211, 6821411

7. Mr Venugopal Menon
Director Engineering
(Sales & Marketing)
Shiv Shakti Engineering Co Ltd
A - 26, Kirti Nagar
New Delhi - 110 015

Tel : 5411065, 5454868
8341358 (Res)

Fax : 91-11-5724135
91-11-5454868

8. Sanden Vikas (India) Ltd
Plot No 65
Sector 27 A
Faridabad - 121 003

Tel : 8-276344, 8-276415

Tlx : 0343-309 SVL IN

9. Mr Manvir Chopra
Executive Director
Coolways India Air Conditioning
Co Pvt Ltd, A 53 DDA Sheds
Okhla Industrial Area II
New Delhi - 110 020

Tel : 6821548, 632650

Fax : 6810203

Servicing Enterprises - Delhi

1. Mr P K Chakravarty
   Service Manager
   Expo Machinery Ltd
   (a wholly owned subsidiary of
   Kelvinator of India Ltd)
   4th Floor, Pragati Tower
   26, Rajendra Place
   New Delhi - 110 008

   Tel : 5712886, 5712911
   Fax : 91-11-5752285
   Tlx : 031-62137

2. Mr Subhash Anand
   Assistant Manager
   Customer Service
   Hyderabad Allwyn Ltd
   (An A P State Government
   Undertaking)
   T 10, Upper Anand Parbat
   New Delhi - 110 005

   Tel : 5730960, 5730985,
   5734892, 5729116/7
   Tlx : 031-62917 HAMW

3. Mr M G Gupta
   Service Manager
   Airserco Pvt Ltd
   B -10/1
   Okhla Industrial Area, Phase II
   New Delhi - 110 020

   Tel : 6846170, 6846171/73
   Tlx : 031-75217 ASCO-IN

4. Mr P K Sethi
   Manager Services
   Subros Service Centre
   Subros Limited
   B - 62, Sector VI
   Noida, Phase I
   Dist Ghaziabad

   Tel : 8921888, 8951017

5. Mr Somnath Lamba
   Service Engineer
   Sanden Vikas (India) Ltd
   12 A, Shivaji Marg
   New Delhi - 110 015

   Tel : 537834, 537717
   Fax : 5451004
   Tlx : 031-61478 SVL IN

6. Mr Harbhajan Singh
   Quick Refrigeration
   C - 54,Lajpat Nagar
   New Delhi - 110 024

   Tel : 6831720, 6832889

7. Mr Manvir Chopra
Coolways (India)
AirConditioning Pvt Ltd
21, Defence Colony Flyover Market
New Delhi - 110 024
Tel : 46262661, 4694934
Fax : 4629275

8. Mr V A Rao
General Manager
Uni-Air Refrigeration
18 T, Defence Colony,Flyover Market
New Delhi - 110 024
Tel : 697456

9. Mr D K Dhawan
Air Conditioning Corp Ltd
D 1, Green Park
New Delhi - 110 016
Tel : 667402, 668420

10. Mr Vivek Malhotra
Breezeways
54 B, Khan Market
New Delhi - 110 003
Tel : 4631009, 4631007

11. Mr Fahim Ahmed
Aramco Refrigeration Co
12, Tamoor Nagar
Main Road
Maharani Bagh
New Delhi - 6837478
Tel : 6837478

12. Mr I D Singh
Works Manager
Sikand & Co
Maruti Authrorised Service Station
260 (1), Ishwar Nagar
Mathura Road
Okhla, New Delhi - 110 065
Tel : 6841480, 6834963

13. Mr V B Mittal
Manager
Hemkunt Service Station Pvt Ltd
Maruti Authorised Service Station
Link Road, Near Lodhi Hotel
New Delhi - 110 003
Tel : 4361301, 4361358

14. Mr Labh Singh
Intercool
B 109, Lajpat Nagar 1
New Delhi - 110 024
Tel : 6838172

15. Mr M Kapoor
Indian Traders & Agents
21-A, Khan Market
New Delhi - 110 003

Tel : 611995, 617504

16. Mr Vijay K Gujral
Capital Refrigeration Corporation
43A, Khan Market
New Delhi - 110 003

Tel : 4626071, 4626185

17. Mr Rameshwar Dayal
Ramesh Tan & Co
5, Jor Bagh Market
New Delhi - 110 003

Tel : 4622118

18. Mr Venugopal Menon
Director Engineering
(Sales & Marketing
Shiv Shakti Engineering Co Ltd
A26, Kirti Nagar
New Delhi - 110 015

Tel : 5411065, 5454868
8341358 (Res)
Fax : 91-11-5724135
91-11-5454868

19. Mr Ashok Gomber
Business Executive
Temprature Control
D152, Flatted Factories Complex
Okhla, New Delhi - 110 020

Tel : 6836211, 6821411

Manufacturing Enterprises - Bombay

1. Mr V Raman & Mr Raghavan
   Voltas Limited
   Airconditioning Refrigeration
   Business Group
   Voltas House
   19, J N Heredia Marg
   Ballard Estate
   Bombay - 400 038

   Tel : 2618131
   Fax : 022-2618504
   Tlx : 011-85939, 86730

2. Mr D Ravindra
   General Manager
   Engineering and R&D
   Blue Star Ltd
   2nd Pokhran Road
   Majiwada
   Thane - 400 601

   Tel : 5346265, 5345892
   Fax : 91-22-5345525
   Tlx : 011-71924

3. Mr Rohit Salhotra
   Dy Manager
   Godrej GE Appliances Ltd
   Maharashtra Branch
   Plot - IIB
   Pirojsha Nagar, Vikhroli
   Bombay - 400 079

   Tel : 5171166, 5171177 & 5171456
   Fax : 91-22-5170900
   Tlx : 011-71913(GOVK)

4. Mr Tushar Ruiya
   Director International
   Business
   Indus Air conditioning Pvt Ltd
   371, Cadell Road, Prabhadevi
   Bombay - 400 028

   Tel : 4303719, 4309270
   Fax : 22-4372014

5. Mr P M Bhalla
   Asst General Manager
   Shri Ram Refrigeration Industries
   Vaswani Chambers, 3rd Floor
   264/265, Dr Annie Besant Road
   Prabhadevi
   Bombay - 400 025

   Tel : 4370982, 4361382
   Fax : 91-22-4223326
   Tlx : 011-71069 SRI IN

6. Mr P N Dhoot
   Director Technical
   Videocon Appliance Ltd
   25, Shah Industrial Estate
   Next to Dhamji Shamji Udyog Bhawan
   Veerh Desai Road, Andheri (West)
   Bombay - 400 058

   Tel : 6295117, 6293087

7. Mr Raghavan
Product Manager
Mr R Kumar
Voltas Limited
Appliances Business Group
19, J N Heredia Marg
Ballard Estate
Bombay - 400 038

Tel : 2618131
Fax : 022-26152

Tlx : 75930

8. Mr Jeten S Padore
Executive Customer Service
Amtrex Ambience Ltd
8th Floor, Shah House
Shir Sagar Estate, Worli
Bombay - 400 018

Tel : 4939104, 4939405

Tlx : 011-75322 AMTX IN

9. Mr J D Buhariwals
J B Enterprises
Mfrs of Airconditioning &
Refrigeration Machineries
315-G, Charni Road
Behind Hinduja College of
Commerce
Bombay - 400 004

Tel : 3861829, 3882940

10. Mr A J Valis &
Mr Raj Kumar
Modern Motor Co
A - 138, Ansa Industrial Estate
Saki Vihar Road
Andheri (East)
Bombay - 400 072

Tel : 456231, 468651

Servicing Enterprises - Bombay

1. Mr P H Pandit
   Assistant General Manager
   Central Services(Appliances)
   Videocon International Ltd
   25, Shah Industrial Estate
   Next to Dhamji Shamji Udyog Bhawan
   Veerh Desai Road, Andheri (West)
   Bombay - 400 058
   Tel : 6295117, 6293087

2. Mr Darryi D'sowza
   Sarayu Investment Ltd
   77/A, Paiky Gally
   Prabha Devi
   Bombay - 400 025
   Tel : 4223682

3. Mr George Verghese
   Poineer Refrigeration Engg Co
   Airconditioning &
   Refrigeration Engineers
   Jayadkhan Street,
   Gala No. 2, Salembhai Compound
   Merol Naka chiman Pada
   Andheri (East)
   Bombay - 400 059
   Tel : 8323117

4. Mr M M Sequeira
   Service Manager
   Voltas Limited
   AC & RCP Service
   Volta Sagar
   Dr Ambedkar Road
   Bombay - 400 033
   Direct Tel : 3726194, 3724062
   Tel : 3711359, 3711462
   Fax : 91-022-3713002
   Tlx : 011-75289, 75823

5. Mr Shohab Rais
   Senior Executive
   Godrej-GE Appliances Ltd
   Maharashtra Branch
   (Service, Plant - 10)
   Pirojsha Nagar, Vikhroli
   Bombay - 400 079
   Tel : 5171166, 5171177
   Fax : 91-22-5171177
   Tlx : 011-71913 GOVK

6. Mr Tushar Ruiya
   Director
   Indus Airconditioning Pvt Ltd
   371, Cadel Road, Prabhadevi
   Bombay - 400 028
   Tel : 4303719, 4309270
   Fax : 22-4372014

7. Mr Rajiv Munshi
Asst Manager (Sales)
Sanvik Systems
Shop No. 14, Agar Bazar
196-A, Transit Tenaments
K D Road, Dadar
Bombay - 400 028

Tel : 4373476

8. Mr K Tayal
Clair Airconditioning
4, Gautam Darshan
Andheri (West)
Bombay - 400 058

Tel : 6231816

9. Mr A J Vallis
Modern Airconditioning Services
18, Anand Building
S T Road, Mahim
Bombay - 400 016

Tel : 464204, 468651 & 456231

10. Mr Nelson Fernandes
Nelson Enterprises
Mathuradas Wills compound
Off Empire Mills
Lower Parel
Bombay - 400 013

11. Mr R L Wagle
Manager Appliance Services
Blue Star Ltd
Sun mill Compound
Lower Parel
Bombay - 400 013

Tel : 4920784, 4923197

Tlx : 011-82660

12. Mr Umesh Shah
Keep It Cool Centre
Gamdevi
Near Lamington Road
Bombay

Tel : 3612937

13. Mr S Baid
Auto cool
Veera Desai Road
Lakshmi Industrial Estate
Andheri (West)
Bombay

Tel : 6266902

14. Mr Rajesh Shah — Tel : 3612171
United Auto Airconditioning
Gamdevi
Bombay

15. Mr P Suresh — Tel : 6203688
Classic Airconditiones
Gilbest Hill Road
Andheri(West)
Bombay - 400 058

16. Mr Arora A — Tel :4302905
Hans Airconditionoing
Prabha Devi
Bombay

17. Mr Bhavesh Mehta — Tel : 4374123
Mehta Cool Tech Co
Prabha Devi
Bombay

18. Mr R Bhandari — Tel : 4931820
Reeta and Co
Worli
Bombay

19. Mr L Gomez — Tel : 6494624
Top Beat Electronics
Santa Cruz (west)
Bombay

20 Mr Prahlad Baid — Tel : 4921696
Jai Automobiles
Worli
Bombay

Appendix = 2.2

CODE NO:_____
(TO BE FILLED BY MANTEC CONSULTANTS PVT LTD ON RECEIPT)

FEASIBILITY STUDY FOR THE RECOVERY AND RECYCLING OF CFC REFRIGERANTS - UNIDO PROJECT MP/IND/93/163

FIELD SURVEY QUESTIONNAIRE FOR MANUFACTURERS

DATE: _____

1.0 NAME AND ADDRESS OF ENTERPRISE:

2.0 YEAR OF INCEPTION:

3.0 NAME OF PROMOTER:

4.0 NAME OF CONTACT PERSON:

5.0 SUB-SECTOR APPLICABLE:

5.1 REFRIGERATORS
5.2 ROOM AIRCONDITIONERS
5.3 PACKAGE AIRCONDITIONERS
5.4 CAR AIRCONDITIONERS
5.5 BUS/VAN AIRCONDITIONING SYSTEMS

6.0 TECHNICAL TIE-UPS:

6.1 NAME OF TECHNOLOGY SUPPLIER/COLLABORATOR

6.2 NATURE OF COLLABORATION:

7.0 MANUFACTURE/ASSEMBLY

7.1 PRODUCT TYPE & SIZE

7.2 INSTALLED CAPACITY (NOS/ANNUM)

7.3 ACTUAL PRODUCTION (IN NOS) BY SIZE

1991-92:
1992-93:
1993-94:

7.4 PRESENT MARKET SHARE (%)

7.5 ESTIMATED LIFE OF PRODUCTS BEFORE SCRAPPING (IN YRS)

8.0 TOTAL ANNUAL CFC CONSUMPTION (1993-94):

8.1 SOURCES OF SUPPLY:

8.2 SIZE OF CONTAINERS PROCURED IN:

8.3 PROCUREMENT PRICE BY CFC TYPE & CONTAINER SIZE:

8.6 CFC CONSUMPTION NORM PER UNIT FOR FRESH CHARGE (BY SIZE)

8.7 ANNUAL CFC QUANTITY USED FOR RECHARGE (BY SIZE)

9.0 FACILITIES AVAILABLE FOR CHARGING AND HANDLING OF CFCs:

9.1 STORAGE:

9.2 MEASUREMENT OF CHARGE:

9.3 LEAK DETECTION:

9.4 FLUSHING:

9.5 ESTIMATE OF CFC WASTAGE PER ANNUM (BY TYPE OF CFC) QTY/BY CAUSE (PAST 1 YEAR):

9.6 WHETHER ANY FACILITY EXISTS:

- FOR RECOVERY: (YES/NO)

- FOR RECYCLING:
  (YES/NO)

10.0 STEPS TAKEN TO REDUCE CONSUMPTION OF CFCs

10.1 BY TECHNICAL IMPROVEMENTS

10.2 BETTER HANDLING PRACTICES:

10.3 BY SUBSTITUTION:

10.4 BY RECOVERY & RECYCLING
TYPE OF EQUIPMENT USED, IF ANY:

10.5 APPROXIMATE % REDUCTION
ACHIEVED IN CFC CONSUMPTION
PER UNIT OF PRODUCT

10.6 PLANS TO SWITCH OVER TO
SUBSTITUTES IF ANY WITH
DETAILS

10.7 EXPECTED RECOVERABLE CFC
QUANTITY PER ANNUM BY USING
RECOVERY AND RECYCLING EQUIPMENT

10.8 ANY OTHER COMMENTS:

Appendix - 2.3

CODE NO:_____
(TO BE FILLED BY MANTEC CONSULTANTS PVT LTD ON RECEIPT)

FEASIBILITY STUDY FOR THE RECOVERY AND RECYCLING OF CFC REFRIGERANTS - UNIDO PROJECT MP/IND/93/163

FIELD SURVEY QUESTIONNAIRE FOR SERVICING ENTERPRISES

DATE: _____

1.0 NAME AND ADDRESS OF ENTERPRISE:

2.0 YEAR OF INCEPTION:

3.0 NAME OF CONTACT PERSON:

4.0 DO YOU UNDERTAKE REPAIR/SERVICING JOBS OF:

4.1 REFRIGERATORS
4.2 ROOM AIRCONDITIONERS
4.3 PACKAGE AIRCONDITIONERS
4.4 CAR AIRCONDITIONERS
4.5 BUS/VAN AIRCONDITIONING SYSTEMS

5.0 WHAT TYPE OF CFC REFRIGERANTS ARE USED BY YOU FOR:

5.1 REFRIGERATORS
5.2 ROOM AIRCONDITIONERS
5.3 PACKAGE AIRCONDITIONERS
5.4 CAR AIRCONDITIONERS
5.5 BUS/VAN AIRCONDITIONING SYSTEMS

6.0 WHAT ARE THE FACILITIES AVAILABLE WITH YOU FOR SERVICING/CHARGING OF CFC REFRIGERANTS ?

7.0 DO YOU HAVE VACUUM PUMP AND GAUGE MANIFOLD ?

8.0 AVERAGE NUMBER OF PRODUCT SERVICING/CHARGING HANDLED PER DAY :

8.1 REFRIGERATORS
8.2 ROOM AIRCONDITIONERS
8.3 PACKAGE AIRCONDITIONERS

8.4 CAR AIRCONDITIONERS
8.5 BUS/VAN AIRCONDITIONING SYSTEMS

9.0 AMOUNT OF CFC REFRIGERANTS USED BY TYPE IN THE PAST ONE YEAR:

10.0 BEFORE CHARGING AND AFTER REPAIR, DO YOU DO THE FLUSHING TO ENSURE THAT THE SYSTEM IS PROPERLY CLEANED ? IS CFC REFRIGERANT OR NITROGEN USED FOR FLUSHING ?

11.0 IF YOU DO THE FLUSHING, CAN YOU GIVE A ROUGH IDEA OF REFRIGERANT/VAPOUR LOST DUE TO FLUSHING IN CASE OF:

11.1 REFRIGERATORS
11.2 ROOM AIRCONDITIONERS
11.3 PACKAGE AIRCONDITIONERS
11.4 CAR AIRCONDITIONERS
11.5 BUS/VAN AIRCONDITIONING SYSTEMS

12.0 ARE YOU USING A LEAK DETECTOR FOR CHECKING LEAKAGE ? IF NOT, HOW ARE YOU CHECKING THE LEAKAGE ?

13.0 WOULD YOU LIKE TO USE A REFRIGERANT LEAK DETECTOR FOR CHECKING LEAKAGE ?

14.0 HOW DO YOU CHARGE YOUR CUSTOMERS FOR SERVICING ?

- FIXED AMOUNT
- FIXED AMOUNT PLUS EXTENT OF REFRIGERANT USED FOR CHARGING

15.0 EXTENT OF WASTED ATTEMPTS (AVARAGE) IN CHARGING (%):

15.1 REFRIGERATORS
15.2 ROOM AIRCONDITIONERS
15.3 PACKAGE AIRCONDITIONERS
15.4 CAR AIRCONDITIONERS
15.5 BUS/VAN AIRCONDITIONING SYSTEMS

16.0 SOURCES OF SUPPLY OF REFRIGERANTS ? ARE THERE SHORTAGES IN SUPPLY DURING SUMMERS ?

17.0 AVERAGE PRICE OF CFC REFRIGERANTS BY TYPE IN THE LAST 2 YEARS:

CFC REFRIGERANT TYPE

1992-93
1993-94

18.0 IN YOUR VIEW WHAT WILL BE THE PRICE OF CFC REFRIGERANTS BY TYPE IN:

CFC REFRIGERANT TYPE

1994-95
1995-96

19.0 ARE YOU AWARE THAT -

A) LEAKAGE OF CFC REFRIGERANTS IN ATMOSPHERE CAUSES ENVIRONMENT PROBLEMS

B) WORLDWIDE USE OF CFC REFRIGERANTS IS TO BE DISCONTINUED BY YEAR 2010 UNDER MONTREAL PROTOCOL

C) AVAILABILITY OF CFCs WILL GO DOWN IN NEXT TEN YEARS DEPENDING UPON DEVELOPMENT OF ALTERNATIVE REFRIGERANTS

D) IN DEVELOPED COUNTRIES, CFC REFRIGERANTS ARE RECOVERED AND RECYCLED

E) EQUIPMENT ARE AVAILABLE FOR RECOVERY AND RECYCLING OF REFRIGERNATS

20.0 DO YOU ANTICIPATE INTRODUCTION OF THESE IN INDIA SHORTLY ?

21.0 IN YOUR VIEW, WHAT ADVANTAGES WILL BE DERIVED BY RECOVERY AND RECYCLING ?

22.0 EXPECTED RECOVERABLE CFC QUANTITY PER ANNUM BY USING RECOVERY AND RECYCLING EQUIPMENT

	PRODUCT TYPE	CFC QUANTITY
22.1	REFRIGERATORS	
22.2	ROOM AIRCONDITIONERS	
22.3	PACKAGE AIRCONDITIONERS	
22.4	CAR AIRCONDITIONERS	
22.5	BUS/VAN AIRCONDITIONING SYSTEMS	

23.0 WHAT FEATURES WOULD YOU EXPECT IN THE RECOVERY AND RECYCLING EQUIPMENT ?

24.0 ANY OTHER COMMENTS:

ENVIRONMENTAL PRODUCTS AMALGAMATED PTY. LTD.
[illegible] ACN 007 431 45
5-23 27 CALLISTER STREET – P O BOX 190, SHEPPARTON, VICTORIA, 3630 AUSTRALIA
Telephone (058) 312 912 – Fax (058) 216 172

TECHNICAL SPECIFICATIONS OF RECOVERY AND RECYCLING EQUIPMENT
(MODEL EP-3)

SKYE

TECHNICAL DATA FOR EP-3

Model: EP-3 **TYPE:** Recovery&Recycle

Application: Automotive and Industrial

Refrigerant: R12 or R22 or R502 Dedicated

Electricals: Siemens (UL and CSA listed)

Recovery Process:

To 25 Kg/hr Automatic low pressure cut off at 5" Hg
High pressure cut out. 18 bar
Recovered system oil separated automatically.

Recycling Process:

To 25 Kg/hr Single pass/multipass - Depending upon refrigerant condition.
Removes particles, oils, moisture, acids, non-condensable gasses.
Manual purge for non-condensable gas
Colour moisture indicator.(clean green - contaminated yellow).
TX valve=Danfoss TF2 - Orifice = 00

Filters:

One filter (45.16cm2) with Molecular sieve/desiccant core.
Twin sight-type oil separators

Compressor/pump power requirements:

1/3 hp reciprocating compressor. (U.L.).
Compressor oil separate.
Automatic oil return.
240 v - 50HZ, 1.80 amp 7.95 cm3 or (110 v - 60 HZ)
Oil Quantity 450 cc of GS-32

Weight, Size, Capacity, Portability:

Weight 55 Kg
Size. H = 1000 mm, W= 450 mm, D= 540 mm
External storage, capacity 25 Kg Cylinder in back of machine.
Internal weight platform.
Mobile on wheels semi-port[illegible]

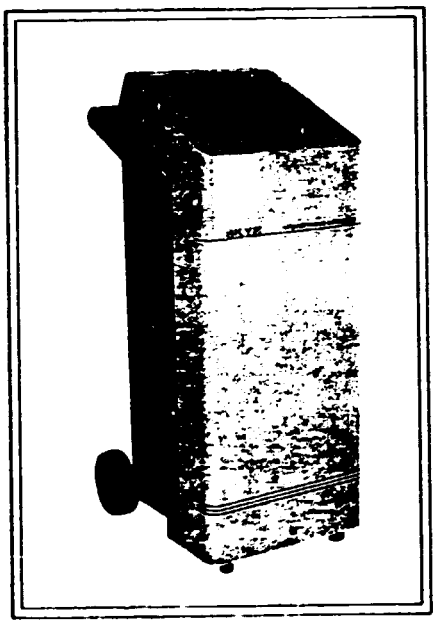
Safety features:

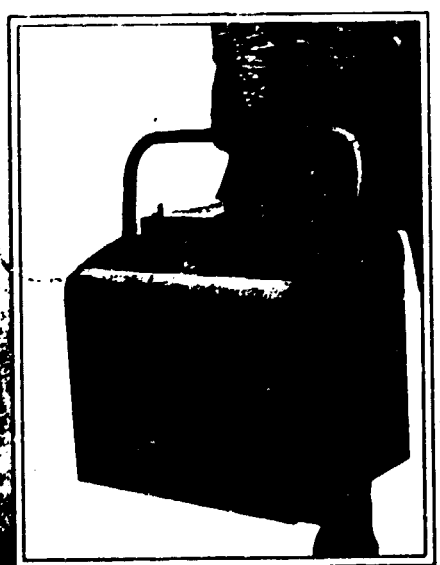
Automatic 80% cut off provided by integral weight platform.
Built in high pressure cut off

Accessories:

Optional Dual valve cylinder, manifold gauges. Cylinder hoses.
Manifold hoses and service couplings, snap connector.

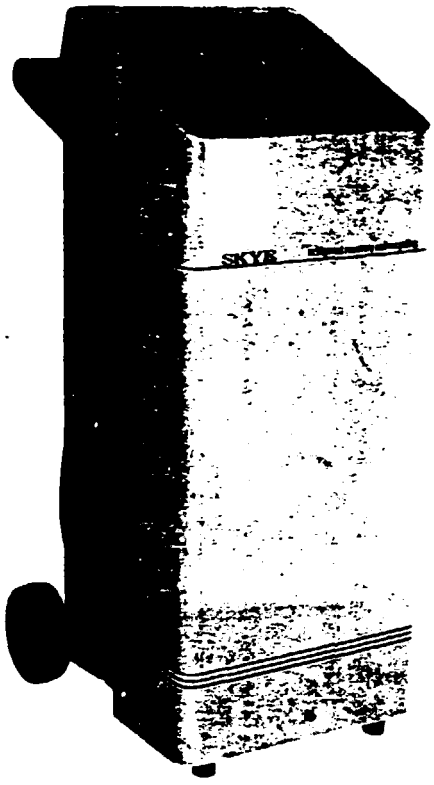
SKYE





The sky is under assault!
Earth's protective ozone canopy is being depleted by CFCs from refrigerants and other sources. Governments worldwide are making the recovery of CFC refrigerants compulsory.

SKYE is a world leader in refrigerant recovery and recycling technology, dedicated to making machines which are innovative, easy to use, reliable and affordable.



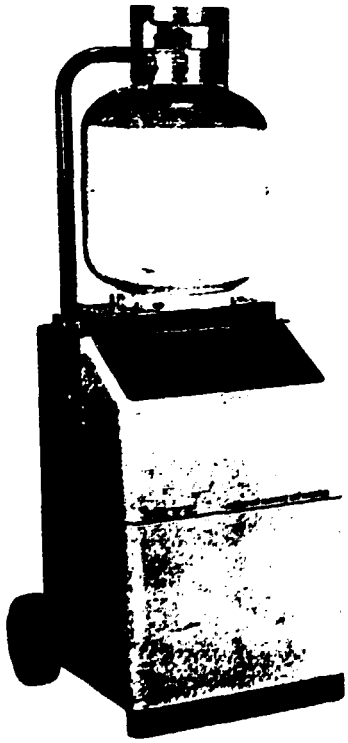
RECOVERY AND RECYCLING UNIT

Designed for onsite recovery and recycling. Available either dedicated to R12, R22, R500 and R502 or for R134a. Also available in a high capacity multi-refrigerant configuration which meets miltary specifications.

- The ergonomically designed console puts everything at your finger tips - control with 2 buttons!
- Simply connect to the system and press the 'on' button.
- Secondary filtration and distillation ensure that contaminants are removed in the recovery operation - protecting the compressor from these destructive substances.
- Oil return system maintains compressor oil level, ensuring safe operation of the compressor.
- Built-in weighing platform with automatic cut-out stops the unit before cylinder reaches 80% full. This protects the operator.

Model Variations: EP3 for R12 or R22 (25 Kg/Hr). EP3HCM Multi-refrigerant (50 Kg/Hr). EP3N for 134a.

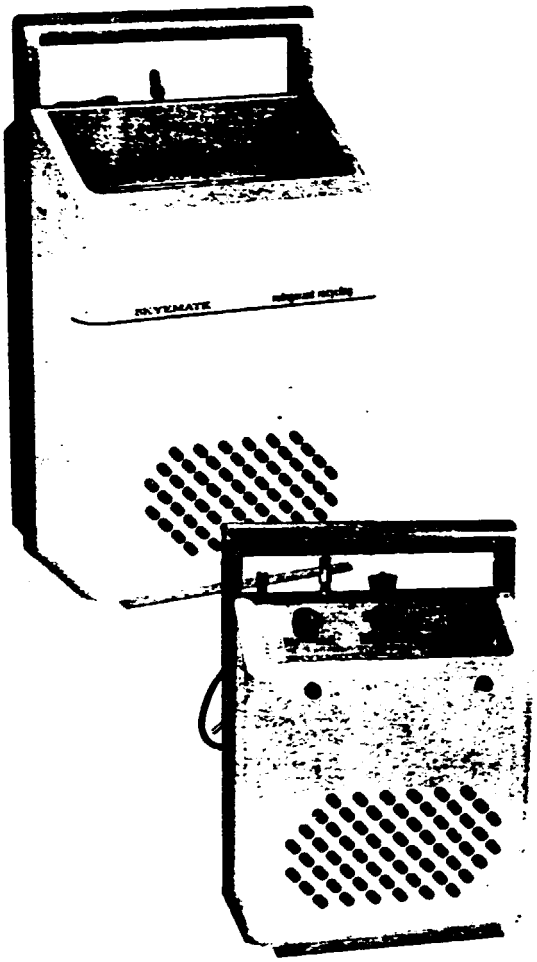
SKYE·EP7



THE COMPACT RECOVERY AND RECYCLING UNIT

This self-contained, compact unit has all of the features of our EP3. Built in a chassis designed for portability, just retract the handle for transport to another location.

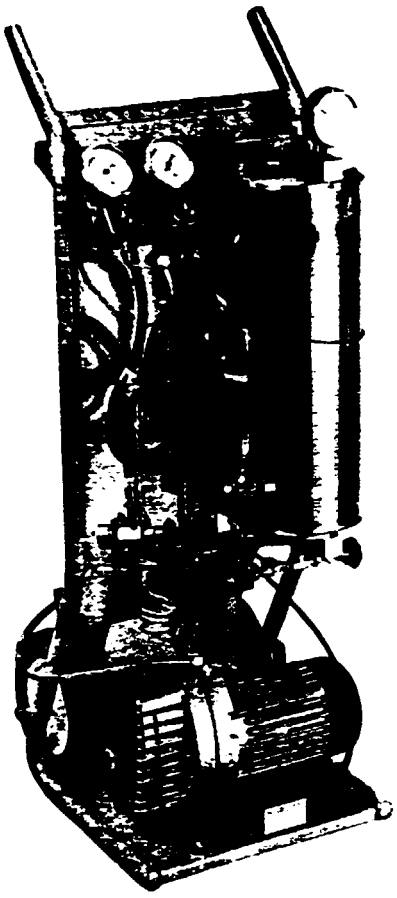
- Simple controls for ease of operation.
- Retractable handle doubling as a support for the recovery cyclinder.
- Built-in cylinder weighing platform with automatic cut-off prevents overfill and protects operator.
- Hour meter to monitor run time for service intervals.
- Includes all of the SKYE inbuilt safety features, pressure and temperature protection.



THE SKYE SPLIT SYSTEM

Two units working together or apart. Both are designed for ease of portability and are easy to use.
Nothing could be simpler.
Keep the SKYEMATE recycling unit in a central location, where it quickly and efficiently removes the contaminants, leaving a purified refrigerant which is ready to use again!
The SKYEMITE recovery unit is portable and ready to go to any site location to recover refrigerants.
Then it's back to your SKYEMATE to complete the recycling.

- Available either as a multi-refrigerant machine for R12, R22, R500 & R502, or for R134a.
- Designed for systems up to 5Kg for vapour recovery only. For larger systems and for liquid recovery we suggest our EP10 TRADESMAN
- Recovers up to 25 Kg/Hr

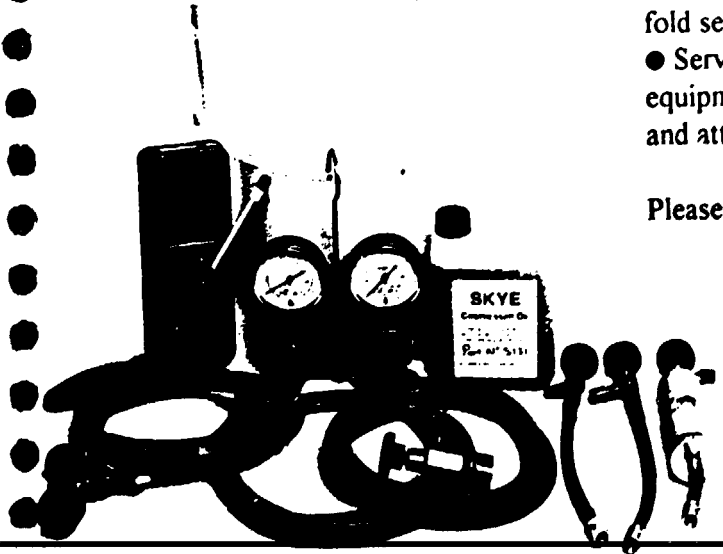


SKYE CHARGING STATION

Accuracy and reliability are inbuilt features of the SKYE Charging Station.

- The precision engineered vacuum pump ensures fast moisture removal in readiness for recharging.
- Easy to read calibrated scale. Adjustable zero point marker ensures the correct charge.
- The high quality manifold gauges provide smooth operation and accurate readings.
- The SKYE Charging Station is designed to attach to any SKYE recovery machine to recover the vapour when filling the charge cylinder. This can save up to 20% of refrigerant purchases, protect our ozone layer and your profits.
- Available for CFC refrigerants R12, R22, R500 & R502, or dedicated to R134a. The correct vehicle service couplings are included with the R134a unit.

ACCESSORIES



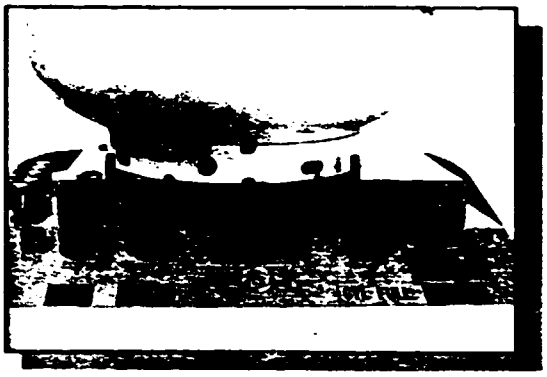
Our range of high quality parts and accessory equipment to support our efficient and profitable machines.

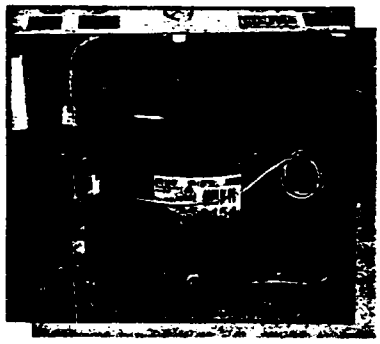
- Dual valve recovery and recycling tanks
- Dual refrigerant TIF leak detectors
- A choice of superior or economical manifold sets and hoses
- Service and maintenance supplies and equipment. A range of field service fittings and attachments to suit both R12 and R134a

Please refer to our price list for further details.

LIQUID AND VAPOUR RECOVERY

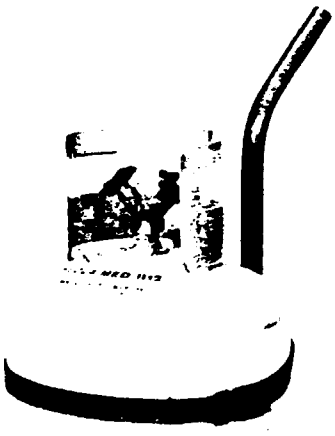
1.The 'All in one' recovery machine. This unit is suitable for recovery of liquid and vapour from all types of Air-conditioning and Refrigeration systems.



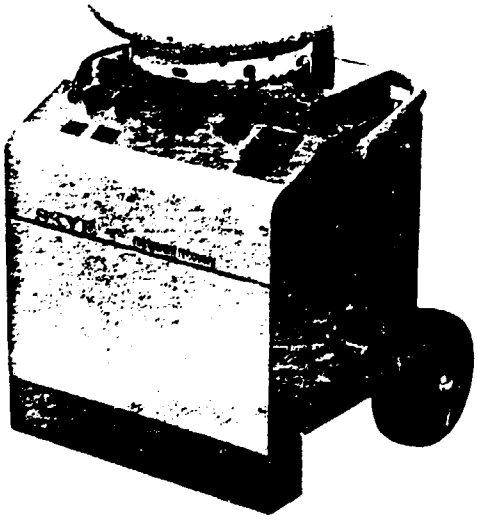


2. Two types of cylinder overfill protection are built-in on most models, a cut-off platform on the top of the unit and a plug to use with cylinders fitted with a float switch.

3. An efficient compressor oil return system ensures compressor life.



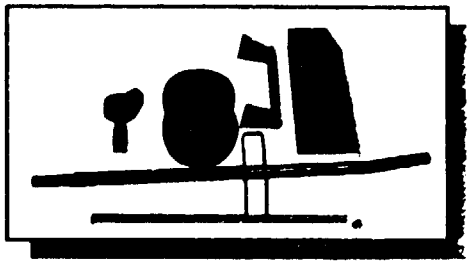
4. Available as a multi-refrigerant unit for R12, R22, R500 & R502 or dedicated to R134a.



5.Fitted with a large capacity fan cooled condensor for continuous operation. Recovers up to 30kg/Hr

6. Efficient design packs all the wanted features into a compact and lightweight unit. A fold away handle is included for ease of transport

7. Simple to operate. Hour meter to monitor run-time and service intervals.



8. An optional trolley kit makes this unit even more portable.

FEATURES

	EP3	EP4	EP5	EP7	EP10	EC12
Available for R12, R22, R502	●	●	●	●	●	●
Available for R134a	●			●	●	●
Meets U.S., S.A.E. specifications for refrigerant purity	●	●	●	●	●	
UL listed*	●	●	●		●	
Pressure & temperature protection	●	●		●	●	●
Compressor oil change and return system	●	●		●	●	
Fan forced condensor	●		●	●	●	
Hour meter	●		●	●	●	
International Service Support	●	●	●	●	●	●

* Limited to certain Model Variations.

	Weight (Kg)	Width (mm)	Depth (mm)	Height (mm)	Recovery Rate* Kg/Hr
EP-3 Recovery and recycling	55	450	540	1000	25
EP-3HCM Recovery and recycling	65	450	540	1000	50
EP-4M Recovery only	20	350	220	460	25
EP-5 Recycling only	20	390	350	660	-
EP-7 Recovery and recycling	46	500	430	750	25
EP-7M Recovery and recycling	50	500	430	750	50
EP-10 Recovery only	22	360	280	330	30

*The Recovery Rate will vary for field applications. The refrigerant type, ambient temperatures and system connections will all have an effect on flow rate.

ENVIRONMENTAL PRODUCTS AMALGAMATED PTY.LTD
(Incorporated in Victoria) ACN 007 431 450
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APPENDIX-7.1

Economic Viability for Refrigerant Recovery & Recycling

1. Estimated Project Cost & Scheme of Finance

Item of cost	Recovery & Recycling	Recovery only
1. Equipment:		
- Landed cost of equipment	Rs. 63,000	Rs. 30,400
- Indigenous	0	0
- Machinery stores & spares	Rs. 3,150	Rs. 1,520
2. Expenses on training of local technicians		
Wage rate (per manday)	Rs. 150	Rs. 150
No of mandays	9	6
Total training cost	Rs. 1,350	Rs. 900
3. Provision for contingencies (@ 10% of above)	Rs. 6,750	Rs. 3,280
Total cost	Rs. 74,250	Rs. 36,100
Scheme of Finance:		
1. Equity	14,850	7,220
2. Secured medium terms loans	27,900	13,680
3. Subsidy on equipment @ 50% of landed cost	31,500	15,200
Total	74,250	36,100

Economic Viability Analysis for Recovery & Recycling

Description	Recovery & Recycling	
	CFC-12	HCFC-22
Quantity of refrigerant recoverable in Kg/annum (Recoverable refrigerant quantities of Kelvinator & Blue Star taken as typical cases for CFC-12 & HCFC-22 respectively)	1400	2290
A. Materials costs		
1. Raw material (recovered refrigerant) @ Rs. 0/Kg	0	0
2. Spare & consumable @ US$ 0.40 (Rs.12.40/Kg)	Rs. 17360	Rs. 28396
Total material cost (A)	Rs. 17360	Rs. 28396
B. Power, @ Rs. 2.50/KWH & 0.05 KWH/Kg	Rs. 175	Rs. 285
C. Labour		
(i) Wage		
Manhours/Kg	0.25	0.25
Wage rate (per manhour)	Rs. 15	Rs. 15
Total wage	Rs. 5250	Rs. 5250
(ii)Supervision salaries		
Manhours/Kg	0.025	0.025
Rate (per manhour)	Rs. 22	Rs. 22
Total salaries	Rs. 770	Rs. 1260
Total labour (C)	Rs. 6020	Rs. 9848

D. Overheads		
Repairs & maintenance (@5%of equipment cost)	Rs. 3150	Rs. 3150
Administrative & selling expenses @ Rs. 6/Kg	Rs. 8400	Rs. 13740
Contingencies at 5%	Rs. 1755	Rs. 2770
Total overhead (D)	Rs.13,305	Rs.19,660
E. Estimate of cost of operation (A+B+C+D)	Rs. 36860	Rs. 58189
F. Expected sales (@ Rs. 140/Kg) for CFC-12 & Rs. 200/Kg for HCFC-22	Rs.196000	Rs.458000
G. Gross profit before interest & depreciation (F-E)	Rs. 159140	Rs.399811
H. Total financial expenses (@ 18% interest)	Rs. 5022	Rs. 5022
I. Depreciation & amortisation (@10% st. line)	Rs. 7425	Rs. 7425
J. Operating profit (G-H-I)	Rs. 146693	Rs.387364
K. Tax (Taken as nil, assuming no tax be levied on the income generated from recovered refrigerants, as an incentive)	0	0
L. Net operating profit	Rs. 146693	Rs.387364

Break - Even Analysis for Recovery & Recycling

Description	Recovery & Recycling	
	CFC-12	HCFC-22
1. Sale price of recovered refrigerant per Kg	Rs. 140	Rs. 200
2. Variable cost per Kg		
- Raw material costs	0	0
- Consumable cost	Rs.12.40	Rs.12.40
- Utilites (power) cost	Rs. 0.13	Rs. 0.13
- Labour cost	Rs. 4.30	Rs. 4.30
Total variable cost/Kg	Rs.16.83	Rs.16.83
Contibution/Kg.	Rs.123.17	Rs.183.17
3. Fixed costs		
- Repair & maintenance (including overheads)	Rs. 4905	Rs. 5920
- Selling & Admn. expenses	Rs. 8400	Rs. 13740
- Financial expenses	Rs. 5022	Rs. 5022
- Depreciation & Amotisation	Rs. 7425	Rs. 7425
Total fixed costs	Rs. 25752	Rs. 32107
4. Break-even quantity in Kg	209	175

Economic Viability analysis for Recovery & Recycling

Description	Recovery only	
	CFC-12	HCFC-22
Quantity of refrigerant recoverable in Kg/annum (Recoverable refrigerant quantities of Exp. Machinery Ltd. & Clair Air Conditioning taken as typical cases for CFC-12 & HCFC-22 respectively)	150	120
A. Materials costs		
1. Raw material (recovered refrigerant) @ Rs. 0/Kg	0	0
2. Spare & consumable @ US$ 0.30 (Rs.9.30/Kg)	Rs. 1395	Rs. 1116
Total material cost (A)	Rs. 1395	Rs. 1116
B. Power, @ Rs. 2.50/KWH & 0.05 KWH/Kg	Rs. 18.75	Rs. 15
C. Labour		
(i) Wage		
Manhours/Kg	0.25	0.25
Wage rate (per manhour)	Rs. 15	Rs. 15
Total wage	Rs. 562	Rs. 450
(ii)Supervision salaries		
Manhours/Kg	0.025	0.025
Rate (per manhour)	Rs. 22	Rs. 22
Total salaries	Rs. 82	Rs. 66
Total labour (C)	Rs. 644	Rs. 516

D. Overheads		
Repairs & maintenance (@5%of equipment cost)	Rs. 1520	Rs. 1520
Administrative & selling expenses @ Rs. 6/Kg	Rs. 900	Rs. 720
Contingencies at 5%	Rs. 223	Rs. 194
Total overhead (D)	Rs. 2643	Rs. 2434
E. Estimate of cost of operation (A+B+C+D)	Rs. 4700	Rs. 4081
F. Expected sales (@ Rs. 84/Kg) for CFC-12 & Rs. 120/Kg for HCFC-22 (i.e. 60% of Virgin gas price.)	Rs.12,600	Rs.14,400
G. Gross profit before interest & depreciation (F-E)	Rs. 7900	Rs. 10319
H. Total financial expenses (@ 18% interest)	Rs. 2462	Rs. 2462
I. Depreciation & amortisation (@10% st. line)	Rs. 3610	Rs. 3610
J. Operating profit (G-H-I)	Rs. 1828	Rs. 4247
K. Tax (Taken as nil, assuming no tax be levied on the income generated from recovered refrigerants, as an incentive)	0	0
L. Net operating profit	Rs. 1828	Rs. 4247

Break - Even Analysis for Recovery & Recycling

Description	Recovery & Recycling	
	CFC-12	HCFC-22
1. Sale price of recovered refrigerant per Kg at 60% of Virgin gas price	Rs. 84	Rs. 120
2. Variable cost per Kg		
- Raw material costs	0	0
- Consumable cost	Rs. 9.30	Rs. 9.30
- Utilites (power) cost	Rs. 0.13	Rs. 0.13
- Labour cost	Rs. 4.30	Rs. 4.30
Total variable cost/Kg	Rs.13.73	Rs.13.73
Contribution/Kg.	Rs.70.27	Rs.106.27
3. Fixed costs		
- Repair & maintenance (including overheads)	Rs. 1743	Rs. 1714
- Selling & Admn. expenses	Rs. 900	Rs. 720
- Financial expenses	Rs. 2462	Rs. 2462
- Depreciation & Amotisation	Rs. 3610	Rs. 3610
Total fixed costs	Rs. 8715	Rs. 8506
4. Break-even quantity in Kg	124	80