UNITED NATIONS

EP

United Nations Environment Programme

Distr.
GENERAL

UNEP/OzL.Pro/ExCom/71/56
1 November 2013

ORIGINAL: ENGLISH

EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Seventy-first Meeting
Montreal, 2-6 December 2013

DISCUSSION PAPER ON MINIMIZING ADVERSE CLIMATE IMPACT OF HCFC PHASE-OUT IN THE REFRIGERATION SERVICING SECTOR (DECISION 68/11)

This document consists of:

- A note by the Secretariat, referring to the discussions held at the 70th meeting, and
- Discussion paper on minimizing adverse climate impact of HCFC phase-out in the refrigeration servicing sector (decision 68/11) prepared by the Secretariat for discussion at the 70th meeting (document UNEP/OzL.Pro/ExCom/70/53/Rev.1).

Note by the Secretariat

1. In response to decision 68/11, the Secretariat prepared a discussion paper for the 70th meeting outlining key issues and considerations involved in further promoting strategies, approaches and technologies to minimize any adverse climate impacts of HCFC phase-out in the refrigeration servicing sector in the context of decision XIX/6 of the Nineteenth Meeting of the Parties (document UNEP/OzL.Pro/ExCom/70/53).

2. During the discussion at the 70th meeting (agenda item 11)[1], several members highlighted particularly useful aspects of the document and their utility for the implementing agencies and Article 5 countries, *inter-alia*, ways to reduce leakages, and the variety of available alternatives, including those with positive results in terms of energy-efficiency, even though to date there had been no experience of use of those technologies under the Montreal Protocol.

3. One member encouraged the Secretariat to conduct further analysis of the issue and to engage in further discussion with implementing agencies in order to exchange ideas and strategies to address the servicing sector in the most effective way possible to achieve compliance and minimize adverse climate impact. Another member noted the relation between the present document and the study being prepared by UNEP on financing options to address climate co-benefits for HCFC phase-out in low-volume-consuming (LVC) countries with servicing sector only (document UNEP/OzL.Pro/ExCom/70/53/Inf.3). One member suggested including a recommendation to encourage Article 5 countries to develop policies and activities to reduce leakage, while another highlighted means of facilitating the introduction of energy-efficient technologies based on non-HCFC and low-global warming potential (GWP) refrigerants.

4. Members from Article 5 countries had difficulties with the recommendation on development of regulations and codes of practice, adoption of standards for the safe introduction of flammable refrigerants, and measures to limit the import of HCFC-based equipment. Some members stated that their countries would need technical support if they were to accomplish the actions therein; while another member pointed out that it would be hard for countries to develop their own standards if such internationally recognized standards did not already exist, as was the case for certain alternatives. One Article 5 member mentioned the need for technical assistance to develop related regulations and other measures such as the certification and registration of technicians and monitoring use of the technologies. Yet, another member felt that starting to limit the import of HCFC-based equipment might have the perverse effect of increasing the use of other high GWP-based alternatives.

5. Considering that more time was needed to review the document and to reflect on the issues and the Secretariat's recommendations, the Executive Committee agreed to defer consideration of the discussion paper on minimizing the adverse climate impact of HCFC phase-out in the refrigeration servicing sector to its 71st meeting.

6. Document UNEP/OzL.Pro/ExCom/70/53/Rev.1 which includes the corrigendum to the original document is attached to this note.

[1] Paragraphs 116 to 120 of the report of the 70th meeting of the Executive Committee (document UNEP/OzL.Pro/ExCom/70/59).

UNITED NATIONS

EP

United Nations Environment Programme

Distr.
GENERAL

UNEP/OzL.Pro/ExCom/70/53/Rev.1*
3 October 2013

ORIGINAL: ENGLISH

EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Seventieth Meeting
Bangkok, 1-5 July 2013

DISCUSSION PAPER ON MINIMIZING ADVERSE CLIMATE IMPACT OF HCFC PHASE-OUT IN THE REFRIGERATION SERVICING SECTOR (DECISION 68/11)

*This revision is issued to combine documents UNEP/OzL.Pro/ExCom/70/53 and Corr.1

Background

1. At the 66th meeting, a member of the Executive Committee raised the issue of the climate impact of HCFC phase-out in the refrigeration servicing sector, in the context of the discussion of HCFC phase-out management plans (HPMPs) for approval. It was mentioned that while some activities, such as training of technicians, could lead to a beneficial climate impact, the climate benefit of retrofitting refrigeration equipment would depend on the global-warming potential (GWP) of the alternatives used. Noting that the issue of climate impact in the sector had been addressed in a number of individual HPMPs, a more comprehensive approach to these interrelated issues would need to be considered by the Executive Committee.

2. On that basis, a draft recommendation containing the following key elements was proposed[1]:

(a) That Article 5 countries with approved HPMPs addressing the refrigeration servicing sector should prioritize activities that promote the reduction of emissions of HCFCs and other refrigerants (e.g., training of technicians, good service practice and recovery/reuse) over those that encourage the replacement or retrofitting of HCFC-based equipment; and

(b) That where low-GWP energy efficient alternatives to HCFCs used as refrigerants in relevant applications are readily and commercially available, countries should give due consideration to understanding the barriers for their introduction, and encouraging dialogue among key stakeholders addressing ozone and energy efficiency; developing policies and/or codes/standards to overcome the barriers and encouraging/promoting the introduction of such alternatives in domestic markets; developing enabling activities; and selecting such alternatives in any incentive programme for end-user conversion when local conditions would allow for their long-term sustainability.

3. In the ensuing discussions, there were suggestions to include references to energy-efficient alternatives to HCFCs, and to have incentive programmes cover more than just end-user conversion. Views were also expressed that more time was required for consultations to consider the implications for already approved HPMPs, the impact on ozone depleting substances (ODS) policies and regulations, and costs. It was also pointed out that, for economic and technical reasons, some countries might be limited in their ability to use low-GWP alternatives to HCFCs even when commercially available. As there was no consensus on the draft recommendation, the Executive Committee deferred it for further consideration at its 67th meeting (decision 66/20).

4. The Committee continued its deliberations on this issue at the 67th and 68th meetings. The same concerns expressed during earlier discussions were raised, as well as new ones which included the potential risks associated with the alternatives to HCFCs that Article 5 countries may not have the necessary training required to use, and their unfamiliarity with the other new alternatives being proposed.

5. On this basis, the Executive Committee requested the Secretariat, in consultation with the bilateral and implementing agencies, to prepare a discussion paper for the 70th meeting outlining key issues and considerations involved in further promoting strategies, approaches and technologies to minimize any adverse climate impacts of HCFC phase-out in the refrigeration servicing sector in the context of decision XIX/6 of the Nineteenth Meeting of the Parties (decision 68/11).

[1] The complete text of the proposed draft recommendation by the Convener of the Contact Group can be found in Annex VI of document UNEP/OzL.Pro/ExCom/67/39.

Scope of the document

6. The Secretariat has prepared this document in response to decision 68/11. The document briefly describes key considerations to minimize adverse climate impact in the servicing sector, provides an overview of the current refrigeration servicing sector, outlines the experiences gained from the phase-out of CFCs in the refrigeration servicing sector applicable to HCFC phase-out; and proposes a recommendation.

7. In preparing this document, the Secretariat took into consideration decisions of the Executive Committee related to the refrigeration servicing sector, the experience gained in the Multilateral Fund from the review of stand-alone activities[2] and phase-out plans[3] addressing the servicing sector; case studies and evaluations completed by the Senior Monitoring and Evaluation Officer; and project completion reports (PCRs). The Secretariat also reviewed relevant publications issued by the UNEP's Compliance Assistance Programme (CAP); technical presentations given in UNEP regional network meetings; the Technology and Economic Assessment Panel (TEAP) report on additional information on alternatives to ODS; as well as refrigeration and air-conditioning journals and publications.

8. The document also benefitted from substantial discussions and consultations with relevant bilateral and implementing agencies, which provided relevant information gathered from the field. The Secretariat is grateful for the input received from the agencies. However, due to the complexity of the task and time available, a final version of the document could not be shared with the agencies.

Key considerations to minimize adverse climate impact in the servicing sector

Refrigeration servicing sector

9. The term "refrigeration servicing sector" principally describes only the service of existing refrigeration equipment. In reality, technicians' expertise is also frequently used for the additional task of assembly, installation, initial charging and commissioning of new refrigeration equipment, in particular when such equipment is custom-made for specific installations (e.g. supermarkets, refrigerated transportation, etc). The initial refrigerant charge in new systems has an estimated share between 20 to 60 per cent of HCFC servicing-sector consumption for most countries. The Secretariat has almost no data regarding the distribution of service-sector consumption between actual service and assembly/installation/initial charging/commissioning. In fact, HCFC-22 use related to the installation and initial charge of refrigeration equipment is absent from almost all HPMPs. The main difference between the two groups of tasks is that in many cases in which the service sector is performing assembly, installation, initial charging and commissioning, the choice of technology is not limited by an already existing system. In comparison, the actual servicing of refrigeration equipment represents only a limited possibility of changing the technology selected when the equipment was procured, as each refrigeration system has been specifically designed for one refrigerant.

[2] Including *inter alia* training programmes for refrigeration technicians and customs officers; recovery and recycling schemes; and retrofit of refrigeration equipment, approved since the 4th meeting of the Executive Committee (June 1991).

[3] Including: refrigerant management plans (RMPs), terminal phase-out management plans (TPMPs), national phase-out plans (NPPs) for non-low volume consuming (non-LVC) countries, and more recently HPMPs.

10. The task of assembly, installation, initial charging and commissioning of new refrigeration equipment, carried out by the same personnel as the servicing of existing equipment, is related to the selection of technology in new refrigeration and air-conditioning systems, but will not be considered in detail in this document. To some degree, the Executive Committee addressed this sector in its decisions relating to the assembly, installation and servicing of refrigeration equipment (decision 31/45) and to the assembly of refrigeration equipment in addition to activities in the refrigeration manufacturing and service sectors (decision 62/14). While the Multilateral Fund has approved activities in some enterprises assembling refrigeration equipment, this has been the case in the context of umbrella projects or phase-out plans where the specific conditions were not known in detail, the approaches used have never been fully discussed in the Executive Committee, and a sector analysis, feedback on experience gained as well as a concise strategy is also lacking so far.

Climate impact of the refrigeration servicing sector

11. Adverse impact on the climate, when it comes to HCFC phase-out in the refrigeration servicing sector, refers to an increase in emissions of greenhouse gases (GHG) (expressed in CO_2 equivalent) with respect to the current situation. In the refrigeration sector[4], emissions of GHG could be related to the supply of, typically, electric energy to drive the cooling process, where in many countries electric energy is generated by the oxidation of fossil fuels. Despite the possibility of increasing the efficiency of a refrigeration cycle to some degree through better design and higher-quality components, the consumption of significant amounts of energy is inherently connected to the operation of a refrigeration system. Depending on the methods used to generate the energy and, where electricity is concerned, their mix in a given electricity grid, significant CO_2 emissions are related to the operation of refrigeration equipment; these emissions are termed indirect emissions.

12. In addition to indirect emissions, refrigerants, which are meant to stay within a sealed cycle, are nevertheless emitted in substantial quantities during equipment manufacturing, installation, operation, servicing and disposal. Virtually all refrigerants are GHG, and in particular non-flammable halogenated refrigerants (CFC-12, HCFC-22, HFC-134a, HFC-125 as component of HFC-410A, and others) frequently have a potency that is more than 1,000 times higher than CO_2, expressed as their GWP. So far, there is limited reliable historical data on direct and indirect emissions related to the refrigeration servicing sector in Article 5 countries.

13. Servicing of refrigeration equipment can have a measurable impact on indirect emissions. The efficiency of refrigeration equipment is not only dependent on the technology used, the design efforts and component selection, but also, to a substantial degree, on the appropriate settings of controls (often performed or adjusted on-site), as well as the cleanliness of the heat exchangers and ease of related airflow. Deteriorated energy efficiency due to lack of non-critical servicing is hardly technology-specific, and can easily have a larger effect on indirect emissions than technology choice. The appropriate settings on controls depend on the expertise of service personnel and the thoroughness of service provided, while cleaning of heat exchangers and ensuring appropriate airflow is related to the frequency and thoroughness of this particular task, may it be carried out by refrigeration service technicians or, partially, less qualified personnel, e.g. the owner of the equipment. Both practices have a substantial impact on the efficiency of each refrigeration or air-conditioning unit serviced; however, this impact is very difficult to quantify and monitor on a national scale, and is hardly related to the phase-out of HCFCs. Nevertheless, activities for awareness and distribution of relevant technical information about the necessary steps to achieve the reduction of energy consumption as described above could be implemented in parallel with the HPMP.

[4] This includes air conditioners and heat pumps.

14. Servicing of refrigeration equipment has, in particular, a major impact on direct emissions. Direct emissions are related to small leaks and ruptures, as well as emissions during installation, servicing and decommissioning/replacement of refrigeration equipment. The emissions per system tend to increase with increasing refrigerant charge of the equipment and increasing repair of the refrigeration cycle. Table 1 provides an overview of a number of causes of emissions of refrigerants into the atmosphere, and possible ways to address them within the servicing sector. Additional considerations on measuring climate impact in the refrigeration servicing sector are included in Annex I.

Table 1: Causes of refrigerant emissions in the operation of refrigeration equipment and possible ways to reduce them

Cause of emission			**Possible general ways to reduce specific emissions**[5]
General	**Detail**	**Related to charge size**	
Small leaks	Use of leaking components/ connections		Improve design / banning of certain components/ connections
	Insufficient brazing or insufficient connection		Improve manufacturing / assembly quality Improve leak testing at manufacturer / during assembly Improve service procedures and quality Improve leak testing in service
Ruptures	Vibrations	X	Improve design Improve assembly Improve installation Improve the adjustment of controls
	Accidents	X	Improve installation procedures and quality
Service practice	All emissions during repair of refrigeration cycle	X	Improved equipment and repair quality to reduce frequency of service
	Venting before repair	X	Recovery and reclamation (recycling)
	Cleaning of brazing residue with refrigerant		Using solvent (not HCFC-141b) Use of nitrogen during brazing (inert atmosphere)
	Function testing w. subsequent venting in case of malfunction	X	Recovery and reuse Improve service quality
	Leak testing w. subsequent venting	X	Use of nitrogen (plus trace refrigerant) Improve service quality Recovery (if pure refrigerant is used)
	Emissions from refrigerant left in hoses		Improve service practices (sequence during charging)
	Emissions from refrigerant left in disposable refrigerant cylinders		Ban disposable cylinders where feasible
End-of-life	No recovery	X	Recovery and reclamation (recycling)
N/A	Charge size reduction		Improve design Improve components Improve assembly

[5] Examples; might require several co-ordinated activities to be achieved; some activities can address multiple pathways.

Approaches to minimize adverse climate impact in HCFC phase-out in the refrigeration servicing sector

15. Minimizing adverse climate impact through HCFC phase-out in the refrigeration servicing sector can therefore be achieved by:

(a) Influencing a shift in technology choice toward technologies with lower climate impact for new, factory-charged refrigeration systems as the most effective approach to minimise the impact on the climate. Possible efforts to attend to this issue do not address the servicing sector and are therefore elaborated only to a limited degree in this document;

(b) Influencing a shift in technology choice toward lower climate impact technologies for new refrigeration systems where the servicing sector performs, in particular, initial charging and commissioning, but frequently also assembly and/or installation. Efforts to attend to this issue include awareness raising as well as training in use and servicing of new technologies, undertaken as part of service-related activities;

(c) Reducing charge size, thus reducing the amounts of refrigerants emitted in a number of different scenarios (see Table 1), in particular for systems where the service sector performs assembly and/or installation;

(d) Reducing refrigerant emissions during servicing;

(e) Improving product quality, installation quality and service quality, thus reducing the frequency of occurrence of leaks, ruptures and repairs;

(f) Improving energy efficiency of equipment through better maintenance (e.g. adjustment of controls and cleaning of systems components); and

(g) Retrofitting refrigeration equipment to technologies with a lower GWP, when feasible, assuming the following preconditions are met: safe conversion is possible; the emissions of refrigerant during conversion, plus the future emissions of refrigerant with a lower GWP through the remaining lifetime, measured in CO_2 equivalent tonnes, are lower than those associated with continuing to operate the existing system without changes; indirect-emission increases due to possible increases in energy consumption related to the retrofit are not overcompensating any direct emission savings; and sufficient incentives (regulatory and/or economic) to avoid reversing the retrofit back to HCFCs.

An overview of the current refrigeration servicing sector

16. Phasing out CFC use in the refrigeration servicing sector has long been one of the Executive Committee's priorities. The Committee approved training programmes for refrigeration technicians, and recovery and recycling projects as early as 1991. As the ODS phase-out programme progressed, recovery and recycling projects and training programmes were subsumed in refrigerant management plans (RMPs) as a more comprehensive and cost-effective approach for reducing ODS consumption in the servicing sector. Towards the end of 2010, RMPs were replaced by national/terminal phase-out management plans (NPPs/TPMPs), including commitments and activities to achieve total phase-out of CFCs.

17. For the majority of Article 5 countries the refrigeration servicing sector continues to be the largest or the only consumer of ODS. Information from approved HPMPs shows that about 95 Article 5 countries use HFCF-22 solely for servicing existing refrigeration and air-conditioning equipment. For the remaining 50 countries, which have, in addition to servicing, enterprises that use HCFCs in manufacturing, the refrigeration servicing sector also becomes critical as HCFCs start to be phased out from manufacturing sectors. Given this fact and the constant emission of refrigerants into the atmosphere,

actions to improve the servicing sector in all Article 5 countries will greatly contribute to minimizing the impact on the climate.

18. The refrigeration servicing sector currently uses HCFC-22 as refrigerant for a large number and variety of residential air-conditioning units (portable, window, split), larger commercial air-conditioning systems (ducted split, roof top, indoor packaged, centralized), commercial refrigeration systems (stand-alone, condensing units, centralized), and other refrigerated applications (fisheries, cold rooms, refrigerated transport). HCFC-22, HCFC-124 and HCFC-142b are also components of refrigerant blends used as drop-ins for CFC-12-based refrigeration systems, HCFC-123 is used as a refrigerant for very large chillers, and HCFC-141b is used as a solvent (for cleaning refrigeration circuits)[6]. In addition to HCFCs, the refrigeration servicing sector uses a sometimes large variety of HFCs pure or in blends, the most common being HFC-134a and HFC-404A in the commercial refrigeration sector, and HFC-410A and HFC-407C in the air-conditioning sector. The share of HCFC-22 imported for servicing refrigeration and air-conditioning equipment as compared with other refrigerants depends on, *inter alia*, the climatic conditions, the main economic activities (i.e., industrial and agricultural), the size and concentration of the population. For a medium size country, HCFC-22 could represent approximately 50 per cent of the total amount of refrigerants imported into the country[7].

19. Article 5 countries face the challenge of selecting alternatives to replace the installed base of HCFC-22 equipment in the context of decision XIX/6. HFCs are already used in most Article 5 countries and under the existing conditions it can be expected that HCFC-based equipment at the end of its useful life will be replaced by HFC-based equipment, which is already taking place in many countries. Given the technologies commercially available as well as other socio-economic factors, HCFC-22-based air-conditioning systems were replaced in many countries by HFC-410A, HFC-407C and HFC-134a (to a lesser extent), while HCFC-123-based chillers were replaced by HFC-134a. In commercial refrigeration, refrigerated transport and some industrial applications (i.e., chemical) HCFC technologies were mainly replaced by HFC-134a and HFC-404A, followed by HFC-507A, HFC-407C and HFC-410A. Hydrocarbons (HC) and CO_2 have been used in some applications but at a very limited scale. A number of not-in-kind technologies had been considered as potential options with positive energy efficient results, and have been introduced in some countries in district cooling systems. So far, there is no experience under the Multilateral Fund with these technologies[8].

20. As described in the report on additional information on alternatives to ODS prepared by the TEAP in response to decision XXIV/7 of the Parties[9]:

(a) HFCs and HFC-based mixtures (e.g., HFC-134a, HFC-404A, HFC-407A/C/F, HFC-410A) refrigerants and the equipment using them have been commercially produced for several years. They could be immediately adopted to replace HCFC-based equipment reducing the installed base of HCFC equipment and future demand for HCFCs in servicing. There is also extensive experience in the design and installation of the equipment and components, which make them acceptable in performance and energy use

[6] An analysis of the distribution in the use of HCFC-22 per subsector in Article 5 countries and associated refrigerant emissions rates is included in Annex II.

[7] Example based on the HPMP of Peru. Comprehensive information of HFC consumption in the refrigeration sector is only included in a few HPMPs.

[8] The 2010 Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee assessment indicates that technologies such as absorption, desiccant cooling systems, stirling systems, evaporative cooling are technically feasible but have not progressed much in terms of commercial viability. However, in some applications such chillers and large air-conditioning systems, the energy savings are significant and some of these technologies become more competitive. UNDP is considering absorption as one of the possible alternatives for a chiller conversion in one of its projects.

[9] SOURCE: TEAP report on additional information on alternatives to ODS (decision XXIV/7). A more detailed overview by substance can be found in the report.

compared to HCFC-22-based systems; however, by using HFCs, direct emissions of HCFCs are replaced by emissions of other high-GWP refrigerants. In general HFCs are not flammable, with some exceptions such as HFC-32 or several blends with HFOs, described separately in (b) and (e) below;

(b) Although HFC-32 is a component of HFC-410A, it is not commonly available pure as a refrigerant. Currently, there is limited supply of HFC-32-based equipment[10] and related components, including compressors. Its energy efficiency is comparable to that of HFC-410A and its GWP is 716, which would represent moderate CO_2 emissions reductions as compared to HCFC-22. As it is classified with lower flammability[11], its introduction would require adoption of regulations, standards and codes of practice for the safe use of lower flammability refrigerants and training of refrigeration technicians;

(c) Pure HCs (e.g., HC-290, HC-600a and HC-1270) are commercially available. Performance and energy efficiency of equipment operating with HC-290 could be comparable to that of HCFC-22 but there is less experience in manufacturing. Moreover, HC-based equipment with refrigerant charges above a certain refrigerant charge is so far very low, although this may change for residential window and split units[12]. Given their low GWP, their use would represent large CO_2 emission reductions as compared to HCFCs and HFCs. Being flammable substances[13], their introduction would require adoption of regulations, standards[14] and codes of practice for the safe use of flammable refrigerants and training of refrigeration technicians;

(d) Although some HFOs and HFO-based mixtures (e.g., HFC-1234yf, HFC-1234ze(E), HCFC-1233zd(E) are currently produced, they are not yet commercially available in most Article 5 countries. Their GWP is below 10. As all except HCFC-1233zd(E) are classified with low flammability[15], as for HCs their introduction would require adoption of regulations, standards and codes of practice for the safe us of low flammable refrigerants and training of refrigeration technicians;

(e) Mixtures of HFCs and HFOs (L-40, L-41, L-20, DR-5, N-13, XP-10, N-40-DR-33) are expected to be commercially available during the next one or two years, some of them initially in Asia. Their costs are expected to be similar or higher than those of HFCs. Their efficiency could be comparable to that of HCFC-22 or R-410A depending on the mixture, and their GWPs oscillate between 330 and 1410. Some of them (L-41, L-20 and DR-5) are classified under low flammability; and

(f) R-717 (ammonia) is currently available and used in large industrial applications. It has low cost, excellent efficiency and zero GWP, but is limited to large installations, requires

[10] The Multilateral Fund approved projects for the manufacturing of air-conditioning units in Algeria, Indonesia and Thailand using HFC-32 (Multilateral Fund Secretariat). Japan has also released air-conditioning units using HFC-32; safety assessments being undertaken by groups like AHRI and AREP will help in the production of new standards and regulations to be adopted (JARN 528, Vol 45, 25 January 2013).

[11] Classification 2L refrigerant under FDIS ISO 817 (low toxicity, lower flammability).

[12] As part of the air-conditioning sector plan under its HPMP, China committed to convert at least 18 manufacturing lines for the production of residential air-conditioning equipment with HC technology. The demonstration project for the use of HC-290 in the production of air-conditioning units in China has also shown positive results.

[13] Classification A3 (lower toxicity, higher flammability).

[14] For instance, designers of systems using flammable refrigerants will need to meet the requirements of applicable safety standards. An example of such standard is IEC-60335-2-40, which specifies construction requirements, charge limits, ventilation requirements and requirements for secondary refrigerant circuits (RTOC, 2010 Report of the refrigeration, air conditioning and heat pumps, section 7.4.7 page 129).

[15] Classification A2L refrigerant under FDIS ISO 817 (low toxicity, lower flammability).

very well-trained technicians and its use has restrictions due to its high toxicity. R-744 (CO_2) is also available and could have good efficiency with specific adaptations. While the cost of the refrigerant is low, the cost of adaptations and materials is high, which restricts its use in small capacity systems.

21. Under the above scenario it appears meaningful for Article 5 countries to start giving due consideration to addressing the barriers to enable the proper introduction of low-climate impact technologies. Some of them can be locally addressed through a number of activities that are already or could be components of the HPMPs, such as training, codes of practice, development of regulations, adoption of standards, use of incentives, technology demonstration projects and awareness rising. A systematic effort in this direction by a significant number of countries would allow for data collection on technology performance in different conditions and could potentially create a sizable demand to stimulate the manufacturing of systems, components and refrigerants.

Experiences gained from the phase-out of CFCs in the refrigeration servicing sector applicable to HCFC phase-out

22. RMPs represent the first comprehensive approach to reducing ODS consumption in the refrigeration servicing sector in Article 5 countries. The main broad components of RMPs were ODS-related policy and customs training; training of refrigeration technicians; recovery, recycling and reclamation; and retrofit and equipment replacement. The same broad components are currently being included in HPMPs to reduce HCFC consumption in the servicing sector. Several of the approaches to minimize adverse climate impact in HCFC phase-out in the servicing sector described in the previous section are also currently being incorporated into HPMPs, taking into account the experience gained during implementation of refrigeration servicing programmes for phasing out CFCs[16], as presented below. These approaches are not meant to be generic or applicable to all cases.

Regulatory and policy framework (including customs training)

23. Article 5 countries have been able to reduce their ODS supply by restricting imports and/or exports mainly through their licensing[17] and quota systems accompanied by other ODS-control regulations. Such restrictions have become increasingly effective in the last few years, as demonstrated by the verification reports reviewed by the Secretariat which showed significant improvements in co-ordination between the National Ozone Unit (NOU), licence issuing bodies, customs and importers. The monitoring of ODS imports has also improved greatly, and an increasing number of countries is using a computerized database for customs.

24. Based on the experience gained in the implementation of licensing and quota systems during the phase-out of CFCs, Article 5 countries will be able to comply with their HCFC phase-out obligations. As decided by the Executive Committee, operational HCFC licensing and quota systems are prerequisite for accessing funds for HCFC phase-out under the HPMPs (decision 54/39 and 63/17 respectively).

25. While the ODS licensing systems in operation in Article 5 countries are related to controls on the import and export of controlled substances as defined by the Montreal Protocol, several countries have established (or are in the process of doing so) controls on import (and export where applicable) of ODS-based refrigeration equipment (both new and/or second-hand). Given that every HCFC-22-dependent system imported will increase the future demand of HCFC-22 for servicing until the end of its lifetime, it becomes critical to limit the growth and, subsequently, reduce the size of the installed base of equipment, as was done by most Article 5 countries during CFC phase-out, while

[16] Annex III presents some of the lessons learned from the phase-out of CFCs in more detail.

[17] Article 4b of the Montreal Protocol requests all Parties to establish and implement a system for licensing the import and export of new, used, recycled and reclaimed controlled substances in Annexes A, B, C and E.

keeping in mind that the timing and the modalities of these controls would influence the selection of technologies phased in to replace HCFCs. As seen earlier, immediate replacement of the installed base of HCFC equipment with energy-efficient equipment based on lower GWP refrigerants seems unlikely, except for specific applications where the use of ammonia could be extended, the use of CO_2 could be introduced with opportunities to reduce refrigerant charge in the systems, or the use of not-in-kind technologies (e.g., absorption) could be introduced in chillers or other applications if cost-effective. However, over the last few years, several Article 5 countries have selected HC-290 and/or HFC-32 technologies to replace the HCFC-22 technology in the manufacturing of refrigeration and air-conditioning equipment[18].

26. As many of the alternatives available or being developed are classified with some level of flammability, regulations, codes of practices, and standards (i.e., on storage, transportation, design of systems and components, maximum refrigerant charge, installation, servicing and disposal of equipment) must be adopted to ensure safe introduction of these technologies. Even if low-GWP-based equipment became commercially available today, manufacturers may not export it to countries where these standards are not in place. The necessary legal framework to adopt, implement and enforce regulations, codes of practices, and standards for the use of flammable refrigerants should be determined (customs training, test facilities) before operation of such equipment is allowed.

27. Other control measures that could have an impact on emission reductions, have been already introduced in several Article 5 countries[19], and appear to be implementable in the short term in some countries. They include mandatory reporting by HCFC importers and exporters; bans on "non-refillable" (disposable) HCFC containers; fees for HCFC imports; extension of the licensing system to all refrigerants imported into the country (as it could help reduce illegal trade, e.g., CFC-12 imported as non-licensed required HFC-134a in the past, or mislabelled refrigerants); HCFC emission control measures; and options related to record-keeping (e.g., HCFC logbooks and HCFC equipment log books).

28. HCFC emissions control measures[20] provide legal support to good servicing practices and refrigeration conservation but are more difficult to enforce. In fact, limited enforcement capacity is a deterrent in many countries when it comes to establishing a more comprehensive set of policies to control HCFCs. Countries have been successful in enforcing trade measures with the assistance of customs departments. However, enforcing emission control measures and those directly related to the operation of the servicing sector in the field is another issue that merits further consideration. These measures can contribute to minimizing adverse climate impact in the servicing sector as governments gain a better understanding of the dynamics of the market and have a better control over the technologies being introduced. Even with the existing limitations on enforcement, the benefits of obtaining data on the equipment inventory by subsector, leakage rates, type and frequency of repairs to specific type of equipment, and refrigerants being imported would be of great value to NOUs in implementing their refrigeration servicing strategies.

[18] The Multilateral Fund has approved projects for the manufacturing of air-conditioning units in Algeria, Indonesia and Thailand using HFC-32 (MFS). Japan has also released air-conditioning units using HFC-32. Safety assessments being undertaken by groups like AHRI and AREP will help in the production of new standards and regulations to be adopted (JARN 528, Vol. 45, 25 January 2013). As part of the air conditioning sector plan under its HPMP, China committed to convert at least 18 manufacturing lines for the production of residential air-conditioning equipment with HC technology. The demonstration project for the use of HC-290 in the production of air-conditioning units in China has also shown positive results.

[19] The UNEP publication on HCFC policy and legislative options, provides a comprehensive analysis of legislative and regulatory options that NOUs could consider in designing and implementing their HPMPs. A summary of key elements is contained in Annex III to the present document.

[20] Including but not limited to penalties for intentional venting of HCFCs to the atmosphere, mandatory leak checking for equipment containing more than certain amount of HCFC charge, requiring the installation of leak detectors for large-capacity equipment, or mandatory recovery of HCFCs from containers and equipment.

Training and certification of refrigeration technicians

29. Training in good refrigeration practices has been provided to practically all Article 5 countries[21]. Although no quantifiable information exists on the final impact in terms of reduction of CFC consumption attributable to technical training, Multilateral Fund evaluations have concluded that the introduction of good practices in refrigeration servicing is an important factor in reducing CFC emissions into the atmosphere[22]. Some of the qualitative outcomes from the training programmes include increased awareness in the sector on conservation, preventive maintenance and knowledge of substitute technologies, and incorporation of knowledge gained into their regular training-centre courses.

30. The Secretariat considers that refrigeration training programmes are more relevant now than during the CFC phase-out period, for at least the following reasons. First, expanded training programmes that integrate considerations on preventive maintenance, enhancing installation quality (including other stakeholders such as civil engineers and construction contractors), and improving the energy efficiency of equipment (including specific actions by technicians and end-users as indicated in paragraph 13 above), could help minimize adverse climate impact by reducing the energy consumption of the equipment as well as the emissions into the atmosphere of multiple high-GWP refrigerants being used. Second, given the flammability of several of the alternative refrigerants to HCFC-22 and the potential risk of accidents associated to their use, training programmes will need to integrate a rigorous approach on safe handling of flammable refrigerants and understanding of related regulations and standards, in particular, given the obvious difference in the consequences of poor installation, repair and decommissioning of equipment using flammable refrigerants.

31. The progression of training programmes for refrigeration technicians from stand-alone activities to integral components of sector and national phase-out plans has continued with the phase-out of HCFCs. As seen in HPMPs and reported by UNEP, training programmes are being implemented through national vocational/training centres, and good practices in refrigeration have been integrated into the curricula of local institutes. Additional efforts should be undertaken during the implementation of HPMPs so that the training programmes become self-sustaining. Through this process, training funded by the Multilateral Fund could focus on enhancing the capacity of the training institutes, and providing updated and specialized training for trainers and targeted audiences (e.g. use of CO_2 in supermarkets, energy efficiency gains in the replacement of chillers, or replacement of window and split units in buildings by central systems, energy efficient air-conditioning options and installation in new buildings, among others). Training on installation, operation, maintenance and disposal of equipment using flammable substances should be a priority subject for training courses during stage I of the HPMPs in countries where these refrigerants are already in the market or expected to be introduced.

32. Past evaluations of training programmes have recommended that certification systems for successfully participating in training programmes should be supported, or even made mandatory, through regulations in the country. While the ultimate goal in many countries appears to be to make good servicing practices mandatory for all refrigeration technicians through a certification scheme, NOUs have faced challenges in making certification mandatory as, often, this decision goes beyond their domain (i.e., is an issue related to the ministries of education and/or labour). However, given the long-term benefits that a proper certification system brings to the safe and restricted use of flammable refrigerants and the potential reduction of emissions of refrigerants into the atmosphere, due consideration should be given to developing such certification systems during HPMP implementation. The results achieved so far through awareness-raising and cooperation with customs departments to control trade in ODS could be extended to the governmental bodies involved in introducing good servicing practices into the curriculum of

[21] The Inventory of projects approved includes more than 450 entries for around US $45 million covering training of technicians through individual projects, as part of RMPs or as tranches related to TPMPs, NPPs and HPMPs.
[22] Final report on the evaluation of the implementation of RMPs (UNEP/OzL.Pro/ExCom/41/7)

vocational and technical centres and issuance of technicians' certification, as is already occurring in several Article 5 countries[23].

33. The work with refrigeration associations, several of which were established and became operational during the phase-out of CFCs, has been consistently reported as positive by Multilateral Fund evaluations and by the implementing agencies. For example, the evaluation of training programmes[24] recommended that consideration should be given to strengthening associations and involving them more closely in project implementation. This recommendation has been incorporated into the HPMPs of several Article 5 countries with positive results, to the extent that some governments have designated and supported the refrigeration association to implement the certification system for technicians, which could potentially generate an income that would contribute to their sustainability. Extending the role of refrigeration associations to other areas of work should also be considered. For example, the associations could raise awareness of their members and voluntarily request them to abide to policy measures related to emissions and record-keeping.

Recovery, recycling and reclamation

34. Implementation of CFC recovery and recycling (R&R) schemes faced a number of issues that prevented them from achieving proper refrigerant conservation and adequate measurement of emissions reductions[25]. These issues included: low CFC prices that prevailed during most of the period of CFC phase-out; lack of regulations to prohibit purposeful emissions of ODS as well as lack of awareness among technician and end-user; high costs of R&R equipment and lack of supplies (e.g., filters) on local markets; weight of equipment, lack of a proper monitoring and reporting systems; and difficulty structuring incentives to ensure that recovered refrigerants was taken to recycling centres and back, especially if the price of the recycled refrigerant was low[26]. In addition, in some Article 5 countries the lack of a certified refrigerant in the R&R schemes caused apprehension on the part of CFC buyers about the quality and performance of the refrigerant.

35. Based on the experience gained regarding R&R schemes, specific factors are being considered to enhance the effectiveness of recovery, recycling and reclamation schemes, subsequently reducing HCFC emissions. With the increased supply of relatively inexpensive reclamation units that can guarantee the return of certified refrigerant[27], in some Article 5 countries the recycling is being replaced by reclamation. The reclamation units have been established in enterprises that are involved in the refrigerant sales business instead of training centres or governmental bodies, according to a business model and with co-financing by the beneficiary enterprise. In other countries, technicians can exchange certain amounts of impure refrigerant for a smaller amount of pure refrigerant at the reclaiming centre, with no money involved. Reclaiming units are also set to work with blends.[28]. Higher HCFC-22 recovery rates are also expected due to the larger charge size of HCFC-based equipment compared to CFC-based equipment addressed in the past. This last point could already be corroborated by HCFC-22 and CFC-12 recovery data provided in several NPPs.

36. In at least three Article 5 countries, the recovery and recycling (or reclamation) scheme partnered with energy-efficiency programmes aimed at exchanging old, inefficient CFC-based domestic refrigerators for energy-efficient ones, with substantial amounts of CFC recovered (for reuse or

[23] UNEP provided an example where an environmental certificate for technicians is being tested in a country in Asia, and several examples in Europe, Africa and the Caribbean where technicians' certification schemes linked to regulatory measures have been established, and where these systems have proven very effective.
[24] Document UNEP/OzL.Pro/ExCom/31/20.
[25] An analysis on measurement of climate impact by recovery, recycling and reclamation is included in Annex I.
[26] Paragraphs 31, 32 and 33 of document UNEP/OzL.Pro/ExCom/31/18.
[27] ARI Standard 700.
[28] Based on UNDP's and UNIDO's feedback, which is presented in more detail in Annex III under the Refrigerant conservation section.

destruction depending on the case) that otherwise would have been vented into the atmosphere during equipment disposal. Some of these programmes could be implemented if national policies or voluntary programmes for replacing HCFC-based equipment are in place. (e.g., some early retirement programmes have extended to window air-conditioning units, where the potential for recovery of the refrigerant is between 4 and 6 times greater per unit as compared to CFC-12-based equipment, and the logistics simpler given the size of the units).

37. Given that one of the main activities to minimize adverse climate impact in refrigeration servicing is refrigerant conservation, establishing recovery, recycling, reclamation and reuse schemes should be given due consideration during HPMP implementation, taking into account the experience gained with previous projects for CFCs, and new options being explored by the implementing agencies.

38. To minimize emissions from the overall refrigeration servicing sector, the equipment provided should be able to recover, recycle and reclaim both HCFCs and HFCs already in the local markets. However, the use of recovery, recycling and reclamation of equipment using flammable refrigerants should only be undertaken upon approval from the manufacturer.

Retrofit and equipment replacement

39. The climate impact of the retrofit of existing refrigeration equipment is very difficult to assess[29]. The guidelines for end-user conversion in the commercial refrigeration sector adopted by the Executive Committee at its 28th meeting established the circumstances which must prevail before priority can be granted to end-user conversion (decision 28/44)[30]. Project proposals for incentive programmes to encourage retrofitting of refrigeration equipment were allowed at the 32nd meeting. The TPMP evaluation in 2009 showed that the incentive projects in retrofits worked well in places where CFC-12 prices were growing rapidly, against a backdrop of stable prices of equally available alternatives. The price difference, the level of the incentive, and NOU-related activities also played a significant role.

40. Applying the principles of decision 28/44 to HCFCs, the relevant circumstances which must prevail before priority would be granted to end-user conversion activities are: (a) production and import controls on HCFCs and HCFC-based equipment are in place and effectively enforced, and restrict the deployment of new HCFC components; (b) the country's major remaining consumption is for the servicing of refrigeration and air-conditioning equipment; (c) either no other possible activities would allow the country to meet its HCFC control obligations, or the comparative consumer price of HCFCs, relative to substitute refrigerants, has been high and is predicted to continue to increase; and (d) codes of practice and standards for the use of flammable refrigerants should be in place and technicians servicing the equipment must have received proper training and certification.

41. In addition to economic and sustainability considerations, in principle the available alternatives suitable for retrofitting at present are high-GWP refrigerants, which would not represent an improvement in refrigerant emissions, or an improvement in energy use based on the principle that an existing refrigeration system is normally always optimised for a particular refrigerant, e.g. HCFC-22, and what is typically considered to be a retrofit would only adjust the system to the alternative refrigerant to the degree possible with relatively simple measures. HCFC-22 has, in almost all cases, a higher inherent efficiency in comparison to possible retrofit candidates; it could thus be assumed that only in a few cases will the design parameters of the existing system be more suited to the retrofit technology than they are to

[29] An analysis on measurement of climate impact by retrofitting is included in Annex I.

[30] (a) production and import control on CFC and CFC-based equipment in place and effectively enforced, and restricts the deployment of new CFC components; (b) the country's major remaining consumption is for the servicing of refrigeration and air-conditioning equipment; (c) comprehensive data on the profile of all remaining consumption has been determined and made available to the Executive Committee, and (d) either no other possible activities would allow the country to meet its CFC control obligations, or the comparative consumer price of CFCs, relative to substitute refrigerants, has been high for at least 9 months and is predicted to continue to increase.

HCFC-22. According to UNIDO's experience and views on the availability of alternative refrigerants[31], a better option would be to address the service sector within the next five years through recovery, reclamation and reuse, rather than through equipment retrofits.

42. During implementation of HPMPs, implementing agencies have been reporting that in several Article 5 countries, mostly in Africa and the Caribbean, HC-290 is being used for retrofitting, operating and/or filling HCFC-22-based equipment. It appears that market conditions may be favourable for this practice, as it is taking place independently of efforts under the HPMPs, in some cases by enterprises that are promoting the practice and providing related training to technicians[32]. In none of the cases has the Secretariat received concrete data on results in terms of performance and energy use in comparison to HCFC-22. More importantly, the Secretariat has major concerns regarding the safe use of HCs in systems designed for non-flammable refrigerants, in places where it appears that there are no policies and regulations allowing the use of flammable refrigerants, limited technical capacity for properly servicing and maintaining equipment charged with flammable refrigerant; the conditions in which some of these retrofits are taking place, and the associated risks to technicians and end-users[33]. In response to this practice, during implementation of the HPMPs implementing agencies should continue giving priority to providing training to technicians on safe handling of HC technologies and developing codes and standards on the use of HCs. Article 5 countries should also consider, as a priority, adopting standards on storage, installation, operation, maintenance and disposal of equipment using flammable refrigerants to ensure safe introduction of these alternatives.

43. The impact on climate associated with the replacement of the installed base of HCFC-22 equipment in a country is practically impossible to calculate. Adequate modelling to estimate prospective scenarios could help Article 5 countries in directing specific sectors toward more climate-friendly options for specific subsectors. A reference is made in Annex I to an example of simulated scenarios to evaluate the impact on climate of technical changes and policies on refrigerants in the commercial refrigeration sector. However, this specific subject needs further analysis.

RECOMMENDATION

44. The Executive Committee may wish to:

(a) Take note of document UNEP/OzL.Pro/ExCom/70/53 on minimizing adverse climate impact of HCFC phase-out in the refrigeration servicing sector (decision 68/11);

(b) Invite relevant bilateral and implementing agencies to consider the information contained in document UNEP/OzL.Pro/ExCom/70/53 when assisting Article 5 countries in the preparation and implementation of activities in the refrigeration servicing sector contained in their HCFC phase-out management plans (HPMPs);

[31] The only HCFC-22 alternatives available for retrofit have high-GWP (such as HFC-407C/F, HFC-404A). HFC-32 does not qualify as retrofit candidate due to its higher operating pressures. The only low-GWP alternative that comes close to HCFC-22 is HC-290; however, its application is limited due to its flammability. Furthermore, the volumetric refrigeration capacity of HC-290 is around 85 per cent of HCFC-22; so a retrofit may also lead to lack of performance at design conditions. Based on experience from the Chinese RAC sector, air conditioners manufacturers reduce the heat exchanger pipe size to ensure proper heat transfer (refrigerant velocity). Trials made at Petra/Jordan with un-optimized heat exchangers showed a drop in efficiency. HC-1270 (propylene) appears to have better volumetric capacity; but concerns about flammability and heat exchanger modifications remain. Better low-GWP replacements are foreseen; HC mixtures as well as HFO/HFC mixtures; but none are commercially available.

[32] Additional information has been collected and reflected in Annex III of the document under the Retrofit section.

[33] These include: the qualifications of the technicians undertaking the retrofits, the need to install leak detectors, the need for visual labels indicating the refrigerant, and the size of the equipment being retrofitted.

(c) Encourage Article 5 countries to consider during the implementation of their HPMPs:

(i) The development of regulations and codes of practice, and the adoption of standards for the safe introduction of flammable refrigerants given the potential risk of accidents associated with their use; and

(ii) Measures to limit the import of HCFC-based equipment and to facilitate the introduction of energy efficient and climate friendly alternatives.

- - - -

ANNEX I

CONSIDERATIONS ON CLIMATE IMPACT MEASUREMENT

1. In order to address any adverse impact of HCFC phase-out in the refrigeration servicing sector, it would be useful to obtain a possibility to quantify the impact and assess the different activities on their effectiveness in regard to the impact. The purpose of such an indicator would be therefore to allow assessing the impact of activities addressing the service sector either directly through support, or indirectly through regulatory activities impacting on the sector. In the following paragraphs the Secretariat tries to provide some insights into different options for qualifying the climate impact on a national scale of both of service sector activities as well as of activities related to the selection of technology for new systems.

2. The Multilateral Fund has calculated the climate impact of investment projects in the refrigeration and air-conditioning sector with the Multilateral Fund Climate Impact Indicator (MCII); such investment projects address the manufacturing of factory-charged refrigeration equipment. This indicator is meant to inform about the effect of technology selection at the time of manufacturing and is calculated using the amount of refrigeration systems specified in the project proposal, i.e. the known production of a previous year, and deducting the impact of continued production with HCFCs from the impact of production with different alternatives. The impact is the sum of direct and indirect emissions of each system manufactured in one year of production over its lifetime. This definition includes refrigerant emissions over the lifetime including emissions related to service, based on the fact that the technology selection on manufacturing determines also the technology used for service. While this approach also allows indicating the effect of different technology choices on overall GHG emissions at the time of import, sales or initial system charging, it does not support the purpose of assessing the impact of different activities addressing the service of existing refrigeration systems. It does also require substantial extension to be able to provide insight of any activity on a national level.

Assessment of the impact of different technology choices for newly commissioned systems

3. When preparing this document the Secretariat found during a literature search a report on "Inventory of Direct and Indirect GHG Emissions from Stationary Air Conditioning and Refrigeration Sources, with Special Emphasis on Retail Food Refrigeration and Unitary Air Conditioning" from March 2009[1]. It is focussing predominantly on the direct and indirect emissions of commercial refrigeration systems, i.e. largely systems where assembly, installation, initial charging and commissioning are carried out by the service sector, and compares different technical alternatives for new systems with a business-as-usual scenario. These comparisons take into account the existing bank of equipment, the time needed before current technologies associated with existing systems are replaced by new technologies when the existing systems have reached the end of their useful life and the associated gradual introduction of new technologies, and assumptions on the delay at which some innovative alternatives will be available in the markets.

4. The amount of basic information required for the modelling appears to be very limited, the approach generally applicable, and the results qualitatively accurate even if only a limited amount of input data is available. A significant share of the information required for such modelling had already been included in HPMP submissions, although in some cases the quality of information might not be yet

[1] Inventory of Direct and Indirect GHG Emissions from Stationary Air Conditioning and Refrigeration Sources, with Special Emphasis on Retail Food Refrigeration and Unitary Air Conditioning: CARB Agreement No. 06-325 - final report; Armines Center for Energy and Processes; Paris, France, 2009

sufficient as a basis for modelling since some estimates in particular regarding banks and emission rates which were provided in HPMPs are difficult to correlate with data from other sources. Other data might be supplied by the MCII, in particular the impact of new systems on energy consumption. If desired by the Executive Committee, it could be investigated further to what degree the approach undertaken in the above report can be adjusted to provide helpful insight for Article 5 countries. Such insight would relate to the impact of different technological and policy options for the technology selection on emissions of GHG with the focus on new refrigeration and air conditioning systems. Such an approach would at the same time inform about the related development of the HCFC consumption for these uses.

Assessment of the impact of activities related to service sector enterprises

5. In at least one previous project submission to the Multilateral Fund, the agency included an investigation on the refrigerant use pattern in the service sector in terms of what type of refrigerant losses in this sector are causing the refrigerant demand, involving *inter alia* experts from system and compressor manufacturers. The study was looking at the different type of repairs performed, the condition of the refrigeration equipment before being repaired by the service, the refrigerant use pattern during service, and the service quality in terms of service patterns inherently leading to a higher number of repairs in the future. In a second round, it was assessed how many of the latter could be remedied through the measures which can be undertaken as part of the service sector plan.

6. With such an approach, technically realistic assumptions of reduction in CFC use through different activities in the service sector can be derived; technically realistic refers in this case to reductions which are technically probable with certain awareness, training and equipment means. If the support provided to service sector enterprises is selected to ensure that the enterprises benefit in a directly recognizable way, it is likely that those potentials can predominantly be utilised. Precondition to such an approach is that a related survey has been carried out, informing about the structure of the service sector[2].

Possibilities for a simplified assessment of the impact of activities in the service sector

7. Some activities in the servicing sector supported by the Multilateral Fund have direct, credible and, sometimes, measurable impact on the climate. The activity most easily quantified is the results from establishing reclamation center. It can be safely assumed that refrigerant being reclaimed (instead of being reused) is suspected of some degree of contamination and would normally have been released to the atmosphere. Consequently, every kg of, e.g., HCFC-22 being reclaimed will reduce emissions by 1.78 tonnes of CO_2 equivalent[3]. The reuse of refrigerant will similarly reduce emissions accordingly; however, the impact of support by the Multilateral Fund is more difficult to gauge since the already existing level of reuse is currently unknown. It might be possible, though, to establish a conservatively estimated assumed minimum impact per recover/reuse machine and have at least a measure for a minimum expected impact.

[2] Based on characteristics for service sector enterprises such as size, level of education, level of equipment, refrigerant use, the enterprises or stand-alone technicians can be divided into groups. For each group, the number of enterprises/technicians in that group, overall refrigerant use and defining characteristics are to be provided. Emissions from different activities in the service sector can be estimated by a number of experts in the service sector with the help of a pre-defined detailed list. Cross-referencing the data can provide an insight about the level of emissions associated with lack of training or equipment for each group. A desired status (education, equipment) for each group can be defined, and the upgrade necessary can be determined by looking at the current characteristics of that group. With iterations taking into account the results as well as other relevant framework conditions in the country, a meaningful distribution of available funds between desired activities can be established.

[3] Assuming economic incentives to provide refrigerant to reclamation are moderate and do not become perverse incentives, redirecting new HCFCs or HCFCs which could easily be reused to reclamation.

With either decreasing accuracy or increasing need for more detailed information to be provided by the agencies, a similar approach could be used for the effects of training and of providing tools to the sector.

Retrofit of refrigeration and air-conditioning equipment

8. The climate impact of the retrofit of existing refrigeration equipment is very difficult to assess. In order to assess it, the climate impact of these systems in their remaining life time needs to be assessed, since these systems are likely to be decommissioned in the foreseeable future in any case. Any type of intervention into an existing refrigeration system is likely to lead to additional emissions, which would presumably not take place if the system would simply continue to operate. Such a consideration would be applicable to all scheduled retrofits, since their inherent characteristic is that they are not undertaken in response to a sudden failure requiring anyway an intervention on the level of the refrigeration cycle. Due to the specific operation of the Multilateral Fund projects, it can be safely assumed that most if not all supported retrofit operations are scheduled, and are therefore associated with additional refrigerant emissions during retrofit.

9. Should a retrofit take place at a time of repair, when intervention in the system and associated losses were inevitable, only the likely future emissions of refrigerant and the indirect emissions related to energy consumption are to be taken into account; these would be relevant for the remaining lifetime of the equipment. Principally, an existing refrigeration system should have been always optimised for a particular refrigerant, e.g. HCFC-22, and what is typically considered to be a retrofit would only adjust the system to the alternative substance to the degree possible with relatively simple measures. HCFC-22 has in almost all cases in comparison to possible retrofit candidates a higher inherent efficiency, and one can assume that only in a few cases will the design parameters of the existing system be more suited to the retrofit technology than they are to HCFC-22. As a consequence, one would expect that a refrigeration system has after a retrofit typically a lower energy efficiency than before. This effect is possibly reversed by the fact that a retrofit would typically incorporate a thorough system maintenance including cleaning of heat exchangers and re-adjustment of the internal controls, which might lead to an improved performance as compared to the time before the retrofit. Of course, a similarly thorough maintenance of the HCFC-22 system would have yielded similarly positive results as well, thus it remains questionable whether any improvements in energy efficiency are to be associated with the retrofit in an assessment of the climate impact. As the above considerations demonstrate, there is no systematic way of assessing the impact of retrofits, since the result of the retrofit in terms of climate impact depends very substantially on the specific situation and the way the retrofit is carried out. An improvement in climate impact cannot be assumed for the majority of retrofits, and the technology introduced by the retrofit might in many cases not play the most important role in the climate impact of such an activity.

ANNEX II

AN OVERVIEW OF THE REFRIGERATION AND AIR-CONDITIONING SECTOR

An estimation of the distribution of use of HCFC-22 in the servicing sector based on HPMPs

1. The analysis of a representative sample of 65 approved HPMPs in LVCs and non-LVCs showed that in average, half of the consumption of HCFC-22 in a country is in the residential air-conditioning sector and around 70 per cent of the consumption is used to serve air-conditioning systems. In average 24 per cent of the consumption is to serve commercial refrigeration, as shown in Table 1.1 below.

Table 1.1. Average consumption of HCFC-22 in the refrigeration servicing sector, by subsector

Subsector	Average share of HCFC-22 consumption per subsector (%)		
	In LVCs	**Non-LVCs**	**Total**
Residential air conditioning	52	46	50
Commercial air conditioning	17	12	16
Industrial, transport and chillers, others	5	5	5
Subtotal air-conditioning	**74**	**63**	**71**
Commercial refrigeration	23	28	24
Industrial refrigeration, others	3	9	5
Subtotal refrigeration	**26**	**37**	**29**
Grand total	100	100	101

SOURCE: A sample of 65 approved HPMPs (47 LVCs and 18 non-LVCs)

2. The distribution of HCFC-22 consumption among subsectors has large variations from country to country, but it is observed that in general larger countries tend to have more consumption in the commercial refrigeration sector than small ones. Many LVCs consume a large portion of the HCFC-22 in the residential air-conditioning subsector. Out of the 47 LVCs analysed, in 34 countries (72 per cent of the sample) residential air-conditioning represented more than 30 per cent of the consumption, and in 17 of them it represented more than 70 per cent.

3. As the consumption data per sector was presented using different formats in the HPMPs, it was not possible to obtain a better representation of consumption per subsector in several large countries. It was also not possible to calculate the amount of HCFC used in installation and assembly or in charging new equipment as only few countries discriminated these categories.

Refrigerant emission rates

4. Several HPMPs have estimated the consumption of HCFC-22 in the refrigeration servicing sector based on the inventory of equipment multiplied by an estimated annual emission rate by subsector, which relates to the amount of refrigerant purchased to service equipment during a year as a proportion of the equipment refrigerant charge. Table 1.2 shows estimated annual emission rates by type of equipment in Article 5 countries according to a global study[4]. Table 1.3 shows information on annual emission rates contained in a representative sample of 38 approved HPMPs where this data was available.

[4] Global inventories of the worldwide fleets of refrigeration and air-conditioning equipment in order to determine refrigerant emissions. The 1990 to 2006 updating. Centre Energetique et Procedes, ADEME. April 2010.

Table 1.2: Estimated annual refrigeration emissions rates per type of equipment

Subsector	Type of equipment	Article 5 countries		Non Article 5 countries	
		Annual emission rates (%)	recovery rate at the end of life (%)	Annual emission rates (%)	recovery rate at the end of life (%)
Residential air-conditioning	Portable	2	0	2	0-8
	Window	2	0	2	0-8
	Split < 5 kw	5	5	5	30-55
	Split > 5 kw	10	5	10	30-55
Commercial air-conditioning	Indoor packaged	6	0	5	50-65
	Roof Top	6	30	5	75-87
	Ducted split < 17.5	6	5	5	50-65
	Ducted split > 17.5	7	10	5	75-87
Commercial refrigeration	Supermarket	35-40	18-30	22-30	70-80
	Condensing units	15	5-50	15	5-50

SOURCE: Global inventories of the worldwide fleets of refrigerating and air-conditioning equipment in order to determine refrigerant emissions. The 1990 to 2006 updating. Final report 2010.

Table 1.3: Estimated annual refrigeration emissions rates per type of equipment as per HPMPs

Subsector	Estimated annual emission rates in HPMPs		
	Average (%)	Lowest value (%)	Highest value (%)
Residential air-conditioning	29	4	79
Commercial air-conditioning	40	3	70
Industrial air-conditioning	40	8	54
Transport	23	8	40
Chillers	22	14	30
Commercial refrigeration	38	2	82
Industrial refrigeration	44	7	100

Source: A sample of 38 approved HPMPs in which this data is available. The data corresponds to estimations made by each country and the methods may differ between countries.

5. It is worth it to mention that the methodology used to estimate the emissions rate is different in every country; it could be based on observation, available data from equipment maintenance, discussions with technicians, amount of refrigerant purchased, or other sources. Therefore, it is important to keep in mind that they are estimations and a degree of error is involved on them.

6. From the data it is observed that the average leakage rate in residential and commercial air-conditioning in the HPMPs is substantially larger than the estimated in the study. It is also observed that it varies from 4 to 79 per cent, which could be an indication of inaccuracy in the data or possible potential to reduce emission and consequently consumption in some countries just by better servicing practices including preventive maintenance and leakage control. The same is observed in the commercial air-conditioning subsector.

7. The emissions rate in commercial refrigeration is in general higher for Article 5 countries and non-Article 5 countries, both in the study and the HPMPs. Some of the reasons for this are a larger refrigerant charge size in the systems and leaks not easily reachable for repair. Given the variety of equipment and installations classified as commercial refrigeration it is more difficult to extract conclusions of these figures.

ANNEX III

LESSONS FROM THE PHASE-OUT OF CFCs

Regulatory and policy framework (including customs training)

1. The establishment and implementation of licensing systems[5], accompanied by quota systems and other ODS control regulations were instrumental in the phase-out of CFCs, especially in the refrigeration servicing sector. While there were CFC reductions expected from training projects, refrigerant recovery, recycle and reclaim projects, and the retirement of older CFC-based equipment, they were difficult to quantify and assumed to be low during the first years of the TPMPs and NPPs before technicians had received training and equipment. This left the appropriate establishment and application of regulations to limit annual CFC imports to the maximum allowed values by the Montreal Protocol, as the most immediate and certain way to ensure compliance with the annual CFC consumption targets. The technical assistance in form of training in good practices in refrigeration, customs training, recovery, recycling and reclamation, retrofits and replacement of equipment, interacted with the set of regulations in helping the consumer sectors to conserve CFCs and encourage the replacement of CFC-based equipment when economic and technical conditions were appropriate, with the ultimate goal of reducing the demand for new CFCs.

2. In recognizing the importance of regulations the Executive Committee established the existence of a licensing system at least in draft form as a prerequisite for customs training, recovery and recycling and retrofits projects. At its 48th meeting the Executive Committee, based on the evaluation of customs officers training and licensing systems projects, reminded Article 5 countries to establish licensing systems for imports and exports of all ODS including HCFCs, and recommended *inter alia* introducing regulations regarding a ban on ODS sales to non-licensed companies, restrictions on the import of ODS-based refrigeration and air-conditioning equipment, and developing electronic licensing systems. At its 49th meeting the Executive Committee recommended National Ozone Units (NOUs) in planning and implementing RMPs and TPMPs updating and complementing ODS-related legislation where additional legal measures were needed and further specification of enforcement mechanisms had been identified, including, for example banning the import and export of CFC-based second-hand refrigeration equipment; mandatory certification of technicians performing professional activities in refrigeration servicing; specification of a system of sanctions in cases of violation of legal regulations; improvement of the mechanisms for import and export quota allocations under the licensing system and the monitoring of their actual use; and enhancement of cooperation between the NOU and the customs authorities.

3. In phasing-out HCFCs, the HCFC licensing and quota systems were established as a pre-requisite for accessing funds under the HPMPs (decision 54/39 and 63/17 respectively). Article 5 countries are currently considering additional regulatory measures to support the phase-out of HCFCs. The UNEP publication "HCFC policy and legislative options" provides a comprehensive analysis of legislative and regulatory options that could be considered in designing and implementing various stages of HPMPs. For example, measures related to monitoring and control trade that could minimize adverse impact on climate include[6], *inter alia*:

(a) Mandatory reporting by HCFC importers and exporters in order to monitor the actual use of the licenses issued and ensure the effectiveness of the licensing system. It would allow comparing the customs data with actual data from the importers/exporters helping verify compliance with consumption targets, ensure a better identification of blends (a common issue in HPMPs submitted), and identify potential illegal shipments through

[5] Article 4b of the Montreal Protocol requests all Parties to establish and implement a system for licensing the import and export of new, used, recycled and reclaimed controlled substances in Annexes A, B, C and E.
[6] HCFC Policy and Legislative Options, A guide for Developing Countries, UNEP, 2010.

discrepancies among the two sets of data in benefit of the importers/exporters. Linking the annual reporting to the issuance of licenses for the next year would give enough incentive to report. This will also revert in more reliable data reported to the Ozone Secretariat;

(b) Ban on "non-refillable" (disposable) HCFC containers. It has been implemented in Australia, Canada, the European Union and it is proposed in the HPMP of Saudi Arabia. This measure can assist in a faster phase-out of HCFCs as it will make the illegal trade more difficult, as it is much easier to counterfeit small cylinders than larger ones. In addition, HCFC emissions from almost empty non-refillable containers will be avoided. It will represent additional effort and cost for dealers and servicing companies that will need to re-package the HCFC form big cylinders to smaller ones, but the price of import in larger cylinders or tanks will be smaller. This measure could be extended to a ban of non-refillable cylinders containing alternatives to close the possibility of illegal trade by mislabelling HCFC cylinders as HFCs. UNEP's feedback from the field indicates that this measure might be possible in some places but more difficult to implement in some regions where most cylinders used are non-refillable and the volumes managed are small. Capacity for local filling would be required and this may require certain volume of operations to be sustainable. It may also increase the price of HCFC, which in some cases may stimulate illegal trade;

(c) Restrictions on imports/placing on the market of products and equipment containing or relying on HCFCs. Several Article 5 countries have proposed in their HPMPs the ban on imports of HCFC-141b and equipment/products containing HCFC-141b to support the total phase out in the foam manufacturing sector. Others have also included a ban on imports of all HCFC-based equipment at some point during the implementation of stage I of the HPMPs. Given the scenario of technology maturity and availability it is important to keep into consideration the timing and the modalities of these controls, as they would influence the selection of technologies phased in to replace HCFCs. There are options that could provide more flexibility while the scenario of alternatives continues evolving, for example a gradual ban by type of equipment, or an extension of the HCFC licensing system to also cover HCFC-based equipment, which would represent more burden to the authorities but would also allow them to monitor and control the flow of products and equipment relying on HCFC to determine future needs of refrigerant for servicing;

(d) Fees for HCFC imports provide disincentives for using expensive HCFCs and incentives for using alternatives, therefore it should be considered to extend the fees to high-GWP alternatives. It also improve recovery rates and would collect resources to help fund cost related to ODS phase-out. This measure is being implemented in Australia, Denmark, Norway and other countries. Mauritius also introduced in 2000 zero duty import in ODS-free alternatives and non-ODS equipment, and 30 per cent duties in ODS including HCFC-22. In order to minimize adverse climate impact this measure should be carefully designed to ensure that there are low-GWP alternatives to replace the HCFC-22 and through the measure they will become more competitive, otherwise it could revert on an incentive to increase high GWP alternatives; and

(e) Extending the licensing system to include the most commonly used refrigerants in the country, namely HFCs and HFC-based mixtures, hydrocarbons (HC-290 and HC-600A), would allow the country to simultaneously achieve ozone and climate benefits as it would limit the use of HFCs, allow a better monitoring and influence on the introduction of alternatives, and reduce the possibility of illegal import of HCFC labelled as HFC. Other monitoring and control trade considered in the study include requirement for proof of

origin for HCFC shipments, electronically operated licensing system and permits for each HCFC shipment.

4. Options related to restrictions on use of HCFCs include *inter alia*:

(a) HCFC use bans (weather starting by the HCFC with the highest ODP or by the most emissive uses like flushing) would have an effect in the demand for HCFC allowing a well-controlled HCFC phase-out minimizing the impact on particular subsectors. Several Article 5 countries included the ban in the use of HCFC-141b in flushing in stage I; and

(b) Ban on new HCFC installations would promote the introduction of non-HCFC technologies and facilitate the HCFC phase out. It would not stop the use of HCFC in existing installations but would reduce demand for HCFC on new installations and avoid future demand for HCFC to serve them. It would also help prevent the dumping of obsolete HCFC equipment. It could be complemented by incentives and financial support for building new installations based on alternatives and disincentives through taxes. It should be accompanied by the promotion of low-GWP alternatives and its promulgation should take into account the availability of these technologies.

5. UNEP is assisting several countries in introducing standards and codes on installation, servicing, design, emission reductions, and records keeping for importers, dealers and servicing companies. Some options related to record keeping include:

(a) Mandatory HCFC logbooks. They could include HCFC importers, exporters and dealers, and HCFC users, and could be complemented with reporting obligation. They could help monitor how legislation is being followed and allow for effective monitoring of HCFCs flow and quantities recovered, recycled and reclaimed; and

(b) Mandatory HCFC equipment logbooks. Their contribution to minimize adverse climate impact is substantial as they provide data on HCFC emissions that can help verify compliance with obligations related to HCFC recovery and related leak checking. They facilitate actual calculation of emissions (or annual leakage rate) per type of equipment. The system would require decisions on minimum size and type of equipment to be included and the creation of a National Register of Equipment and a system to report data. Record keeping for equipment containing 3 kg or more of HCFC is mandatory in European Union, and in India all users of ODS, including owners of HCFC equipment must register, but there is no obligation of record keeping or reporting data. According to UNEP's experience record keeping can be introduced initially in large and medium size companies. In small will be more difficult, but many individual technicians will try to comply with the requirements to join medium and large companies. In the long term many small will follow medium and large standards.

6. Limited enforcement capacity is a deterrent in many countries when it comes to establishing a more comprehensive set of policies to control HCFCs. Countries have been successful in enforcing trade measures with the assistance of customs departments. However, enforcing emission control measures and those directly related to the operation of the servicing sector in the field is another issue that merits further consideration.

Training in good practices in refrigeration

7. Guidelines on training in good practices in refrigeration were approved at the 23rd Executive Committee meeting (decision 23/48) and several evaluations compiled important lessons learned on this

activity. Training in good refrigeration practices has been provided to practically all Article 5 countries[7]. Many of them were implemented in cooperation with training institutes and/or included technicians' certification schemes.

8. Although no quantifiable information exists on the final impact in terms of reduction of CFC consumption attributable to technical training, Multilateral Fund evaluations have concluded that the introduction of good practices in refrigeration servicing is an important factor in reducing CFC emissions into the atmosphere[8]. Some of the qualitative outcomes from the training programmes include increased awareness in the sector on conservation, preventive maintenance and knowledge of substitute technologies, and incorporation of knowledge gained into their regular training-centre courses. Some punctual quantitative evidence is available, but is difficult to extrapolate. For instance, recent feedback from the case study undertaken as part of the multi-year agreement (MYA) evaluation in India indicates that all servicing workshops visited confirmed a permanent change in their servicing practices after the training course due to a favourable reaction by their clientele, achieving between 10 and 40 per cent reductions in their refrigerant consumption.

9. One of the lessons learned from the implemented projects is that the training should become sustainable in order to contribute to a permanent change of behaviour after the project is completed. The evaluation of RMPs in 2003 indicated that training had already covered between 30 to 70 per cent of the technicians in registered workshops and informal technicians in some cases, and that training was already a self-sustaining process, as local trainers were trained and the training modules incorporated into the curricula of the refrigeration courses of Technical Colleges. The TPMP evaluation in 2009 reported that in most of the eight countries visited, refrigeration training modules had been incorporated in the curriculums of technical schools and vocational training courses, or respective agreements with universities and other technical canters had been established to prepare training material and to organize courses for refrigeration technicians, ensuring the sustainability.

10. Recommendations from past evaluations also included that certification systems for successfully participating in training programmes should be supported through regulations in the country, or even considering mandatory certification of technicians performing professional activities in refrigeration servicing. Many countries complemented the training with technicians' certifications schemes. The understanding and scope of certification schemes vary from country to country from the issuance of a certificate by the NOU to each participant in the training in good practices, to the establishment of a scheme supported by technical norms to provide different levels of certification by a third body upon the approval of technical tests. While the ultimate goal in many countries appears to be making good servicing practices mandatory for all refrigeration technicians through a certification scheme, UNDP and UNEP indicated that NOUs faced challenges to make certification compulsory as often this decision goes beyond their domain (i.e., is an issue related to the ministries of education and/or labour). This difficulty has been overcome in some countries, but not in all. UNEP has explored alternative ways to tackle the issue, environmental certificate issued by the environmental authorities is currently being tested in Iraq, this certificate would be comparable to the one issued by the United States Environmental Protection Agency, as it is issued by the environmental authorities.

11. There also seems to be evidence supporting the idea that the technician's certification schemes could be further developed and combined with regulations on record keeping. Several concrete examples discussed in UNEP regional network meetings demonstrate how comprehensive strategies combining training, certification schemes and regulations have achieved measureable results on leakage reduction.

[7] The inventory of projects approved includes more than 450 entries for around US $45 million covering training of technicians, be it through individual projects, as part of RMPs or as tranches related to TPMPs, NPPs and HPMPs.
[8] Final report on the evaluation of the implementation of RMPs (UNEP/OzL.Pro/ExCom/41/7)

12. One of them is the certification scheme in Hungary, managed by the refrigeration association, which provides different categories of certification to personnel and companies, according to their level of knowledge, and also registers stakeholders. Under this scheme, non-certified technicians or companies cannot buy refrigerant in the market. The system is enforced by around 30 inspectors in 11 authorities that receive periodic training. In Poland, the certification is handled by the State Office of technical inspection and is complemented by a registry system with reporting obligations to entities importing, exporting, using, recovering, recycling, reclaiming or destroying ODS refrigerant. The system is supported by penalties for intentional venting of ODS, one reclamation centre and one destruction facility.

13. The work with refrigeration associations has been reported as positive. The evaluation on training programmes[9] recommends that consideration should be given to strengthening of associations and involving them more closely in project implementation. Evaluation on TPMPs found that cooperation with RAC associations is important, most countries have one that covers up to 80 per cent of the population. Sometimes it is an entrepreneurs' association, but it is a private or a private/public body that groups the key stakeholders, technicians, importers, distributors, among others[10]. An efficient and operational public-private partnership forum was instrumental in achieving CFC phase out[11].

Refrigerant conservation (recovery, recycling and reclaiming):

14. Implementation of CFC recovery and recycling (R&R) schemes faced a number of issues that prevented them from achieving proper refrigerant conservation and adequate measurement of emissions reductions. These issues included: low CFC prices that prevailed during most of the period of CFC phase-out; lack of regulations to prohibit purposeful emissions of ODS as well as lack of awareness among technician and end-user; high costs of R&R equipment and lack of supplies (e.g., filters) on local markets; weight of equipment, lack of a proper monitoring and reporting systems; and difficulty structuring incentives to ensure that recovered refrigerants was taken to recycling centres and back, especially if the price of the recycled refrigerant was low[12].

15. Several Executive Committee decisions[13] requested not commence R&R projects until incentives or regulatory measures were put in place in order to ensure their sustainability and other prerequisites for success addressing the issues above were in place. The RMP evaluation[14] observed that R&R was better in larger installations, recovered gas was rarely brought to recycling centers, and lighter oil-less equipment with capacity to recover also HCFC-22 was preferred. The evaluation gave recommendations on more pre-requisites for R&R subsequently reflected in decision 41/100. The decision, subsequently reiterated in decision 49/6, requested Article 5 countries and bilateral and implementing agencies to consider concentrating recovery and reuse of CFC on large-size commercial and industrial installations and mobile air conditioner (MAC) sectors, if significant numbers of CFC-12 based systems still exist and the availability of CFC is strongly reduced by the adoption of effective import control measures. It also requested becoming more selective in providing new recovery, and in particular recycling equipment, by establishing during project preparation a sounder estimate of the likely demand for recovery and recycling equipment; delivering equipment to the country only against firm orders and with significant cost participation by the workshops for equipment provided, using locally-assembled machines to the extent possible; procuring, delivering and distributing equipment in several stages, after reviewing the utilization of equipment delivered and verifying further demand; and ensuring that adequate follow-up service and information are available to keep the recovery and recycling equipment in service. It also recommended monitoring the use of equipment and knowledge acquired by the beneficiaries, on an ongoing basis.

[9] UNEP/OzL.Pro/ExCom/31/20.
[10] UNEP/OzL.Pro/ExCom/58/8.
[11] UNEP/OzL.Pro/ExCom/58/8.
[12] UNEP/OzL.Pro/ExCom/31/18.
[13] Decisions 22/24 and 38/38 among others.
[14] UNEP/OzL.Pro/ExCom/41/7.

16. The TPMP evaluation reported that some countries replaced their R&R projects by the distribution of tools to technicians in their TPMPs and others submitted substantially modified R&R projects based on the lessons learned reflected in decisions 41/100 and 49/6. Allowing the procurement of R&R equipment that could operate with other substances had positive results as it has been historically reported more recovery of HCFC-22 than CFC-12. However, NOUs still had difficulties in receiving the information from beneficiaries despite contractual commitments to report data R&R of refrigerant.

17. Feedback provided by the implementing agencies on the implementation of the HPMPs indicates that there are some factors that can enhance the effectiveness of recovery, recycling and reclaiming, subsequently reducing HCFC emissions.

UNDP identified as major shortcomings in previous recovery/recycling/reclamation projects the absence of a counterpart stake or ownership from the recipients, the absence of a commercial incentive for recovery/recycling or reclamation of CFCs); inadequate size and definition of ownership of reclamation facilities, inadequate logistics for managing the flow of recovered CFCs from technicians to the reclamation facilities and the absence of standards or certification of recycled and reclaimed CFCs (causing apprehension or suspicion in CFC buyers about the quality of such CFCs). With the increased supply of relatively inexpensive reclamation units that can guarantee the return of certified refrigerant (ARI 700), in some countries the recycling is being replaced by reclamation. The reclamation units have been established in enterprises that are involved in the refrigerant sales business following a business model and co-financing by the beneficiary enterprise. In several countries technicians can change certain amount of impure refrigerant by a smaller amount of pure in the reclaiming center, with no money exchange. Reclaiming units are also set to work with blends..

18. According to UNIDO:

(a) Service sector is approached in the best manner by introducing centralized reclaim in combination with decentralized recycling/re-use (through adding an external filter kit to a recovery unit). Both concepts are technically sound and meet the standards' guidelines (e.g. EN-378). Applying recycling as a centralized operation is not considered; since purity is not guaranteed and equipment is not widely available;

(b) CFC recovery basically took place from domestic refrigerators and automotive air-conditioning (MAC). As for domestic refrigeration; quantities recovered were very small due to the small refrigerant charge (100-150 g) in combination with handling losses. As for MAC's the approach was typically recovery and direct re-use through a MAC service unit; where the re-use rate may not be logged;

(c) When recovering HCFC-22, we expect much higher recovery rates due to the larger charge size – in particular from air-conditioning units. Emphasis should also be given – to a larger extent – to push-pull recovery methods; which is applicable for larger charges;

(d) A recovery, reclaim and re-use scheme should preferably be integrated into the existing refrigerant supply chain. We believe it's important to involve the private sector; possibly through a selection process, where the business model is also a selection criteria.

Retrofit and replacement activities in end-user sector

19. The guidelines for end-user conversion in the commercial refrigeration sector adopted by the Executive Committee at its 28th meeting[15] established that the relevant circumstances which must prevail before priority would be accorded to end-user conversion activities were:

(a) Production and import control on CFC and CFC-based equipment in place and effectively enforced, and restricts the deployment of new CFC components;

(b) The country's major remaining consumption is for the servicing of refrigeration and air-0conditioning equipment;

(c) Comprehensive data on the profile of all remaining consumption has been determined and made available to the Executive Committee, and

(d) Either no other possible activities would allow the country to meet its CFC control obligations, or the comparative consumer price of CFCs, relative to substitute refrigerants, has been high for at least 9 months and is predicted to continue to increase.

20. Under the above circumstances for an initial period of 18 months the retrofitting of commercial refrigeration equipment continued to be assessed on a case by-case basis and priority was given to projects for the conversion of cold stores in the agricultural, fisheries or other food-chain industries which are important for the economies of the countries concerned. Only a few end-user conversion projects were considered and approved by the Executive Committee within the established period.

21. The Executive Committee decided at its 31st meeting that incentive programmes to encourage retrofitting could be submitted under (decision 31/48). At the 32nd meeting UNDP developed the concept of incentive programmes for retrofit/replacement of refrigeration equipment in the commercial and industrial end-user and submitted three projects.

22. The evaluation on the implementation of RMPs conducted in 2003 reported pilot tests on retrofitting domestic and small commercial appliances to HC in several countries visited (Ghana, Senegal, Uruguay), which were seen as a potential option to continue operating CFC-based refrigerators with limited cost after the CFC phase-out. They required intensive safety training for technicians and adaptations of workshops, and claimed that the energy efficiency would improve, although this was not documented. Conversions of refrigerators to HFC-134a were found not economically viable in most cases due to its relative high cost, the cost of ester oil and difficulties to handle the system. Drop-in refrigerants were at the time considered worth it to explore as useful transitional solutions.

23. The limited evidence collected on end-user conversions during this evaluation suggested again that incentive programmes can, in principle, be effective if the following elements are in place: an operational and effective import licensing system with quota allocations, a reliable control of the level of CFC consumption, a narrowing or even inverted price differential between CFCs and alternative refrigerants, the introduction of economic incentives to industrial and commercial companies, and last not least, economic growth which helps to mobilize public and private funds for modernization investments. The evaluation also concluded that it was the anticipation of market developments and not awareness-raising what could induce the private sector to embark upon conversion of technologies implying additional investments, and that further analysis on the factors for success was required.

[15] Decision 28/44.

24. By 2007, twenty refrigeration end-user incentive programmes had been approved and a subsequent desk study on incentive programmes for retrofits was undertaken. The study confirmed that it was possible and also essential for a country to meet the pre-requisites established by the Executive Committee for approval of incentive programmes - i.e production and import controls on CFCs and CFC-based equipment in place and effectively enforced, and restricted development of new CFC components-, and without these pre-conditions being in place, the necessary close cooperation with the potential beneficiaries was very difficult or impossible to realize, as some countries experienced. Project delays observed in this evaluation were attributed primarily to lack of necessary preconditions for the successful start of the incentive projects[16].

25. The study showed that a series of substitutes were considered in the end-user incentive programmes, including retrofitting to HCFC-22, HFC-134a, HFC-404A, hydrocarbon, or dropping in refrigerant HFC-406, HFC-409 and C-10M1. The beneficiary enterprise from the incentive programme confirmed significant economic benefits derived from the conversion due to the lower price of HCFC-22 (in all the cases between 20 and 52 per cent of the price of CFC-12). In cases of conversion to HFC-134a or HFC-404A, owners of refrigeration equipment advised that even though the price per kilogram of new alternatives was currently higher than that of CFC-12, the economic benefits derived from the operational efficiency of the new systems far outweigh the differences in the prices of the refrigerants and should be an incentive for converting to new alternatives. Drop-in conversion using ternary blends containing HCFC had at the time limited applications in Article 5 countries due to their low availability and high cost, especially given the high leakage rate of aging refrigeration equipment. Almost all companies reported that refrigerant leakages and frequent breakdowns have been reduced or completely stopped resulting in drastic reductions of operational expenses and periodic losses of stored products.

26. Some of the factors that motivated the end-users to retrofit their equipment included a limited remaining life time of existing equipment and increased cost of maintenance; increase in price of CFC-12 refrigerant and comparatively low price of HCFC-22; increased awareness of owners regarding ODS phase-out and future shortage of CFC refrigerants; relatively simple procedures for accessing funds under the incentive programme; increased awareness about additional benefits resulting from conversion such as energy savings, lower cost of maintenance, reduced leakages, and emerging business opportunities associated with better performance of the replaced or retrofitted refrigeration equipment. The retrofit of existing equipment resulted in extension of its life span and deferral of otherwise inevitable investments in equipment in the food processing industry; availability of alternative technology and local contractors providing quality service for replacement and retrofit; and good connection of local consultants with servicing technicians and local refrigeration contractors through the national refrigeration association.

27. In 2009, the evaluation of TPMPs concluded that incentive projects in retrofit worked well in places where CFC-12 prices were growing rapidly while the prices of equally available alternatives was stable and that the price difference, the level of the incentive and the NOU related activities also played a significant role[17].

Views on retrofit expressed by UNIDO

28. The only HCFC-22 alternatives available for retrofit are high-GWP (such as HFC-407C/F, HFC-404A). HFC-32 does not qualify as retrofit candidate due to its higher operating pressures. The only low-GWP alternative that comes close to HCFC-22 is HC-290 (propane); however, its application is limited due to the flammability. Furthermore, the volumetric refrigeration capacity of HC-290 is around 85 per cent of HCFC-22; so a retrofit may also lead to lack of performance at design conditions. Also, based on experience from the Chinese RAC sector, A/C manufacturer reduce the heat exchanger pipe size

[16] UNEP/OzL.Pro/ExCom/52/18.
[17] UNEP/OzL.Pro/ExCom/58/8.

to ensure proper heat transfer (refrigerant velocity). Trials made at Petra/Jordan with un-optimized heat exchangers showed drop in efficiency. HC-1270 (propylene) appears to have better volumetric capacity; but concerns about flammability and heat exchanger modifications remain. Better low-GWP replacements are foreseen; both hydrocarbon mixtures as well as HFO/HFC mixtures; but none are commercially available. The only option to address service sector within next 5 years is through recovery, reclaim and re-use.

Feedback on retrofit of HCFC-based equipment to HCs

29. UNEP informed that in some countries in Africa and the Caribbean HC-290 is being used for retrofitting, operating and/or filling HCFC-22-based equipment. It appears that market conditions may be favourable for this practice, as it is taking place independently of efforts under the HPMPs, in some cases by enterprises that are promoting the practice and providing related training to technicians. In response to this practice, during implementation of the HPMPs, UNEP and other agencies that have found a similar situation have given priority to providing training to technicians on safe handling of HC technologies already to some extent in the market and developing codes and standards on their use.

30. In Africa, Malawi is one of the countries where HC-290 is used for retrofitting window and split air conditioners, the price of HCFC-22 is approximately US $10.20/kg, and the price of HC-290 is approximately US $15.30/kg. It is estimated that in average, out of ten potential air conditioners, only two could be retrofitted due to inadequate capacity on handling HCs. UNEP's role has been providing training on the proper use of HC technologies to refrigeration technicians; assisting in strengthening of Refrigeration Associations and Certification Programme and providing assistance to develop a code on the use of HCs. In a train-the-trainers national workshop it was demonstrated how to undertake a proper conversion including changes to the electrical system and other modifications operate with a flammable refrigerant.

31. The German bilateral agency Gesellschaft für Internationale Zusammenarbeit (GIZ) informed during discussions on the subject and in the context of submission of HPMP tranche requests, that it is providing assistance to Article 5 countries in ensuring proper introduction of HCs as alternative refrigerants to HCFC-22. For example: in Seychelles, GIZ is providing training on retrofits to HCs following European Standards for the use of flammable refrigerants, and implementing a demonstration project to replace the use of HCFC-based splits air-conditioning units with a HC-based chiller operated by solar energy. The publication Guidelines for the Safe Use of HC Refrigerants by GIZ (2010) provides comprehensive orientation on the safe introduction of HCs and existing international standards.