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EXECUTIVE COMMITTEE OF
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PRELIMINARY DISCUSSION PAPER PROVIDING ANALYSIS ON ALL RELEVANT COST CONSIDERATIONS SURROUNDING THE FINANCING OF HCFC PHASE-OUT (DECISION 53/37 (I))

EXECUTIVE SUMMARY

1. Currently, HCFC-141b, HCFC-142b and HCFC-22 account for more than 99 per cent of the total consumption of all HCFCs in Article 5 countries. These HCFCs are mainly used in the manufacturing of foam products and refrigeration equipment and in the refrigeration servicing sub-sector. While it is not possible at present to precisely ascertain the total number of countries with HCFC-based manufacturing enterprises or the amounts of HCFCs used in the servicing sector, it is clear that HCFC-based manufacturing enterprises may be found in less than 50 Article 5 countries. Conversely, HCFC-22 is likely to be used in all Article 5 countries as a refrigerant for servicing of refrigeration equipment, mainly used for air conditioning and in commercial refrigeration. Therefore, the refrigeration servicing sector will play an important role in achieving the 2013 freeze and 2015 reduction, particularly in those countries without HCFC-based manufacturing enterprises.

2. In line with decision 53/37, viable substitute technologies for phasing out HCFCs have been identified, and their corresponding ranges of incremental capital and operating costs estimated. The cost calculations were not intended as templates for calculation of incremental costs, but rather to demonstrate the relative levels of incremental capital and operating costs or savings and their impact on project costs so as to better inform the on-going discussion of the Executive Committee. In the foam sector, particularly for HCFC-141b, several technologies have already been proven and widely applied in Article 5 countries (i.e., water-based systems and hydrocarbons, namely n-pentane, cyclopentane, isopentane and their blends). Newer technologies (i.e., HFC-245fa, HFC365mfc/HFC-227ea) yet to be introduced commercially in Article 5 countries, have also proven their performance in non-Article 5 countries. Also methyl formate technology appears to have high prospects of meeting the foam production needs of Article 5 country enterprises and at lower costs. For HCFC-22 in the refrigeration sector, the situation is similar, and HFC and hydrocarbon replacements are available. Both of these technologies have been already used in Multilateral Fund projects. Implementing agencies and several countries are, therefore, well placed to apply these technologies for the phase-out of HCFCs. There remains the issue that the typically used HFC alternatives have a higher GWP than the HCFCs they replace, while low GWP substances, in particular hydrocarbons, are not only associated with higher capital cost but also with safety issues.

3. The demand for HCFC-22 in the service sector is to a large degree linked to the import of HCFC-22 air conditioning equipment into the countries. In order to simplify subsequent reductions of consumption for the service sector, the possibility of introducing controls on import of HCFC-22 equipment at a national basis should be considered at an early stage, in particular for air conditioners. This might have repercussions on the demand on the Multilateral Fund for funding the conversion of HCFC-22 air conditioner manufacturing facilities sooner rather than later, to be able to supply other Article 5 countries with HCFC-free air conditioning equipment.

4. Policies and guidelines that governed the phase-out of CFCs have resulted in the overall technological upgrade[1] of foam enterprises in Article 5 countries. As a result, no additional expenditure on equipment will be required for phasing out HCFCs for most of the alternative

[1] Hand mixing techniques that produce foam of inferior insulation properties irrespective of the blowing agent were eliminated and replaced with high pressure foaming machines in most cases while low pressure foaming machines were also replaced with high pressure machines to improve foam insulation properties through more efficient mixing of the reacting foam mixture.

technologies (i.e., HFC-245fa, HFC-365mfc/227ea, methyl formate and water-based systems). For these alternatives the ICC would mainly consist of technical assistance, including training and trials of new foam systems, albeit at a higher level of funding than the transitions from CFCs to HCFCs (at least at the initial stages) due to the relative lack of familiarity with the new technologies, the potential need for finessing formulations more than was the case with HCFC-141b, and for more extensive as well as more expensive trials. If, however, a hydrocarbon-based technology is selected, major capital expenditures would be needed as the majority of the manufacturing equipment would need to be replaced and new additional pieces of equipment would also need to be installed. Also, in some special circumstances such as a technical requirement for a new storage tank when the baseline tank is not suitable to safely handle the substitute chemical, e.g. HFC-245fa a need for some ICC to be covered would arise.

5. Since the inception of the Fund, funding of investment project proposals has been based on the evaluation of incremental capital and operating costs. As the number of phase-out projects increased, prices of major pieces of equipment became well established and capital costs were known and generally decreased over time. With this experience, sector and national phase-out plans were developed. Such a framework, where all components have become well known over time, has not yet been established for HCFC phase-out. Some issues that might need to be further considered are:

(a) IOC are proportional to the duration they are paid for. It is the prerogative of the Executive Committee to determine the period for which IOC are to be funded. The importance of discussing IOC and determining the duration for which they will be calculated is demonstrated by the high share of these costs within the total project cost as calculated for this paper;

(b) Historically, the Executive Committee has funded the conversion of manufacturing equipment well before the end of its useful life, in the majority of cases by providing new equipment. While this modality showed significant advantages related to incentives for early phase-out, it also led to premature retirement and destruction of expensive, fully functional infrastructure. It might be possible to consider in which cases support could be provided by the Multilateral Fund at a time when equipment is reaching the end of its useful life to avoid such premature retirement. This would, however, need to be assessed in the overall time-frame for compliance of each Article 5 country;

(c) The majority of the HCFC-based enterprises in the rigid foam sub-sector appear to be those with HCFC consumption below 40 tonnes (4.4 ODP tonnes HCFC-141b or 2.2 ODP tonnes HCFC-22), including large numbers of SMEs most of which are producers of “non-appliance rigid foam”. In order for all rigid and integral skin foam enterprises to have equal access to the available substitute technologies there is need to review the cost-effectiveness thresholds applicable to projects phasing out HCFCs in appliance foam, non-appliance foam and integral skin foam applications and to address the disparities in the cost-effectiveness threshold values. This would provide incentives to enable more rigid foam manufacturing enterprises that may wish to adopt hydrocarbon conversion option to do so;

(d) During the phase-out of CFCs in the foam sector, funding was approved for several systems houses in a few Article 5 countries for producing suitable non-CFC based pre-blended polyols, as well as providing technology transfer and training for their customers. For the HCFC phase-out their involvement could be regarded as a crucial component of the strategies and to provide a more efficient and sustainable approach to the process, since most of the technological issues involved in the transition to new technologies would be better resolved at the systems level in the early stages;

(e) Although there is evidence that in recent times HCFC-142b has been used in large quantities in a blend with HCFC-22, this application appears to be restricted to relatively large foam producing enterprises in a limited number of Article 5 countries. However for the phase-out of the HCFC-142b/HCFC-22 blend additional survey and studies would be required before funding for phase-out could be embarked upon;

(f) From the information in the refrigeration section it becomes evident that without some project-by-project cost assessment experience, in particular in the new sub-sectors and, to a lower degree, also in existing ones, it will be very difficult to provide appropriate technical guidance to the Executive Committee on costs of sectoral or national phase-out plans related to the conversion of manufacturing capacity in these sub-sectors.

6. In preparing this paper, the Secretariat examined the related issues of indicators for environmental impact and their application, incentives to be provided to reach or surpass such levels, and health, safety and economic considerations. At the present point of time it is not possible for the Secretariat to provide further guidance in advance of a discussion by the Executive Committee of certain policy principles. This relates in particular to the most suitable indicators for assessing the environmental impact of alternatives, and how they should be applied.

7. The present situation in regard to incentives and opportunities for co-funding has also been considered and results in a number of observations as set out below:

(a) The significant time needed to approve and implement co-funded projects by different entities, might lead to the use of co-funding modalities only for projects not related just to the 2013 and 2015 HCFC reduction targets. The Executive Committee might wish to consider in a future meeting an early definition of the objectives related to co-funding and a preliminary framework for co-funding HCFC projects. This could assist an early approach from possible co-funding entities, allowing them to consider related funding needs when their overall budget is under discussion;

(b) Guidance for projects where additional benefits are created through support by the Fund that might have a certain value, or obtain such a value in the future, e.g. by being eligible for carbon financing.

I. INTRODUCTION

1. This preliminary discussion document that contains an analysis on several relevant cost considerations surrounding the financing of HCFC phase-out is presented in response to the Executive Committee's decision 53/37(i).

I.1 Executive Committee's mandate

2. At its 53rd Meeting in November 2007, the Executive Committee considered a paper prepared by the Fund Secretariat on options for assessing and defining eligible incremental costs for HCFC consumption and production phase-out activities.[2]

3. The Executive Committee concluded by requesting, *inter alia*, "that the Secretariat, in consultation with technical experts with knowledge of experiences in Article 5 countries with different levels of development and non-Article 5 countries, would prepare by 25 March 2008 a preliminary discussion document providing analysis on all relevant cost considerations surrounding the financing of HCFC phase-out, taking into account the views expressed by Executive Committee Members in the submissions referred to in paragraph (l), and including:

(a) Information on the cost benchmarks/ranges and applicability of HCFC substitute technologies; and

(b) Consideration of substitute technologies, financial incentives and opportunities for co-financing which could be relevant for ensuring that the HCFC phase-out resulted in benefits in accordance with paragraph 11(b) of decision XIX/6 of the Nineteenth Meeting of the Parties" (decision 53/37(i)).[3]

I.2 Scope of the paper

4. Since 1991 the Multilateral Fund has developed a large array of cost norms. On the basis of experience in costing of stand-alone projects, more complex approaches have been developed, leading to instruments such as cost-effectiveness thresholds as well as sector and national costing approaches for cases with either a small number (below 25) or a large number (over100) of similar enterprises. This led to securing cost-efficiency, prioritization of funding activities in accordance with the policies of the Executive Committee, and the maintenance of funding equity between Article 5 countries.

5. The mandate in decision 53/37(i) indicates an expectation by the Executive Committee that the existing instruments and approaches can be extended to cover HCFCs. As a first step it was therefore necessary to consider what conditions have to be fulfilled to allow these to be extended to a degree that would provide suitable costing benchmarks/ranges, and enable the reliability of these benchmarks to be assessed. The following underlying principles were used for the analysis:

(a) Any assumption taken in this paper regarding the extension of existing policies

[2] UNEP/OzL.Pro/ExCom/53/60.

[3] Executive Committee Members were invited to submit their views on elements to be considered in the guidelines for the preparation of HCFC phase-out management plans, cost considerations to be taken into account by the Secretariat, cut-off date for funding eligibility, and second-stage conversions to the Secretariat by 15 January 2008.

would avoid pre-empting any policy discussion of the Executive Committee regarding that subject;

(b) Document UNEP/zL.Pro/ExCom/54/54 does not contain assumptions on policy decisions where no discussion has taken place in the Executive Committee;

(c) Eligibility issues, such as the question of whether to fund a second conversion or funding of manufacturing capacity established after a certain cut-off date, were not considered part of the mandate of this paper. On the same basis, instruments for programme management, such as cost effectiveness thresholds originally intended for prioritizing projects, were not investigated in detail; and

(d) A conflict needed be avoided between the mandate for this paper and decision XIX/10 of the Meeting of the Parties regarding terms of reference for the study on the 2009–2011 replenishment of the Multilateral Fund for the Implementation of the Montreal Protocol.

6. Empirical experience is partly available in the foam sector, in particular in rigid and integral skin foam applications representing the major use of HCFC-141b. In that sub-sector, technologies that have already been used in Multilateral Fund projects can be utilised for HCFC phase-out while other newer technologies appear to have technical characteristics very similar to those of CFCs and HCFCs. The situation is different for uses related to HCFC-22, where information on alternatives to the extent needed is available neither for the refrigeration and air conditioning sector, nor for use of HCFCs in extruded polystyrene foams.

7. The paper covers the following main content:

(a) A summary of policies for funding HCFCs, and an overview of HCFCs uses in Article 5 countries. This is supported by Annex I, Relevant policies and decisions adopted by the Parties to the Montreal Protocol and the Executive Committee regarding phase-out of HCFCs, and Annex II, Overview of HCFC consumption in Article 5 countries;

(b) An analysis of the incremental costs for phasing out HCFC consumption in the foam sector, supported by Annex III containing a detailed analysis on technical and costs issues related to the foam sector;

(c) An analysis of incremental costs for phasing out HCFC consumption in the refrigeration sector, supported by Annex IV containing a detailed analysis on technical and costs issues related to the refrigeration sector, including the service sector (this annex will be issued separately from this paper);

(d) Environmental issues, in particular the necessary steps to operationalize decision XIX/6 in the Multilateral Fund context;

(e) Incentives and opportunities for co-financing; and

(f) Recommendations.

8. In preparing this paper, consideration was taken of input received from Executive Committee Members as requested by decision 53/37(l).

I.3 Existing policies which could be applied for funding HCFC phase-out

9. The evaluation of the incremental costs of Multilateral Fund projects is based on the general principles agreed by the Parties to the Montreal Protocol at their 2nd Meeting.[4] On the basis of these principles, and on the Indicative List of Categories of Incremental Costs, the Executive Committee has developed specific policies and guidelines for categories of incremental costs in different industrial applications.

10. Funding of Multilateral Fund projects has been based on the assessment of eligible incremental capital and operating costs. Capital costs are related to the additional equipment that would be needed to replace ozone depleting substances (ODS) with the alternative technology selected by the enterprise, technology transfer, training, trials and commissioning. Incremental operating costs or savings (IOC) reflect changes in costs attributable to the conversion to ODS alternatives and arise from changes in chemicals used in the manufacturing process such as propellants, refrigerants or foam blowing agents. The level of IOC is influenced by fluctuations in prices of raw materials and the period of time over which such costs are paid. As decided by the Executive Committee, the duration of IOC in Multilateral Fund projects has varied among industrial sectors from zero (no IOC) for enterprises manufacturing compressors or MAC systems to four years for aerosol and flexible slabstock manufacturing enterprises (see Annex I).[5]

11. If the current policies and criteria for funding ODS phase-out remain unchanged, the eligible incremental costs of investment projects for phasing out HCFCs would continue to be based on the assessment of incremental capital and operating costs. The analysis undertaken in this document attempts to analyze the implications of these cost components on Multilateral Fund funding obligations.

12. Special funding options have been agreed by the Executive Committee for funding projects from low-volume consuming (LVC)[6] countries with manufacturing facilities by establishing a special funding window for investment projects where the cost-effectiveness threshold values[7] would not apply. For the phase-out of ODS by small and medium-sized enterprises (SMEs) the guidelines provided for a funding window to facilitate conversions of significant groups of small enterprises in the aerosol and foam sectors from non-LVC countries. Whether or not the Executive Committee may wish to continue with a similar practice in the case of HCFCs is an issue for further consideration by the Executive Committee.

[4] Appendix 1 of decision II/8 (Financial Mechanism).

[5] The duration of incremental operating costs for the sectors where HCFC technologies have been chosen to phase-out the use of CFCs in Article 5 countries is presented in Annex I to this document.

[6] A LVC country is a country with a CFC baseline consumption of 360 ODP tonnes. As of March 2008 there are 102 Article 5 countries classified as LVC countries.

[7] Cost-effectiveness threshold values applicable to different industrial sectors were adopted by the Executive Committee at its 16th Meeting as a way to prioritize approval of investment projects. The cost-effectiveness value is calculated as the ratio between the sum of the total incremental capital and operating costs and the total amount of ODS to be phased out in ODP kilograms. Additional information on cost-effectiveness and the threshold values adopted by the Executive Committee are presented in Annex I to this document.

13. As HCFCs[8] are controlled substances under the Montreal Protocol, and specific decisions addressing the phase-out of these ODS have been taken by the Parties since their 5th Meeting in November 1993, and by the Executive Committee since its 12th Meeting in March 1994. Of particular importance to the phase-out of HCFCs are those decision of the Executive Committee that request implementing agencies to provide a full explanation of the reasons why conversion to HCFC-based technology was recommended, including an analysis of prospective non-HCFC alternatives. Furthermore, it had to be made clear that the enterprises concerned had agreed to bear the cost of subsequent conversion to non-HCFC technologies. Information on alternative technologies provided by implementing agencies over the years as a result of these decisions by the Executive Committee has also informed the review of prospective technologies considered in this document.

14. At its 53rd Meeting the Executive Committee considered the policy framework for funding the phase-out of HCFCs, and decided that the existing policies and guidelines of the Fund would be applicable to funding HCFC phase-out unless otherwise decided in light of, in particular, decision XIX/6 (paragraph d of decision 53/37). This discussion paper has therefore been prepared against the background of the policies and guidelines outlined above and in Annex I of the document.

I.4 Overview of HCFC uses

15. The total consumption of HCFCs of 396,100 metric tonnes in all Article 5 countries in 2006 is more than two times the CFC consumption of 189,830 metric tonnes reported in 1995 when the maximum amount ever of CFCs was reported. However, the overall negative effect of HCFCs on the ozone layer (i.e., 35,160 ODP tonnes in total) is lower than that of CFCs (187,730 ODP tonnes) due to their lower ozone depleting potential.

16. The 2006 HCFC consumption in Article 5 countries can be characterized as follows:

(a) Consumption of HCFC-141b, HCFC-142b and HCFC-22[9] represents more than 99 per cent of total HCFC consumption;

(b) HCFC consumption in 71 countries is below 360 metric tonnes. Twenty nine other countries[10] either reported zero consumption or did not report any consumption;

(c) HCFC-141b is used in 43 Article 5 countries[11], 20 of which had a consumption below 10 ODP tonnes (91 metric tonnes), while HCFC-142b is used only in 21[12] Article 5 countries, 18 of which had a consumption below 10 ODP tonnes (154 metric tonnes);

[8] All HCFC decisions adopted by the Parties to the Montreal Protocol and the Executive Committee are presented in chronological order in Annex I to the present document.

[9] The ODP values of HCFC-141b is 0.11, of HCFC-142b is 0.065 and of HCFC-22 is 0.055.

[10] Twenty seven of the 29 countries are currently classified as LVC countries.

[11] Including 1,028.7 ODP tonnes (9,352 metric tonnes) consumed by Republic of Korea, Singapore and United Arab Emirates.

[12] Including 126.7 ODP tonnes (1,949 metric tonnes) consumed by Republic of Korea and Singapore.

(d) Seventy three[13] of the 117 Article 5 countries that reported consumption of HCFC-22[14] had consumption below 10 ODP tonnes (182 metric tonnes); and

(e) HCFCs are mainly used in the manufacturing of foam products (32.5 per cent of the total HCFC consumption), and in the refrigeration manufacturing and servicing sub-sectors (66.2 per cent). Small amounts are also used in the aerosol (0.2 per cent), fire extinguisher (0.1 per cent) and solvent (1.0 per cent) sectors.[15]

17. These data indicate that a few countries with a high level of HCFC consumption and the presence of a large number of SMEs among Article 5 countries. These conclusions are supported by the fact that, based on the analysis of funded individual foam projects, more than 80 per cent of all foam enterprises that converted from CFCs to HCFC-based technologies were located in no more than 12 Article 5 countries. In the same manner, it is estimated that more than 70 per cent of all foam enterprises in Article 5 countries had an annual CFC consumption below 40 ODP tonnes per year.

II. INCREMENTAL COSTS FOR PHASING OUT HCFC CONSUMPTION IN THE FOAM SECTOR

18. Through the assistance of the Multilateral Fund over 89,370 ODP tonnes of CFCs used as foam blowing agent have been phased out in Article 5 countries. These include CFC-11 used in flexible and rigid polyurethane foams and CFC-12 in extruded polyethylene and polystyrene foams. Article 5 countries selected permanent technologies to phase-out CFC-11 used in the rigid and integral skin sub-sectors, including water-based systems, hydrocarbons (pentanes) for enterprises that could safely operate foam producing equipment using flammable substances, as well as HCFCs as a transitional technology. The use of HCFCs as an alternative blowing agent accounted for about 40 per cent of all CFCs phased out. The use of CFC-11 and CFC-12 in the other foam sub-sectors was phased out using permanent conversion technologies[16].

19. In most non-Article 5 countries, foam blowing technologies based on use of HFCs (mainly HFC-245fa, HFC-365mfc and its blend HFC-365mfc/HFC227ea), methyl formate, and other less widely used technologies have been deployed as replacement for HCFCs used initially as transitional CFC phase-out technologies in the same manner as in Article 5 countries. Although their current availability is limited in Article 5 countries due to lack of demand, these technologies could be used in Article 5 countries also for phasing out HCFCs as a blowing agent.

II.1 Range of costs for phasing out HCFCs

20. Similar to the phase-out of CFCs in foam applications, the incremental capital costs (ICC) for conversion from HCFCs to non-ODS-based technologies depends on the enterprise's

[13] Including 1,213.9 ODP tonnes (22,071 metric tonnes) consumed by Republic of Korea, Singapore and United Arab Emirates.

[14] An additional 16 Article 5 countries had reported HCFC-22 consumption in 2005. Republic of Korea, Singapore and United Arab Emirates are excluded from the analysis.

[15] HCFC surveys conducted by UNDP for 12 selected Article 5 countries (UNEP/OzL.Pro/ExCom/51/Inf. 2).

[16] CFC-12 used for producing extruded polyethylene and polystyrene foam sheets was phased out mainly with butane and liquid petroleum gas (LPG). CFC-11 in flexible slabstock polyurethane foam sub-sector was phased out using methylene chloride and liquid carbon dioxide while CFC-11 used in moulded polyurethane foam was phased-out using water-based systems.

existing baseline equipment; the type of foam products being manufactured and the volume of production; the alternative blowing agent selected; and the location of the enterprise, which in several cases could be an important factor for deciding whether or not to select a technology that uses flammable substances.

Ranges of incremental capital costs

21. As requested in decision 53/37(i), two parallel ICC estimates for the cost benchmarks/ranges in relation to HCFC substitute technologies in foam applications were made. One has been based on the retrofit of existing equipment and another on the replacement of existing equipment for the following alternative technologies: water-based systems, hydrocarbons (both pentane and cyclopentane), HFC-245fa and methyl formate. The description below explains the reasons for two parallel estimates.

22. For the conversion from HCFCs to HFC, water-based systems or methyl formate technology:

(a) Based on existing policies, no additional capital costs will be required for all the rigid polyurethane and integral skin foam enterprises that upgraded their production facilities to allow for the interim use of HCFC blowing agents with assistance from the Multilateral Fund, except where a specific property of the substitute blowing agent poses a problem of incompatibility with some baseline equipment.[17] For example, the cost of a new storage tank could be an eligible incremental capital cost where the baseline tank is not suitable to safely handle HFC-245fa. Any need for retrofit or replacement of any existing equipment or installation of additional equipment for conversion from HCFCs to non-ODS alternatives would have to be technically justified and fully demonstrated. Costs related to technology transfer, training, trials and commissioning would be required to adapt the alternative technologies to local conditions;

(b) The same conditions as in paragraph (a) above will apply to enterprises that have modified their equipment for use with HCFCs either by replacing their low pressure dispensers with high pressure ones or by retrofitting their high pressure dispensers without assistance from the Multilateral Fund, since such enterprises have similar baseline as those that were assisted by the Multilateral Fund. Similarly the same conditions will apply to enterprises that established new facilities with high pressure dispensers. Assistance for technology transfer, training, trials and commissioning would be required; and

(c) Capital cost for retrofit or replacement of existing baseline equipment as well as technology transfer, training, trials and commissioning, might be required only for those enterprises that still process HCFC-141b foam on hand-mixing facilities and possibly low pressure dispensers either installed after the existing eligible cut-off date of 25 July 1995 or that were not eligible for funding during the Multilateral

[17] As a requirement for funding Multilateral Fund projects, enterprises converting to HCFC-based technologies had to make a commitment, together with their Governments, to phase out the residual ODP without further assistance from the Multilateral Fund. Almost all the justifications for the use of HCFC-141b in Multilateral Fund projects confirm that the final conversion would not require additional investment in equipment.

Fund intervention. The mode of funding will, however, depend on eligibility rules that may be decided by the Executive Committee. Thus, cost benchmarks for the replacement option have been estimated to address such an eventuality.

23. Conversion to pentane-based technologies for rigid or integral skin polyurethane foam enterprises will involve major capital costs compared to other available technologies. These will require high pressure dispensers suitable for use with hydrocarbon blowing agents, new polyol pre-mixers, hydrocarbon storage systems, and safety equipment to handle flammable substances. Local works to accommodate the hydrocarbon storage system and plant modifications would also be needed. In some circumstances plant relocation could be required.

24. Table II.1 below provides a summary of the ICC ranges for various foam applications. These costs are based on enterprises with only one foam dispenser and auxiliary equipment in the baseline, and with HCFC consumption of 5, 25 or 75 metric tonnes (or 0.6, 2.8 or 8.3 ODP tonnes) for manufacturing rigid foams, or 10 or 30 metric tonnes (or 1.1 or 3.3 ODP tonnes) for manufacturing integral skin foams. These levels of consumption represent typical small scale, medium scale and large scale operations. The minimum cost in the range was based on retrofitting all required equipment items, while the maximum cost was based on the cost of replacing old equipment with new equipment, and represent the absolute levels. Costs of technology transfer, training and trials, which are a component of capital costs, were estimated at a higher level than for the transition from CFCs to HCFCs due to an anticipated need for more activities to optimise foam formulations with potentially higher cost of trials than was the case with transition to HCFC-141b.

25. The calculations show that in all cases except conversion to hydrocarbon technology the retrofit costs are much lower than the replacement option. In the case of conversion to hydrocarbon technology, it was observed that the difference between the cost of a retrofit and that of replacing the existing dispenser is minimal. Incremental capital costs for HFC-365mfc and methyl formate would be similar to those of HFC-245fa, except for possible replacement of storage tanks.

Table II.1: Summary of ICC ranges for various foam applications (US $)

Foam application	**HFC-245fa/HFC-365mfc/ methyl formate**		**Water-based systems**		**Pentane**	
	Low	**High**	**Low**	**High**	**Low**	**High**
Panels, pipe in pipe, thermoware, domestic and commercial refrigeration						
Retrofit	20,000	60,000	15,000	55,000	375,000	710,000
Replacement	135,000	250,000	130,000	245,000	405,000	780,000
Spray foam (*)						
Retrofit	15,000	55,000	15,000	55,000		
Replacement	50,000	110,000	60,000	110,000		
Discontinuous block (box) foam (**)						
Retrofit	15,000	55,000	15,000	40,000		
Replacement	85,000	140,000	65,000	95,000		
Integral skin foam						
Retrofit	40,000	70,000	75,000	125,000	265,000	405,000

(*) The flammability of pentanes would make their on-site application unacceptable.
(**) Box foam operation would make the use of pentane risky.

Ranges of incremental operating costs

26. The levels of IOC for conversion from HCFCs to non-ODS-based technologies depend mainly on the nature of the new formulations and the relative prices of chemicals used in those formulations. Costs associated with increase in foam density, where applicable, and in-mould coating chemicals used in water-blown integral skin foams could increase the level of operating costs. For hydrocarbon technologies additional maintenance and energy usage costs due to installation of additional new equipment, and additional insurance cost due to the use of flammable substances, also drive up the IOC.

27. The proportions of main chemical ingredients in foam formulations, namely the blowing agent, the polyol and the isocyanate (MDI) and their prices are the key determinants of the level of IOC. Prices of these main chemical ingredients have varied widely among Article 5 countries and continue to be so as shown in Table II.2 below. As per the experience with the phase-out of CFCs, this situation could result in substantial IOC for one enterprise but savings for another enterprise for the same type and amount of foam produced, depending on the prices of some or all of the ingredients, and the price differences before and after conversion.

Table II.2: Current prices of chemicals used in foam formulations

Chemical	**Prices US $/kg**	
	Low	**High**
HCFC-141b	1.40	3.50
MDI	1.50	3.50
Pentane	0.50	2.50
Cyclopentane	0.80	3.30
HFC-245fa	10.40	12.00
Methyl formate	2.20	3.20

28. Increase in foam density, which is a cost penalty resulting from the cost of additional foam material, has a significant impact on IOC, representing 50 per cent or more of the total operating costs in some cases.[18] The levels of increases in foam density used in calculating IOC were based on the transition from CFC-11 to HCFC-141b, and need to be revisited for the phase-out of HCFC-141b. However, information currently available appears to indicate that foam density increase would not be an issue with the conversion from HCFC to HFC and methyl formate alternatives.

29. Ranges of IOC for the following alternative technologies: water-based systems, hydrocarbons (both pentane and cyclopentane), HFC-245fa and methyl formate were calculated. The calculations were based on the proportions of main chemical ingredients in the foam

[18] The levels of increase in foam density associated with different foam applications were approved at the 31st Meeting of the Executive Committee (decision 31/44) with a view to revisiting the issue in future and making modifications where necessary.

formulations, their prices[19] and, where applicable, factors that impact the level of the given IOC. The calculations were checked against approved projects to ensure consistency and accuracy.

Table II.3: Summary of annual IOC ranges for various foam applications per metric kilogram of HCFC-141b phased-out (US $/kg)[20]

Blowing agent	**Rigid foam**		**Integral skin foam**	
	Low	**High**	**Low**	**High**
HFC-245fa	2.50	6.40	2.50	6.40
Methyl formate	(0.30)	(1.90)	(0.30)	(1.90)
Water-based systems	0.85	1.75	3.55	12.78
Pentane	0.50	1.60	1.59	3.55
Cyclopentane	0.65	2.00		

30. To demonstrate the scope of IOC at the enterprise level, the average unit incremental costs shown in the above table were applied to rigid foam enterprises with HCFC-141b consumption of 5 metric tonnes (0.6 ODP tonnes), 25 metric tonnes (2.8 ODP tonnes) and 75 metric tonnes (8.3 ODP tonnes), for a two-year period, which represents the current duration of operating costs in the rigid foam sector. The resulting indicative IOC are shown in Table II.4 below:

Table II.4: Total IOC calculated over two years at the enterprise level (US $)

Technology	**Enterprise consumption (tonnes)**					
	5.0 metric (0.6 ODP)		**25.0 metric (2.8 ODP)**		**75.0 metric (8.3 ODP)**	
	Low	**High**	**Low**	**High**	**Low**	**High**
HFC-245fa (50%)	21,750	33,060	108,750	165,300	326,250	495,900
HFC-245fa (75%)	47,850	55,680	239,250	278,400	717,750	835,200
Water-based system	7,395	15,225	36,975	76,125	110,925	228,375
Methyl formate	(2,610)	(16,530)	(13,050)	(82,650)	(39,150)	(247,950)
Pentane	4,350	13,920	21,750	69,600	65,250	208,800
Cyclopentane	5,655	17,400	28,275	87,000	84,825	261,000

31. The following observations were made on the analysis of the IOC:

(a) Significant reductions in IOC can be achieved when some amounts of HFC-245fa are replaced with water in foam formulations. This, however, depends on the trade-offs between economy and foam insulation properties that the foam producer wants to achieve;

[19] The prices of HCFC-141b, pentane and MDI were based on the range of prices reported in project completion reports in the 2000 to 2006 period compared with the latest prices provided in March 2008 by some Article 5 countries through the bilateral and implementing agencies. The prices of HFC-245fa and methyl formate were based on prices provided by the manufacturers. The lower price of HFC-245fa is reported global list price for bulk containers (iso-tank) while the higher price is estimated price for small packages, based on a 15 per cent difference.

[20] Incremental operating costs associated with the phase-out of HCFC-22 may be higher than the estimated amounts presented in the table, as HCFC-22 is usually cheaper than HCFC-141b.

(b) The use of methyl formate results in incremental operating savings for both rigid and integral skin foam applications because of its comparatively low price and low level of usage[21];

(c) For rigid foam applications converting to pentane-based technologies, even though the blowing agent has a relatively lower price compared to other blowing agents, as well as a lower usage rate of about half that of the HCFC-141b it would replace, the overall conversion resulted in significant IOC. This is due to increase in foam density, and additional maintenance, insurance and energy costs consistent with the methods of calculation of IOC of Multilateral Fund projects; and

(d) HFC-245fa and water-based systems, especially in integral skin foams where in-mould coating is used to improve the quality of the foam to meet market requirements, have the highest IOC.

32. As IOC will be a major component of the overall cost of projects to phase out HCFCs, priority should be given to addressing issues linked to their calculation (i.e., duration, prices of chemicals and price structure, foam densities and other factors). During the phase-out of HCFCs the nature of formulations, particularly of HFCs and methyl formate, will play a significant role in determining the appropriate level of IOC for an enterprise. Hence project preparation may have to be approached somehow differently and with more involvement of systems suppliers at an earlier stage than before.

II.2 Special consideration of appliance and non-appliance foam applications

33. Under the Multilateral Fund, funding for phasing out CFC-11 used as a blowing agent has traditionally been done under the foam sector for enterprises manufacturing rigid polyurethane foam (known as non-appliance foam) with cost-effectiveness threshold of US $7.83/kg. It was however addressed under the refrigeration sector for enterprises manufacturing domestic and commercial refrigeration equipment (known as appliance foam) with sub-sector specific cost-effectiveness thresholds of US $13.76/kg for domestic refrigeration and US $15.21/kg for commercial refrigeration.

34. A large number of Multilateral Fund projects under the domestic and commercial refrigeration sectors converted their foam insulation to HCFC-141b technologies, while the refrigerant component was converted to non-HCFC alternatives. Therefore, the next stage of the conversion of HCFC-141b to non-ODS alternatives now should be addressed under the foam sector. The Executive Committee might need to consider whether the funding for appliance foam and non-appliance foam applications should be treated in similar manner.

II.3 Conversion of HCFC-142b use in Article 5 countries

35. HCFC-142b and HCFC-22 have been used widely in non-Article 5 countries as replacements for CFC blowing agents since the early 1990s, particularly in extruded polystyrene

[21] The price is within the same range as the pentanes and 1 part HCFC-141b is replaced by 0.5 part methyl formate.

insulation foam boardstock in the construction industry. Such HCFCs have been phased out in the majority of these countries[22].

36. Currently, the experience available in the Multilateral Fund for phasing out HCFC-142b/HCFC-22 is very limited, and only exists in relation to extruded polystyrene foam sheets and nets. However, over the last several years, the strong development of the insulation market in China, and to a lesser extent in a few other Article 5 countries, is driving the rapid introduction of extruded polystyrene enterprises using HCFC-based-technologies[23]. Further study of this foam sub-segment in relevant Article 5 countries needs to be undertaken in order to clarify the technological and cost issues involved.

II.4 Active participation of systems houses in the phase-out of HCFCs

37. In rigid and integral skin polyurethane foam production, most enterprises rely on polyols that are commercially premixed with the blowing agent and other essential ingredients (premixed polyols) that are provided by companies known as systems houses. During the first phase of CFC phase-out, systems houses played a key role in the market penetration of HCFC-141b in Article 5 countries.[24] Funding was approved for a limited number of systems houses for producing suitable non-CFC based pre-blended polyols as well as providing technology transfer and training for their customers (i.e., downstream foam enterprises).

38. The transition from HCFC to non-ODS technologies could be challenging in Article 5 countries due to the current limited availability of HFCs, and potential handling and processing problems in some regions when using the newer technologies such as HFC-245fa. To mitigate such problems, systems houses in Article 5 countries could be encouraged or supported ahead of the project preparation phase to explore the possibilities of developing or optimizing suitable formulations for their local markets and possibly neighbouring countries where low levels of HCFC consumption would not make a systems house operation feasible.

39. Other critical areas that could be addressed through collaboration between local systems houses and the foam industry are the following:

(a) Reduction in the costs of foam formulations which are based on expensive blowing agents (i.e., HFC-245fa or HCF-356mfc), providing a competitive insulation product in cost-sensitive applications (e.g. by using a blend with hydrocarbon or co-blowing with water);

(b) Development and introduction of hydrocarbon-based premixed polyols, which could accelerate the move away from HCFCs in Article 5 countries; and

(c) Training and technical assistance to enterprises that selected HFC-based

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[22] The main technologies selected are: HFC-134a, HFC-152a, CO2 (or CO2/alcohol) and isobutane. However, in Canada and the United States the phase-out has been more difficult because of particular product requirements, especially in the residential sector. The use of HCFC-142b and HCFC-22 is therefore expected to continue until 2010 in these countries.

[23] This sector alone has an additional 20,000 metric tonnes per year consumption since previously assessed in 2001 (2006 Assessment Report of the Rigid and Flexible Foams Technical Options Committee).

[24] Eleven group projects involving 290 SMEs centred around local indigenous systems houses were approved in four countries at a total cost of US $7.2 million. The direct impact of involvement of the systems houses was a phase-out of over 1,300 ODP tonnes of CFC-11.

technologies to ensure that those enterprises conduct their production activities in a manner that poses the lowest risk to the global environment, such as limiting emissions of HFCs during foam production.

40. Demonstrations projects linked to interested systems houses could be one of the ways to promote the optimizing of systems and introducing phase-out technologies to the local industry.

III. INCREMENTAL COSTS FOR PHASING OUT HCFC CONSUMPTION IN THE REFRIGERATION SECTOR

41. Currently, HCFC-22 is the predominant substance used in the refrigeration and air-conditioning sector in Article 5 countries. In 2006, 123 Article 5 countries reported an HCFC-22 consumption of 12,375 ODP tonnes (225,000 metric tonnes) used in the refrigeration and air-conditioning sector for manufacturing new equipment (mainly air-conditioners and to a lesser extent commercial refrigerators) and servicing existing equipment[25]. There are a number of other HCFCs that feature in the refrigeration sector, particularly HCFC-123 in chillers, and HCFC-124 and HCFC-142b as drop-in alternative refrigerants for CFC-12. Since it appears that there are no dedicated manufacturing capacities in Article 5 countries for products using these refrigerants, and since the quantities used are very small compared to HCFC-22, these HCFCs have not been further investigated in this paper.

III.1 Sectors and sub-sectors

42. In air conditioning, HCFC-22 has for more than 60 years been the predominant refrigerant, i.e. the refrigerant of choice for small, medium and large-size air conditioning systems, the latter with the exception of centrifugal chillers. It appears that almost all of the global manufacturing capacity for small residential air conditioning systems is concentrated in a small number of Article 5 countries (less than 15). The Secretariat has, for the purpose of this paper, defined the sub-sectors of room and split air conditioning, which also covers residential products; of commercial ducted and packaged air conditioning, that are medium-size, air-to-air systems used e.g. on the roof of larger commercial buildings; and HCFC-22 chillers, which have capacities below 500 kW used for air conditioning as well as for a number of process cooling applications in industry. The air conditioning sector is dominated by large industries with centralised manufacturing facilities.

43. Commercial refrigeration is the sub-sector with the most diffuse product range and variety as all refrigeration equipment used in commercial enterprises and not explicitly belonging to another sub-sector fall into this category. The products are largely, but not exclusively, used in retail, for the display and sales of refrigerated and frozen goods. Other applications range from water coolers to storage rooms for meat and dairy products. The wide range of applications and the catering to specific needs leads to a very dispersed industry with very few large but many medium and small enterprises producing highly customised products. There the borders between some parts of the commercial refrigeration sector and the service sector are blurred. Commercial refrigeration systems are probably manufactured in both every large consuming country as well as in most of the low consuming ones. HCFC-22 use in the sector has been driven, *inter alia*, by CFC-12 phase-out, and by the fact that service contractors and small companies have HCFC-22

[25] It is estimated that an additional consumption of 300 ODP tonnes (5,500 metric tonnes) of HCFC-22 have been used as a blowing agent in combination with HCFC-142b for production of polystyrene foam.

infrastructure available for air conditioning servicing. They can significantly simplify their operations if they use the same refrigerant for the assembly and charging of commercial refrigeration equipment as well as servicing.

III.2 Alternatives

44. For the different sectors, a number of alternative refrigerants are available. Technically, there are many possibilities to generate low temperatures for refrigeration. This paper concentrates on those that have, at the present point in time, a level of development and a field of application that suggest they might be candidates for HCFC-22 replacement in Article 5 countries in the mid-term. These alternatives are essentially HFC refrigerants, hydrocarbons and ammonia. A detailed description of alternative technologies can be found in Annex IV.

45. HFC are refrigerants with similar general characteristics as CFC and HCFC; some important specifics of their technology are well known from the introduction of HFC-134a during the CFC-12 phase-out. The typical replacements for HCFC-22, which are most widely used in non-Article 5 countries, all have a global warming impact (GWP) higher than HCFC-22. Only HFC-134a has a lower GWP than HCFC-22 and could be used for some, in particular smaller capacity applications. For Article 5 countries, it appears that these applications cover a large share of the equipment likely eligible for funding. HFC-134a has, so far, not been used to replace HCFC-22, therefore cost data are not available. A number of HFCs have been developed to replace HCFC-22 in specific applications, and have been successfully and widely introduced in both non-Article 5 and Article 5 countries. Some, in particular HFC-410A, have characteristics that require substantial changes in equipment design, component manufacturing and service equipment due to their higher working pressures. There are a number of blends of HFCs and hydrocarbons available that allow simple drop-in conversion of HCFC-22 equipment to ODS-free alternatives to be carried out in many cases.

46. Hydrocarbons and ammonia are low-GWP refrigerants, which have continuously been used for many years. Both have safety related challenges. Hydrocarbons have a high flammability, and ammonia is flammable and toxic. While the necessary technology to safely handle these refrigerants is well known, these characteristics lead to higher ICC at the time of conversion, and restrictions regarding the use of the related equipment:

(a) Hydrocarbons, in particular iso-butane, propane and propylene are like ammonia, excellent refrigerants. Their flammability requires safe handling in manufacturing and during servicing, limits the amount of hydrocarbons charged per equipment and imposes restrictions with regard to the location of production facilities (outside residential areas) and the equipment installed (full ventilation, out of contact with the public in case of larger charges). Hydrocarbons have been successfully used in refrigerators, where they are a fully established and widely used technology, small air conditioning and small commercial refrigeration equipment; and

(b) Ammonia technology has in the past been used in large refrigeration plants, in particular related to food processing and the chemical industry, and large chillers. The know-how needed to assemble and service ammonia refrigeration equipment is different from CFC/HCFC/HFC technology. Ammonia is presently used in a number of Article 5 countries, mainly because of historical reasons, but has proven difficult to introduce in countries where there are no prior uses.

47. The available information regarding energy efficiency indicates that there is, for most relevant applications, both an HFC as well as a low GWP refrigerant which can lead to the same or better energy efficiency as provided by HCFC-22 equipment. This might, in some cases, require significant redesign or use of an optimised compressor, both resulting in some cost increases that can for the foreseeable future only be quantified on a case-by-case basis.

48. It is likely that at least for the initial stage of HCFC phase-out, the alternatives described above will represent all of the potential choices. New developments for some low GWP refrigerants with no flammability and low toxicity are reported, but presently is unclear when these will be available and if they will in fact eventually be commercialised. CO_2 has been under development as an alternative refrigerant for the last 20 years, and is presently used in demonstration trials. It remains unclear if and under what circumstances it will be used on a larger scale, since it has fundamentally different design, components and, in particular, service characteristics than other refrigerants.

III.3 Specific challenges in the service sector

49. The service sector is an HCFC-22 consumer in all or most Article 5 countries. Wherever air conditioning equipment is being used, HCFC-22 is likely to be present for servicing it. While many air conditioning units do not require much repair, their large and rapidly increasing number will lead to an overall high service demand. The use of HCFC-22 in commercial refrigeration is further boosting service demand. The structure of the service sector is known from the phase-out of CFC-12. In the efforts to phase-out CFCs, activities in this sector have been grouped with, in particular, activities relating to legislation and enforcement of licensing and quota systems, as part of RMPs and TPMPs. A brief overview on these is therefore also provided under this chapter.

50. It is likely that a large number of Article 5 countries will have HCFC consumption almost exclusively in the service sector (which includes the sub-sector for assembly and charging of commercial refrigeration equipment). In contrast to the situation for CFC phase-out, when in most countries at least some manufacturing (e.g. soft foams) was CFC based and could be addressed to support the country in fulfilling its phase-out obligations, in the case of HCFCs there might be no such option for many Article 5 countries. For several reasons, it is not possible to address and monitor the service sector on an enterprise-by-enterprise basis. Therefore, CFC phase-out under the Multilateral Fund has mainly relied on supply restrictions through licensing and quota systems, while at the same time enabling the service sector to cope with dwindling CFC supplies through training in good practices and the provision of tools and equipment. The support by the Fund for the service sector has at the same time assured governments that supply side regulations would not lead to significant problems in the servicing of refrigeration equipment. The results of this approach have so far generally been good. The new challenge for HCFC phase-out is that supply side management has to start much earlier in the phase-out schedule, and to continue over a longer time-frame.

51. The demand for HCFC-22 in the servicing sector is linked to the import of HCFC-22 air conditioning equipment by Article 5 countries. In order to facilitate subsequent reductions in consumption for the servicing sector, it appears appropriate to consider on a national basis whether it is possible to limit the imports of HCFC-22 equipment, in particular air conditioners,

at an early stage. This would have repercussions on the timing of the demand for funding the conversion of in particular HCFC-22 air conditioner manufacturing facilities. Such facilities would need to be converted early on to enable them to supply other Article 5 countries with HCFC-free air conditioning equipment.

52. For low volume consuming countries to be able to decide on import controls, there would need to be sufficient support for their service sector to minimise HCFC-consumption and to enable appropriate handling of alternatives. It might therefore be appropriate to consider funding HCFC phase-out activities in the service sub-sector and related sectors (assembly, charging and end-user) in countries with predominant consumption in the service sector in or even before 2010, with a view to facilitating compliance with the 10 per cent reduction step in 2015. The exact nature and volume of these interventions remains to be discussed, *inter alia* on the basis of the experience with RMPs and TPMPs. Nevertheless, it already appears that some major components of TPMPs, namely legislation and enforcement support, upgrading of technicians equipment and education as well as implementation monitoring, will continue to play an important role. These components relate typically to a large portion of the funding requested for TPMPs.

III.4 Cost considerations

53. In order to develop an understanding of the possible costs related to HCFC phase-out in the refrigeration sector, experts with experience in Article 5 countries were consulted in gaining an understanding of the structure of the sectors and sub-sectors. In a next step, an attempt has been made to define one or two typical, HCFC-using, conversion-seeking enterprises for each sub-sector. Using the experience in the phase-out of CFCs, as well as services of experts, price lists and other available data, allowed for an estimation of the range of ICC and IOC for each of the alternatives. The approach is based on the assumption of replacement or upgrade of existing facilities during their useful life, as was the practice during the period of CFC phase-out projects. Since several of the sub-sectors have no guidelines to determine the duration of IOC payments, all IOC durations were normalised to one year, to facilitate fast calculation of the impact of the various longer or shorter IOC periods. Alternative technologies for the different sub-sectors, description of those sub-sectors, and conditions and results of the calculation of incremental cost resulting in indicative cost ranges are shown in Annex IV.

54. The approach of using a “typical” enterprise for ICC determination limits the uncertainty in estimating conversion cost per enterprise as the capital cost items will vary only within limits between different sizes of operations. But since the number of enterprises in a sector remains unknown, as well as the exact product ranges, extrapolation to determine conversion costs for entire sectors remains elusive for the foreseeable future. It should be noted that in case of CFC-phase-out, capital costs, but even more so the costs of items related to IOC (compressors, oils, refrigerants), usually decreased over time, and showed also significant variations in different markets.

55. The cost calculations for different model enterprises lead to the results presented in Table III.1. The operating cost are shown as annual ones. If the Executive Committee would decide e.g. on a four-year duration, the values for the IOC shown in the table would increase accordingly. Related decisions have already been taken for phasing-out CFCs in certain sub-sectors, but in particular the refrigeration and air conditioning sector is so far predominantly void of such determinations.

56. The calculation carried out on IOC demonstrates that they often take a larger share of the incremental cost than was typical for CFC-phase-out projects. It should be noted that IOC, being the only support under the Fund actually paid in cash, provide significant incentives. For example, if it is possible to choose between several technologies for one conversion project, the least economically sustainable technology, i.e. the option with highest per unit cost increase, is likely to have the highest IOC associated with it.

Table III.1 ICC and IOC forecast for selected project templates in the refrigeration sector

Sector/ sub-sector and type of equipment	Annual production (unit/year)	ICC (US $)		IOC (US $)	ICC (US $)		IOC (US $)	ICC (US $)		IOC (US $)
		Max	Min	Annual	Max	Min	Annual	Max	Min	Annual
Air conditioning		**R410A**			**R407C**			**R290**		
Room and split AC	250,000	275,000	950,000	2,660,000	190,000	250,000	4,250,000	545,000	670,000	4,512,000
Commercial ducted and packaged AC**	1,000	245,000	145,000	36,600	120,000	80,000	28,500	n/a	n/a	n/a
	100									
Chillers	200	300,000	85,000	Tbd	n/a	n/a	n/a	n/a	n/a	n/a
Commercial refrigeration		**R404A**			**R134a**			**R290**		
Stand-alone units: commercial freezer	1,000	35,000	35,000	15,000	35,000	35,000	11,000			
Stand-alone units: vending machines	10,000							500,000	800,000	150,000
Condensing units	1,000	25,000	30,000	26,000	35,000	35,000	20,000			

IV. ENVIRONMENTAL ISSUES

IV.1 Indicators for environmental impact

57. Decision XIX/6 calls for the Parties "to promote the selection of alternatives to HCFCs that minimize environmental impacts, in particular impacts on climate, as well as meeting other health, safety and economic considerations." This sets the immediate challenge of evaluating a series of parallel environmental impacts, most of which will be assessed using different environmental indicators and measured in different terms.

58. Among the indicators that could be applied to the HCFC phase-out, are:

(a) The ODP value as the indicator used under the Montreal Protocol;

(b) The GWP[26] of the alternative chemical selected;

(c) The effect of the emissions of alternatives on the climate; the effect caused by energy consumption related to the characteristics of equipment using the alternatives; and/or other environmental effects, such as health and safety related issues, and emission of volatile organic compounds; and

(d) A combination of one or several of the above. Examples where such approaches have been taken are the total equivalent warming impact (TEWI[27]) and more

[26] GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide whose GWP is by definition equal to 1.

[27] TEWI is the sum of the GWI and the carbon dioxide emitted in the production of energy to run the air-conditioning system.

recently the life cycle climate performance (LCCP[28]).

59. The process of selecting the appropriate indicators and their values would, assuming typical Multilateral Fund procedures, be carried out jointly by the beneficiary and an implementing agency. This will likely pose challenges in their implementation that would need to be further examine if the Executive Committee wishes so.

IV.2 Application of the indicators

60. Once a suitable indicator has been defined, the Executive Committee might address the question on how to apply the indicator. In the Montreal Protocol, the indicator of ODP has been used to prioritize projects under the Multilateral Fund against a threshold, with projects above this threshold receiving lower funding priority. (i.e., phasing out first the ODS with the highest ODP).

61. The application of the indicator needs to be flexible to take into account that almost all available alternative technologies based on fluorinated gases (HFCs) have higher GWP value than the HCFC they seek to replace. The mandate of decision XIX/6 might be interpreted as avoiding, as a minimum, the increase in climate impact due to HCFC phase-out. At the same time, it needs to be recognized that the conditions which prevail at a number of users of HCFCs in Article 5 countries are such that some fluorinated alternatives are well suited for their situation and/or application, while other alternatives with low GWP are not. Nevertheless, a GWP value is available for most alternative substances with the exception of hydrocarbons and methyl formate, which in the short-term could be consider to be a default of 25 (currently understood to be at the top-end of the range of hydrocarbon options) pending a determination by the International Panel on Climate Change or the Science Assessment Panel.

62. The factoring of energy efficiency benefits and dis-benefits might be achieved by using a functional unit approach, adapted for each project based on the product portfolio being supported. However, to apply such an approach, the product portfolio of an individual enterprise would need to be well-defined and relatively stable. The calculation would also need to consider the carbon intensity of the energy used which might vary from one part of a country to another part. These variations might be assessed in the context of the HPMP as a comparison between different alternative choices in a given country. Resulting calculations may then provide rationales for different cost scenarios. It is likely that the energy efficiency of the technology choice and a more comprehensive accounting for climate benefits would be very complicated and expensive to assess and verify.

63. In the calculation of incremental costs of Multilateral Fund projects issues related to health and safety have been considered and funded. For example, enhanced ventilation systems have been provided for flexible foam enterprises that replace CFC-11 with methylene chloride. Funding has also been provided for hydrocarbon sensors, explosion proof machines, emergency ventilation and alarm systems for enterprises that selected hydrocarbon-based technologies as replacement for CFCs, to ensure safe operation of the enterprises. This approach could continue to be used in phasing-out HCFCs

[28] LCA models the interaction between a product and the environment from cradle to grave. There are two main steps in an LCA: a description of which emissions will occur and which raw materials are used during the life of a product; and an assessment of the impacts of these emissions and raw material depletions.

IV.3 Incentives

64. For certain applications, in order to achieve environmental benefits other than the protection of the ozone layer, incentives to beneficiaries might need to be introduced. One of the principles of the Multilateral Fund has always been to fund the incremental cost for phasing out ODS and to allow the beneficiary to decide on their technology choice within established cost-effectiveness thresholds.

65. In the past, the Executive Committee has developed a number of concepts which ensure that these principles are adhered to, while at the same time providing incentives to beneficiaries to decide on a specific way forward. For example, in case of the refrigeration manufacturing sub-sector, the cost effectiveness threshold was increased by 30 per cent for projects where hydrocarbon technology was selected as a CFC alternative technology. A similar approach could be considered as an incentive for a large number of SMES that may wish to adopt hydrocarbon technologies as replacement for HCFCs. The concept of funding windows, where a fixed level of funding was reserved for projects meeting certain conditions, could be explored.

66. It might also be possible that, in some cases, the selection of a more complex and thus more expensive technology for phasing out HCFCs could result in greater benefits to the environment as compared to other technologies. For example, a technological upgrade of the conversion of HCFC-based compressors for air-conditioning systems could result in the development of high efficiency compressors with substantial reductions in energy consumption by the end-users. These additional benefits could be fundamentally larger than the associated increment in funding would suggest.

67. The Executive Committee may wish to consider climate benefits initially with respect to those norms that directly measure environmental benefits such as GWP, and consider measures of energy efficiency in the context of the overall HCFC phase-out management plans (HPMPs).

IV.4 Other considerations

68. Projects supported by the Multilateral Fund might create significant environmental benefits not only in relation to the ozone layer, but also to climate change. Through, in particular, carbon finance, some of those benefits might be used to generate tradable certificates related to emission reduction. Since this would constitute double funding, the Executive Committee might wish to consider possible ways to limit this.

V. INCENTIVES AND OPPORTUNITIES FOR CO-FINANCING

69. In preparing this preliminary discussion document, the Secretariat was requested to consider financial incentives and opportunities for co-financing, which could be relevant for ensuring that HCFC phase-out results in benefits in accordance with paragraph 11(b) of decision XIX/6 of the Parties to the Protocol.

70. All Multilateral Fund projects have been approved as grants to beneficiary enterprises and institutions in Article 5 countries, with a small number of projects where co-financing was needed as in the case of chillers. The level of grants had been determined on the basis of an analysis of eligible incremental costs. Other, non-eligible or non-incremental expenses related to projects have been paid, in many instances, by the beneficiary enterprises. Examples for

non-incremental costs paid by the enterprises are construction costs associated with plant conversion, capacity increase or technology upgrades beyond the baseline level. These constitute examples for what could be seen as beneficiary co-funding in Multilateral Fund projects[29]. These non-incremental costs have not been assessed and recorded by the Secretariat, and therefore quantitative information cannot be provided at this time since it has to be compiled.

71. In the refrigeration servicing sector, incentive programmes, particularly for the end-user sector, have been developed as part of RMPs, TPMPs and national phase-out plans, where partial funding is given to beneficiary end-users to retrofit or replace their ODS-based refrigeration system to alternative refrigerants.

72. At the 45th Meeting, the Executive Committee decided to establish a funding window for centrifugal chiller replacement. Subsequently, the Secretariat undertook in documents 46/37, 47/20 and 47/21 an analysis of important aspects and relevant experience. A number of the related findings are also valid for the mandate for this paper. The funding window for the replacement of chillers was established on the understanding that there would be multiple benefits from replacing old CFC-based chillers by chillers with alternative technologies.

73. The chiller projects were approved at the 47th and 48th Meeting, on the understanding that funding would be disbursed only when co-funding had been assured. In terms of co-funding, the chiller projects fall into three groups: co-funding from owners of the equipment; from environment funds; and co-funding through either carbon markets or electricity companies trying to reduce their consumption load. The projects with co-funding from the owners were first to be implemented, within a few months of the Executive Committee approving the projects. Significant funds from the Global Environment Facility (GEF) or other environmental funds started to materialise from about 18 month after project approval, and are still not fully established. Funds from international finance instruments, which require establishment and acceptance of benefit modelling as well as complex funding facilities, have not been available up to date, despite significant progress. The same is true for funds from electricity companies.

74. From an assessment of the process necessary to achieve the 2013 and 2015 compliance targets, it became clear that projects would need to be developed and implemented between 2009 and 2014 to achieve the necessary reductions in consumption. The experience suggests that significant delays in the implementation of projects are likely if they are linked to co-funding from sources other than the owners. This time-frame would need to be taken into account when considering co-funding for projects meant to support countries in achieving the compliance targets in 2013 and 2015.

75. Therefore, the very long lead time needed to mobilize co-funding would mean that some related issues would need to be are considered by the Executive Committee in the near future, ideally within approximately the next 12 month. This concerns the need to define the objectives to be pursued by the Executive Committee in attracting co-funding, as well as a preliminary framework for co-funding projects. Both are needed to establish an understanding on the side of potential co-funding entities on the possibilities of co-operation, and would allow such entities to adapt in a timely manner their cash-flow planning to possible funding needs for projects supported by the Multilateral Fund to achieve HCFC phase-out.

[29] Under other funding mechanisms these costs are seen as “counterpart funding” or “co-funding”.

VI. RECOMMENDATIONS

76. The paper identifies the following as some key issues that need prior consideration as prerequisite for defining the funding levels for the phase-out of HCFCs, as well as laying the groundwork for sustainable HCFC phase-out. The Executive Committee may wish to include these items as part of the priority issues to be considered in its preliminary discussions:

(a) Incremental operating costs (IOC) and factors that influence its determination including the duration for payment of IOC, chemical prices and modalities for establishing their levels in a reliable manner;

(b) Replacement of manufacturing equipment to accommodate for the alternative technology well before the end of its useful life;

(c) Environmental indicators and potential incentives to promote the selection of alternatives to HCFCs that minimize environmental impacts, in particular impacts on climate. In the short-term, priority could be given to activities phasing-out HCFCs with the highest ODP values to adopting alternatives with a low GWP when feasible or with other environmental benefits such as energy efficiency ;

(d) Other issues:

(i) Outstanding issues from decision XIX/6, in particular the cut-off date for newly established manufacturing enterprises and the eligibility of second conversions; and

(ii) Issues related to co-financing.

ANNEX I

POLICIES FOR FUNDING HCFC PHASE-OUT

1. The evaluation of the incremental costs of all Multilateral Fund project has been based on the general principles agreed by the Parties to the Montreal Protocol at their 2nd Meeting[1], namely:

(a) The most cost-effective and efficient option should be chosen, taking into account the national industrial strategy of the recipient Party. It should be considered carefully to what extent the infrastructure at present used for production of the controlled substances could be put to alternative uses, thus resulting in decreased capital abandonment, and how to avoid deindustrialization and loss of export revenues;

(b) Consideration of project proposals for funding should involve the careful scrutiny of cost items listed in an effort to ensure that there is no double-counting;

(c) Savings or benefits that will be gained at both the strategic and project levels during the transition process should be taken into account on a case-by-case basis, according to criteria decided by the Parties and as elaborated in the guidelines of the Executive Committee; and

(d) The funding of incremental costs is intended as an incentive for early adoption of ozone protecting technologies. In this respect the Executive Committee shall agree which time scales for payment of incremental costs are appropriate in each sector.

I.1 Categories of incremental costs

2. On the basis of these principles, the Executive Committee has developed specific policies and guidelines of categories of incremental costs in different industrial applications. The two main categories of incremental costs are capital costs and operating costs:

(a) Capital costs are typically related to the additional equipment that would be needed to replace ODSs with the alternative technology selected by the enterprise, technology transfer, technical assistance, training, trials and commissioning. They also include safety equipment and modifications to the enterprise when the technology selected is based on flammable substances. The size of the capital costs depends on the installed production capacity of the enterprise, the equipment available before the conversion, the alternative technology selected, and the location of the enterprise. Throughout the years, as the number of investment projects increased, the actual prices of major pieces of equipment required for the conversion were well established and used in the majority of the projects.

(b) Incremental operating costs reflect changes in costs attributable to the conversion

[1] Appendix 1 of decision II/8 (Financial Mechanism).

to CFC alternatives and arising from changes in starting materials and chemicals used in the production process such as additives, propellants and blowing agents. Fluctuations in raw material prices leading to changes in incremental operating costs occur frequently[2], and vary widely at the local and regional levels[3]. Typically enterprises respond to these changes by passing the increases to their customers in an orderly manner and as market conditions allow;

(c) The level of incremental operating costs is associated with their duration. According to decisions adopted by the Executive Committee, the duration for the application of incremental operating costs varies among sectors and sub-sectors[4], as follows:

(i) No operating costs for compressors;

(ii) For domestic refrigeration, ten per cent of incremental cost to be paid up-front, or six months of incremental operating costs calculated at current prices and paid up-front, or incremental operating costs for a duration of one year adjusted according to prevailing costs at the time of disbursement, when the modified plant was operating, which ever is greater;

(iii) Two years for commercial refrigerator, rigid and integral skin foam manufacturing plants; and

(iv) Four years for aerosol and flexible slabstock manufacturing plants.

I.2 Cost-effectiveness thresholds

3. In order to prioritize the approvals of investment projects, at its 16th Meeting in March 1995, the Executive Committee established cost-effectiveness threshold[5] values for different sectors and sub-sectors, as shown in Table I.1 below. The values were established on the basis of project proposals that were fully prepared and submitted by implementing agencies, as well as proposals that were partially developed where costs and amounts of ODS to be phased out were roughly estimated.

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[2] For example, the price of HCFC-141b dropped from US $5.45/kg in 1993 to US $3.40/kg in 1998, a reduction that is typical of pricing trends once a product is introduced, production is optimised, economies of scale increase and competition becomes established in the marketplace. Enterprises that received funding in 1993 when the price of HCFC-141b was at US $5.45/kg were overcompensated for the incremental operating costs that they actually incurred (UNEP/OzL.Pro/ExCom/36/34).

[3] According to the progress report on the implementation of the 2007 country programme submitted to the Fund Secretariat by Article 5 countries the 2006 price of HCFC-22 ranged from less than US $1.00 to US $30.00 per kilogram.

[4] These are the sectors where HCFC technologies were chosen for phasing-out the use of CFCs in Article 5 countries.

[5] The cost-effectiveness value is calculated as the ratio between the sum of the total incremental capital and operating costs and the total amount of ODS to be phased in kilograms ODP.

Table I.1. Sectoral cost-effectiveness threshold values established by the Executive Committee

Sector	Subsector	CE (US$/kg ODP)
Aerosol	Hydrocarbon	4.40
Foam	General	9.53
	Flexible polyurethane	6.23
	Integral skin	16.86
	Polystyrene/polyethylene	8.22
	Rigid polyurethane	7.83
Halon	General	1.48
Refrigeration	Domestic	13.76
	Commercial	15.21
Solvent	CFC-113	19.73
	TCA	38.50

4. While adopting the threshold values, the Executive Committee recognized that the conversion from CFCs to hydrocarbon technology of domestic refrigerators manufacturing enterprises would require additional funding for the provision of safety equipment and agreed that when calculating the cost of domestic refrigeration projects the safety related costs be discounted in a way that ensures parity with other options[6].

5. The Committee also recognized the special situation of low-volume consuming (LVC) countries and decided to reserve US $6,630,000 for allocation to projects from these countries in addition to any funds received as a result of approval of projects from LVC countries that qualified under the cost effectiveness threshold values.

I.3 Small and medium-sized enterprises (SMEs)

6. Special consideration has been given by the Executive Committee to the phase-out of ODSs by small and medium-sized enterprises SMEs since its 22nd Meeting in May 1997, when it constituted a contact group to address issues related to SMEs.

7. Subsequently, at its 25th Meeting, the Executive Committee allocated US $10 million from the resource allocation for 1999 for a funding window designed to facilitate pilot conversions of significant groups of small firms in the aerosol and foam sectors from non-LVC countries. The maximum allowable levels of consumption per enterprise were 25 ODP tonnes/year for flexible and extruded polyethylene/polystyrene foams and 10 ODP tonnes/year for flexible integral skin and rigid polyurethane foams. It was also decided that group projects should: be at a level of US $1 million or less; have an overall cost-effectiveness of no more than 150 per cent of the level of the current cost-effectiveness threshold values; use the most cost-effective technologies reasonably available; and consider the possible use of centralized use of equipment and industrial rationalization. These projects should be submitted with a Government

[6] The cost effectiveness threshold value for domestic refrigeration projects was adjusted at the 20th Meeting by discounting the numerator by 35 per cent which was sufficient to maintain parity between HCFC 141b/HFC 134a and cyclopentane/HFC 134a technology options in the domestic refrigeration sector (decision 20/45).

plan including policies and regulations designed to ensure that the specific level of agreed reduction to be achieved was sustained (decision 25/56).

I.4 Policies on HCFCs

8. As HCFCs are controlled substances under the Montreal Protocol, specific decisions addressing the phase-out of these ODSs have been taken by the Parties since their 5th Meeting in November 1993, and the Executive Committee since its 12th Meeting in March 1994. As reference, all relevant decisions adopted by the Parties to the Montreal Protocol and the Executive Committee regarding HCFCs are presented below in chronological order of adoption.

Fifth Meeting of the Parties (November 1993)

9. The Fifth Meeting of the Parties decided (decision V/8) that each Party is requested, as far as possible and as appropriate, to give consideration in selecting alternatives and substitutes, bearing in mind, *inter alia*, Article 2F, paragraph 7, of the Copenhagen Amendment regarding hydrochlorofluorocarbons, to:

(a) Environmental aspects;

(b) Human health and safety aspects;

(c) The technical feasibility, the commercial availability and performance;

(d) Economic aspects, including cost comparisons among different technology options taking into account:

(i) All interim steps leading to final ODS elimination;

(ii) Social costs;

(iii) Dislocation costs; and

(e) Country-specific circumstances and due local expertise.

Twelfth Meeting of the Executive Committee (March 1994)

10. The Twelfth Meeting of the Executive Committee adopted the following recommendations on the use of transitional substances as substitutes for ozone depleting substances:

(a) In view of the ongoing review requested of the Technology and Economic Assessment Panel by the Parties to the Montreal Protocol, the paper on The Use of Transitional Substances as Substitutes for Ozone Depleting Substances (UNEP/OzL.Pro/ExCom/12/34) may not be considered as a policy guideline but as a possible input to the work of the Open-ended Working Group of the Parties to the Montreal Protocol.

(b) Meanwhile, consideration of the use of HCFC in the Multilateral Fund projects should be sector-specific and approved for use only in areas where more environment-friendly and viable alternative technologies are not available.

Fifteenth Meeting of the Executive Committee (December 1994)

11. The Fifteenth Meeting of the Executive Committee stated that, whenever possible, HCFCs should not be used. It further requested that the applicability of HCFCs in commercial refrigeration projects should be examined by an expert group, possibly the OORG, which should prepare a report for submission to the Executive Committee.

12. The Executive Committee also requested Implementing Agencies to take the following issue into consideration when preparing projects for domestic refrigerator insulation foam conversion:

(a) As HCFCs were not controlled substances for Article 5 countries, incremental costs for conversion of HCFC-141b plants were not eligible for funding;

(b) Implementing Agencies should note a presumption against HCFCs when preparing projects; and

(c) Where HCFC projects were proposed, the choice of this technology should be fully justified and include an estimate of the potential future costs of second-stage conversion.

Nineteenth Meeting of the Executive Committee (May 1996)

13. The Executive Committee, noting the recommendation of the Sub-Committee (UNEP/OzL.Pro/ExCom/19/5, para. 12), decided (decision 19/2):

(a) To take note of decision VII/3 of the Seventh Meeting of the Parties to control HCFCs and to note further that projects involving conversion to HCFCs should be considered in the light of that decision, as well as other relevant factors;

(b) That in the future, in cases where conversion to HCFCs was recommended, the Implementing Agencies should be requested to provide a full explanation of the reasons why such conversion was recommended, together with supporting documentation that the criteria laid down by the Executive Committee for transitional substances had been met, and should make it clear that the enterprises concerned had agreed to bear the cost of subsequent conversion to non-HCFC substances; and

(c) To request the Secretariat to prepare for examination by the Executive Committee at its Twentieth Meeting a paper on:

(i) The historical background to HCFC conversion projects;

(ii) What information on alternatives to HCFCs had been provided by the

Implementing Agencies to the applicant countries, and how that information had been received and acted upon; and

(iii) The justifications given for the choice of one technology over another.

Twentieth Meeting of the Executive Committee (October 1996)

14. The Twentieth Meeting of the Executive Committee, decided (decision 20/48 (b, c)):

(a) To request the Implementing Agencies to ensure that adequate information on all alternative technologies was provided to enterprises converting from CFCs;

(b) To reaffirm paragraph (b) of its decision 19/2 which stated that, in cases where conversion to HCFCs was recommended, the Implementing Agencies should be requested to provide a full explanation of the reasons why such conversion was recommended, together with supporting documentation that the criteria laid down by the Executive Committee for transitional substances had been met, and should make it clear that the enterprises concerned had agreed to bear the cost of subsequent conversion to non-HCFC substances.

Eighth Meeting of the Parties (November 1996)

15. The Eighth Meeting of the Parties decided (decision VIII/13):

(a) That UNEP distribute to the Parties of the Montreal Protocol a list containing the HCFCs applications which have been identified by the Technology and Economic Assessment Panel, after having taken into account the following:

(i) The heading should read "Possible Applications of HCFCs";

(ii) The list should include a chapeau stating that the list is intended to facilitate collection of data on HCFC consumption, and does not imply that HCFCs are needed for the listed applications;

(iii) The use as fire extinguishers should be added to the list;

(iv) The use as aerosols, as propellant, solvent or main component, should be included, following the same structure as for other applications;

(b) That the Technology and Economic Assessment Panel and its Technical Options Committee be requested to prepare, for the Ninth Meeting of the Parties, a list of available alternatives to each of the HCFC applications which are mentioned in the now available list.

Twenty-third Meeting of the Executive Committee (November 1997)

16. The Twenty-third Meeting of the Executive Committee decided (decision 23/2):

(a) To request the Fund Secretariat to produce a paper containing figures on an analysis of what projects were being submitted for funding using HCFC technologies, to see whether there existed any trend towards or away from HCFC use in specific sectors, particularly the foam sector;

(b) To request the Secretariat to incorporate the following elements in the project evaluation sheets and, in the case of (i) below, in the list of projects and activities presented to the Committee for approval:

(i) Information on the conversion technology to be used;

(ii) A comprehensive outline of the reasons for selection of the HCFC technology, if used; and, where possible,

(iii) An indication of how long an enterprise intended to use a transitional HCFC technology.

Twenty-sixth Meeting of the Executive Committee (November 1998)

17. The Twenty-sixth Meeting of the Executive Committee decided (decision 26/26):

(a) That the full information provided in the project document should be included in the project evaluation sheet;

(b) That where, upon review by the Fund Secretariat, a project proposal requesting HCFC technology was considered to provide inadequate information justifying the choice of that technology, the project should be submitted for individual consideration by the Sub-Committee on Project Review.

Twenty-seventh Meeting of the Executive Committee(March 1999)

18. The Executive Committee at its Twenty-seventh Meeting (decision 27/13) expressed its appreciation for the increased information/justification provided for the selection of HCFCs and noted that that was the level of information originally expected, and that at least that level was expected in the future; stressed to the Implementing Agencies that it considered this to be more than a paper exercise, and urged the Agencies to take seriously the obligations related to providing information on alternatives available; and decided, in recognition of Article 2F of the Montreal Protocol, to request that Implementing Agencies provide, for all future projects or groups of projects for HCFCs from any country, a letter from the Government concerned. In the letter, the country should:

(a) Verify that it had reviewed the specific situations involved with the project(s) as well as its HCFC commitments under Article 2F;

(b) State if it had nonetheless determined that, at the present time, the projects needed to use HCFCs for an interim period;

(c) State that it understood that no funding would be available for the future conversion from HCFCs for these companies.

Twenty-eighth Meeting of the Executive Committee (July 1999)

19. The Twenty-eighth Meeting of the Executive Committee decided (decision 28/28) that information on a possible study comparing costs of alternative technologies and the impact on their choice of support from the Multilateral Fund should be the subject of a separate agenda item for its Twenty-ninth Meeting, for consideration by the Executive Committee itself.

Eleventh Meeting of the Parties (December 1999)

20. The Eleventh Meeting of the Parties decided (decision XI/28) to request the Technology and Economic Assessment Panel to study and report by 30 April 2003 at the latest on the problems and options of Article 5 Parties in obtaining HCFCs in the light of the freeze on the production of HCFCs in non-Article 5 Parties in the year 2004. This report should analyze whether HCFCs are available to Article 5 Parties in sufficient quantity and quality and at affordable prices, taking into account the 15 per cent allowance to meet the basic domestic needs of the Article 5 Parties and the surplus quantities available from the consumption limit allowed to the non-Article 5 Parties. The Parties, at their Fifteenth Meeting in the year 2003, shall consider this report for the purpose of addressing problems, if any, brought out by the report of the Technology and Economic Assessment Panel.

Thirtieth Meeting of the Executive Committee (March 2000)

21. The Thirtieth Meeting of the Executive Committee decided (decision 30/1) to establish an open-ended contact group, with Sweden as convener, in order to consider the question of policy on HCFC use as an interim technology and that the outcome of the group's work would be discussed under "Other matters".

Thirty-fourth Meeting of the Executive Committee (July 2001)

22. The Thirty-fourth Meeting of the Executive Committee decided (decision 34/51) to request the Secretariat, in relation to all future projects which involved conversion to HCFC-141b, to include in the meeting documentation the letter from the Government concerned, explaining the reasons for the choice of the technology, as per Decisions 23/20 and 27/13.

Thirty-sixth Meeting of the Executive Committee (March 2002)

23. The Thirty-sixth Meeting of the Executive Committee decided (decision 36/56):

(a) To take note with appreciation of the paper submitted by France;

(b) To request the Multilateral Fund Secretariat to update document UNEP/OzL.Pro/ExCom/36/34 with new costs for various options and to investigate the availability of non-ODS pre-blended polyol, and to submit the updated document and its findings for the consideration of the 39th Meeting;

(c) To request Implementing Agencies to amplify the relevant enterprise information pursuant to Decision 20/48 with data concerning import restrictions into non-Article 5 countries and the cost situation for alternatives, and to inform the enterprises that they should acknowledge having received that information. The corresponding documentation should accompany the project proposal;

(d) To request the Secretariat to send to the National Ozone Unit of the recipient country, a letter recalling that HCFC-141b projects would be excluded from funding in the future (no second conversion), with copies to the Ministries of the Environment and Foreign Affairs;

(e) That the annual Executive Committee report to the Meeting of the Parties should state by country the amount of HCFC-141b consumption phased in through projects using HCFC as replacements, a consumption which would - in application of Decision 27/13 - be excluded from funding at future stages.

Thirty-eighth Meeting of the Executive Committee (November 2002)

24. The Thirty-eighth Meeting of the Executive Committee decided (decision 38/38) for projects to phase-out CFCs by conversion to HCFC technologies, Governments had officially endorsed the choice of technology and it had been clearly explained to them that no further resources could be requested from the Multilateral Fund for funding any future replacement for the transitional HCFC technology that had been selected.

Fourteenth Meeting of the Parties (November 2002)

25. The Fourteenth Meeting of the Parties (decision XIV/10), noting that the Intergovernmental Panel on Climate Change and the Technology and Economic Assessment Panel are invited by the Convention on Climate Change to develop a balanced scientific, technical and policy-relevant special report as outlined in their responses to a request by the Subsidiary Body for Scientific and Technological Advice of the Convention on Climate Change (UNFCCC/SBSTA/2002/MISC.23), decided to request the Technology and Economic Assessment Panel to work with the Intergovernmental Panel on Climate Change in preparing the report mentioned above and to address all areas in one single integrated report to be finalized by early 2005. The report should be completed in time to be submitted to the Open-ended Working Group for consideration in so far as it relates to actions to address ozone depletion and the Subsidiary Body for Scientific and Technological Advice of the Convention on Climate Change simultaneously.

Fifteenth Meeting of the Parties (November 2003)

26. The Fifteenth Meeting of the Parties decided:

(a) That the Parties to the Beijing Amendment will determine their obligations to ban the import and export of controlled substances in group I of Annex C (hydrochlorofluorocarbons) with respect to States and regional economic organizations that are not parties to the Beijing Amendment by January 1 2004 in accordance with the following:

(i) The term “State not party to this Protocol” in Article 4, paragraph 9 does not apply to those States operating under Article 5, paragraph 1, of the Protocol until January 1, 2016 when, in accordance with the Copenhagen and Beijing Amendments, hydrochlorofluorocarbon production and consumption control measures will be in effect for States that operate under Article 5, paragraph 1, of the Protocol;

(ii) The term “State not party to this Protocol” includes all other States and regional economic integration organizations that have not agreed to be bound by the Copenhagen and Beijing Amendments;

(iii) Recognizing, however, the practical difficulties imposed by the timing associated with the adoption of the foregoing interpretation of the term “State not party to this Protocol,” paragraph 1 (b) shall apply unless such a State has by 31 March 2004:

(i) notified the Secretariat that it intends to ratify, accede or accept the Beijing Amendment as soon as possible;
(ii) certified that it is in full compliance with Articles 2, 2A to 2G and Article 4 of the Protocol, as amended by the Copenhagen Amendment;
(iii) submitted data on (i) and (ii) above to the Secretariat, to be updated on 31 March 2005, in which case that State shall fall outside the definition of “State not party to this Protocol” until the conclusion of the Seventeenth Meeting of the Parties;

(b) That the Secretariat shall transmit data received under paragraph 1 (c) above to the Implementation Committee and the Parties;

(c) That the Parties shall consider the implementation and operation of the foregoing decision at the Sixteenth Meeting of the Parties, in particular taking into account any comments on the data submitted by States by 31 March 2004 under paragraph 1 (c) above that the Implementation Committee may make.

<u>Forty-second Meeting of the Executive Committee (April 2004)</u>

27. The Forty-second Meeting of the Executive Committee decided (decision 42/7):

(a) To request the Government of Germany to take into account the views expressed on the eligibility of funding HCFC phase-out management studies by the Multilateral Fund at the 42nd Meeting of the Executive Committee, in the informal group meeting and, in addition, further submissions of additional ideas and opinions sent by e-mail to GTZ-Proklima, as the German bilateral Implementing Agency, provided that they were received 10 weeks prior to the 43rd Meeting of the Executive Committee; and

(b) Also to request the Government of Germany to circulate to the Executive Committee, through the United Kingdom delegation, a policy paper on the issues of the responsibility of the Multilateral Fund and potential eligibility requirements for such a study and to reformulate the project proposal for submission and consideration at the 43rd Meeting of the Executive Committee on that basis.

<u>Forty-third Meeting of the Executive Committee (July 2004)</u>

28. The Forty-third Meeting of the Executive Committee decided (decision 43/19):

(a) To note that:

(i) The May 2003 Technology and Economic Assessment Panel's HCFC Task Force Report predicted a dramatic increase in HCFC consumption in China in the foreseeable future;

(ii) The intent of the proposed project was also to allow utilization of its results for all Article 5 countries; and

(iii) Established Executive Committee policies did not support conversion of capacity installed after July 1995 nor a second conversion and the study was therefore not aiming at preparing or initiating any conversion projects;

(b) To approve the project "Development of a suitable strategy for the long-term management of HCFCs, in particular HCFC-22, in China", addressed in documents UNEP/Ozl.Pro/ExCom/43/21 and UNEP/OzL.Pro/ExCom/43/51, at the level of funding of US $300,300 plus support costs for the Government of Germany of US $39,039 on an exceptional basis on the condition that, as one of the outcomes, a study would look into the effects of management of HCFCs in China and in other Article 5 countries; and

(c) To further note that:

(i) A schedule for the study, indicating a project duration of 21 months, had been submitted to the Fund Secretariat. Both the Government of Germany and the Government of China would strive to adhere to that schedule;

(ii) The Government of China intended to use relevant outcomes of the study as a basis for subsequent national action by the Government and expected that such action would take place within three years after finalization of the study; and

(iii) Interested Executive Committee members and Implementing Agencies would be invited to participate in an informal advisory group, which might discuss survey methodologies, the evaluation of information gathered, and policies.

Nineteenth Meeting of the Parties (September 2007)

29. The Nineteenth Meeting of the Parties agree (decision XIX/6) to accelerate the phase out of production and consumption of hydrochlorofluorocarbons (HCFCs), by way of an adjustment in accordance with paragraph 9 of Article 2 of the Montreal Protocol and as contained in annex III to the report of the Nineteenth Meeting of the Parties, on the basis of the following:

(a) For Parties operating under paragraph 1 of Article 5 of the Protocol (Article 5 Parties), to choose as the baseline the average of the 2009 and 2010 levels of, respectively, consumption and production; and

(b) To freeze, at that baseline level, consumption and production in 2013;

(i) For Parties operating under Article 2 of the Protocol (Article 2 Parties) to have completed the accelerated phase out of production and consumption in 2020, on the basis of the following reduction steps:

(ii) By 2010 of 75 per cent;

(iii) By 2015 of 90 per cent;

(iv) While allowing 0.5 per cent for servicing the period 2020–2030;

(c) For Article 5 Parties to have completed the accelerated phase out of production and consumption in 2030, on the basis of the following reduction steps:

(i) By 2015 of 10 per cent;

(ii) By 2020 of 35 per cent;

(iii) By 2025 of 67.5 per cent;

(iv) While allowing for servicing an annual average of 2.5per cent during the period 2030–2040;

(d) To agree that the funding available through the Multilateral Fund for the Implementation of the Montreal Protocol in the upcoming replenishments shall be stable and sufficient to meet all agreed incremental costs to enable Article 5 Parties to comply with the accelerated phase out schedule both for production and consumption sectors as set out above, and based on that understanding, to also direct the Executive Committee of the Multilateral Fund to make the necessary changes to the eligibility criteria related to the post-1995 facilities and second conversions;

(e) To direct the Executive Committee, in providing technical and financial assistance, to pay particular attention to Article 5 Parties with low volume and very low volume consumption of HCFCs;

(f) To direct the Executive Committee to assist Parties in preparing their phase-out management plans for an accelerated HCFC phase-out;

(g) To direct the Executive Committee, as a matter of priority, to assist Article 5 Parties in conducting surveys to improve reliability in establishing their baseline data on HCFCs;

(h) To encourage Parties to promote the selection of alternatives to HCFCs that minimize environmental impacts, in particular impacts on climate, as well as meeting other health, safety and economic considerations;

(i) To request Parties to report regularly on their implementation of paragraph 7 of Article 2F of the Protocol;

(j) To agree that the Executive Committee, when developing and applying funding criteria for projects and programmes, and taking into account paragraph 6, give priority to cost-effective projects and programmes which focus on, inter alia:

(i) Phasing-out first those HCFCs with higher ozone-depleting potential, taking into account national circumstances;

(ii) Substitutes and alternatives that minimize other impacts on the environment, including on the climate, taking into account global-warming potential, energy use and other relevant factors;

(iii) Small and medium size enterprises;

(k) To agree to address the possibilities or need for essential use exemptions, no later than 2015 where this relates to Article 2 Parties, and no later than 2020 where this relates to Article 5 Parties;

(l) To agree to review in 2015 the need for the 0.5 per cent for servicing provided for in paragraph 3, and to review in 2025 the need for the annual average of 2.5 per cent for servicing provided for in paragraph 4 (d);

(m) In order to satisfy basic domestic needs, to agree to allow for up to 10% of baseline levels until 2020, and, for the period after that, to consider no later than 2015 further reductions of production for basic domestic needs;

(n) In accelerating the HCFC phase out, to agree that Parties are to take every practicable step consistent with Multilateral Fund programmes, to ensure that the best available and environmentally-safe substitutes and related technologies are transferred from Article 2 Parties to Article 5 Parties under fair and most favourable conditions.

30. The Nineteenth Meeting of the Parties also decided (decision XIX/8):

(a) To request the Technology and Economic Assessment Panel to conduct a scoping study addressing the prospects for the promotion and acceptance of alternatives to HCFCs in the refrigeration and air-conditioning sectors in Article 5 Parties, with specific reference to specific climatic conditions and unique operating conditions, such as those as in mines that are not open pit mines, in some Article 5 Parties;

(b) To request the Technology and Economic Assessment Panel to provide a summary of the outcome of the study referred to in the preceding paragraph in its 2008 progress report with a view to identifying areas requiring more detailed study of the alternatives available and their applicability.

<u>Fifty-third Meeting of the Executive Committee (November 2007)</u>

31. The Fifty-third Meeting of the Executive Committee decided (decision 53/37):

(a) That ratification of or accession to the Copenhagen Amendment was the prerequisite for an Article 5 Party to access Multilateral Fund funding for phasing out the consumption of HCFCs;

(b) That ratification of or accession to the Beijing Amendment was the prerequisite for an Article 5 Party to access Multilateral Fund funding for phasing out the production of HCFCs;

(c) That, in the case of a non-signatory country, the Executive Committee might consider providing funding for conducting an HCFC survey and the preparation of an accelerated HCFC phase-out management plan, with the commitment of the government to ratify or accede to the necessary Amendment and on the understanding that no further funding would be available until the Ozone Secretariat had confirmed that the government had ratified or acceded to that Amendment, through the deposit of its instrument in the Office of the United Nations Headquarters in New York;

(d) That the existing policies and guidelines of the Multilateral Fund for funding the phase-out of ODS other than HCFCs would be applicable to the funding of HCFC phase-out unless otherwise decided by the Executive Committee in light of, in particular, decision XIX/6 of the Nineteenth Meeting of the Parties;

(e) That institutions and capacities in Article 5 countries developed through Multilateral Fund assistance for the phase-out of ODS other than HCFCs should be used to economize the phase-out of HCFCs, as appropriate;

(f) That stable and sufficient assistance from the Multilateral Fund would be provided to guarantee the sustainability of such institutions and capacities when deemed necessary for the phase-out of HCFCs;

(g) That the production sector sub-group would be reconvened at the 55^{th} Meeting to consider issues pertaining to the phase-out of HCFC production, taking into account decision XIX/6 of the Nineteenth Meeting of the Parties and the following issues, as well as further elaboration and analysis of those issues to be prepared by the Secretariat in consultation with technical experts:

(i) The continued applicability of the current approach to funding HCFC production phase-out being based on the assumption of plant closures;

(ii) The timing of funding HCFC production phase-out in view of the long duration between the HCFC freeze in 2013 and the final phase-out in 2030, taking into consideration that production and consumption phase-out could take place simultaneously;

(iii) The eligibility of the CFC/HCFC-22 swing plants in view of the commitment in the CFC production phase-out agreement not to seek funding again from the Multilateral Fund for closing down HCFC facilities that use the existing CFC infrastructure;

(iv) The cut-off date for funding eligibility of HCFC production phase-out;

(v) Other measures that could facilitate management of HCFC production phase-out; and

(vi) Other issues related to the HCFC production sector, taking in account subparagraph (g)(ii) above.

(h) That the Secretariat would work with the implementing agencies to examine the existing guidelines for country programmes and sector plans (decision taken at the 3rd Meeting of the Executive Committee and decision 38/65), and propose draft guidelines to the 54th Meeting for the preparation of HCFC phase-out management plans incorporating HCFC surveys, taking into consideration comments and views relating to such guidelines expressed by Executive Committee members at the 53rd Meeting and the submissions to the 54th Meeting referred to in paragraph (l) below, and that the Executive Committee would do its utmost to approve the guidelines at its 54th Meeting;

(i) That the Secretariat, in consultation with technical experts with knowledge of experiences in Article 5 countries with different levels of development and non-Article 5 countries, would prepare by 25 March 2008 a preliminary discussion document providing analysis on all relevant cost considerations surrounding the financing of HCFC phase-out, taking into account the views expressed by Executive Committee Members in the submissions referred to in paragraph (l) below, and including:

(i) Information on the cost benchmarks/ranges and applicability of HCFC substitute technologies; and

(ii) Consideration of substitute technologies, financial incentives and opportunities for co-financing which could be relevant for ensuring that the HCFC phase-out resulted in benefits in accordance with paragraph 11(b) of decision XIX/6 of the Nineteenth Meeting of the Parties;

(j) That the current classifications of low-volume-consuming (LVC) countries and small and medium-sized enterprises (SMEs) should be maintained until the cost-effectiveness thresholds of HCFC phase-out had been developed and the potential impact of those thresholds on LVC countries and SMEs had become better known. It would then be possible to review those classifications including a classification for very low-volume consuming countries, and current policies and funding arrangements targeting those countries and enterprises;

(k) To note that the following cut-off dates for funding HCFC phase-out had been proposed:

(i) 2000 (Cap of HCFC production/consumption in one major country);

(ii) 2003 (Clean Development Mechanism);

(iii) 2005 (proposal for accelerated phase-out of HCFCs);

(iv) 2007 (Nineteenth Meeting of the Parties);

(v) 2010 (end of the baseline for HCFCs);

(vi) Availability of substitutes;

(l) As a matter of priority, and taking into account paragraphs 5 and 8 of decision XIX/6 of the Nineteenth Meeting of the Parties, to invite Executive Committee Members to submit their views on the following issues to the Secretariat, by 15 January 2008, with the understanding that the Secretariat would make the submissions available to the 54^{th} Meeting:

(i) Elements the Secretariat should consider in the draft guidelines for the preparation of national HCFC phase-out management plans;

(ii) Cost considerations to be taken into account by the Secretariat in preparing the discussion document referred to in paragraph (i) above;

(iii) Cut-off date for funding eligibility; and

(iv) Second-stage conversions;

(m) To approve 2008 expenditure of up to US $150,000 to cover the costs of consultations with technical experts and other stakeholders required for the preparation of the documents referred to in the present decision.

ANNEX II

OVERVIEW OF HCFCS USES

1. HCFCs have been used as early as 1936 when HCFC-22 was commercialized as a refrigerant. Production and consumption levels of HCFCs were substantially increased as a result of new applications particularly in the air conditioning sector as well as the Montreal Protocol, since several countries selected these substances as interim replacements of CFCs and other controlled substances.

2. As a consequence, global production of HCFCs reached 37,749 ODP tonnes (549,941 metric tonnes) in 2000 while the global consumption reached 38,219 ODP tonnes (546,996 metric tonnes) in the same year of which Article 5 countries accounted for 23 per cent. Since then, HCFC production and consumption levels have been reduced worldwide as a result of their phase-out in non-Article 5 countries.

3. However, against the global reduction trend, a substantial growth in HCFC production and consumption occurred in Article 5 countries[1] resulting in this group of countries accounting for nearly 80 per cent of the global production and over 75 per cent of the global consumption, as shown in Table II.1 below:

Table II.1 Levels of production and consumption of HCFCs (*)

	2000	2001	2002	2003	2004	2005	2006
HCFC production							
In ODP tonnes:							
Non-Article 5 countries	29,981	26,176	25,271	17,095	14,180	11,863	7,075
Article 5 countries	7,768	8,460	10,482	13,629	17,589	20,543	27,003
Total ODP tonnes production	37,749	34,635	35,753	30,724	31,769	32,406	34,078
In metric tonnes:							
Non-Article 5 countries	420,785	359,889	335,577	254,287	221,251	205,779	118,044
Article 5 countries	129,156	140,358	165,778	211,580	276,476	326,518	413,659
Total metric tonnes production	549,941	500,247	501,355	465,867	497,727	532,297	531,703
HCFC consumption							
In ODP tonnes:							
Non-Article 5 countries	25,219	23,360	22,333	14,865	10,975	10,278	7,120
Article 5 countries	13,000	12,435	13,403	15,826	19,783	21,536	28,040
Total ODP tonnes consumption	38,219	35,795	35,736	30,691	30,758	31,814	35,160
In metric tonnes:							
Non-Article 5 countries	347,741	321,823	291,318	225,013	185,019	182,326	122,107
Article 5 countries	199,255	191,854	201,023	230,354	287,407	329,104	396,099
Total metric tonnes consumption	546,996	513,677	492,341	455,367	472,426	511,430	518,206

(*) Data reported under Article 7 of the Montreal Protocol

[1] This category includes data from the Republic of Korea, Singapore and United Arab Emirates, representing countries that have so far not received assistance from the Multilateral Fund.

II.1 HCFCs consumption in Article 5 countries

4. Based on an analysis of HCFC data reported by Article 5 countries under Article 7 of the Montreal Protocol , it was noted that:

(a) HCFC-141b, HCFC-142b and HCFC-22 accounted for more than 99 per cent of the total amounts of HCFCs that were produced or consumed in 2006;

(b) Consumption of HCFC-22 represented 48.5 per cent of the total consumption of HCFCs in 2006, while consumption of HCFC-141b and HCFC-142b represented 43.5 and 7.2 per cent respectively of the total HCFC consumption;

(c) Seventy one countries reported a total HCFC consumption below 360 ODP tonnes in 2006 while 29 other countries either report zero consumption or not reported consumption (27 of these countries are currently classified as LVC countries);

(d) HCFC-142b increased significantly from 106.5 ODP tonnes (1,639 metric tonnes) in 2000 to 2,029.9 ODP tonnes (31,229 metric tonnes) in 2006. Consumption of HCFC-141b increased by 19 per cent while consumption of HCFC-22 increased by 8 per cent over the same period;

(e) In 2006, the total production and consumption of HCFCs by Republic of Korea, Singapore and United Arab Emirates amounted to 146.5 ODP tonnes (6,764 metric tonnes) and 1,016.2 ODP tonnes (33,372 metric tonnes) respectively. These three Article 5 countries have not received any assistance from the Multilateral Fund for phasing out their production and consumption of ODSs;

(f) For the purpose of comparison, the total consumption of CFCs reported by all Article 5 countries under Article 7 amounted to 189,830 metric tonnes in 1995, which represented the maximum amount ever reported. The total 2006 consumption of HCFCs in metric tonnes is more than two times the CFC consumption reported in 1995.

5. Consumption of HCFC-141b and HCFC-142b was reported only in 43 and 21 Article 5 countries respectively in 2006. Twenty[2] of the 43 countries reported consumption of HCFC-141b consumption below 10 ODP tonnes (91 metric tonnes). Similarly, 18[3] of 21 countries reported consumption of HCFC-142b below 10 ODP tonnes (154 metric tonnes). Thus, virtually three countries accounted for the entire HCFC-142b consumption of Article 5 countries in 2006. These levels of HCFC consumption point to a large number of SMEs among Article 5 countries with respect to HCFCs.

[2] Including 1,028.7 ODP tonnes (9,352 metric tonnes) consumed by Republic of Korea, Singapore and United Arab Emirates.
[3] Including 126.7 ODP tonnes (1,949 metric tonnes) consumed by Republic of Korea and Singapore.

6. Seventy three[4] of the 117 Article 5 countries that reported consumption of HCFC-22[5] in 2006 had consumption below 10 ODP tonnes (182 metric tonnes). It appears that the consumption of HCFC-22 in these countries is mainly for servicing refrigeration systems.

7. The number of countries by level of consumption and type of HCFC is presented in Table II.2 below.

Table II.2 Number of countries by level of HCFC consumption in 2006 (ODP tonnes)

HCFC	<10	>10 and <50	>50 <100	>100 < 1,000	>1,000	Total
HCFC-141b**	22	8	6	6	1	43
HCFC-142b**	18		1	1	1	21
HCFC-22(*)	73	20	7	16	1	117

(*) An additional 16 countries had reported HCFC-22 consumption in 2005.

II.3 Sectoral distribution of HCFCs

8. The only information on the sectoral uses of HCFCs in Article 5 countries available at the Fund Secretariat was that contained in the preliminary surveys on HCFCs undertaken by the Government of Germany for China[6] and UNDP for 12 selected Article 5 countries[7]. Some of the results of these surveys were the following:

(a) Excluding HCFC feedstock consumption, about 4,950 ODP tonnes of HCFC-22 were used in China in 2004 as refrigerant and 550 ODP tonnes as foaming agent and in the aerosol sector. The largest share of HCFC-22 consumption in China is for room air-conditioners, with a total production of 67.6 million units in 2005. During the next ten years, the use of HCFC-22 is likely to increase to about 16,500 ODP tonnes for domestic consumption, unless constrained by policy and technology improvements;

(b) The room air-conditioner and the expanded polystyrene foam sub-sectors in China are expected to grow at an annual rate of 7 per cent and 9 per cent, respectively;

(c) According to the surveys conducted by UNDP, the two main industrial sectors where HCFCs are currently consumed in Article 5 countries are the foam sector (32.5 per cent of the total consumption) and the refrigeration sector (66.2 per cent). The remaining consumption is in the aerosol (0.2 per cent), fire extinguisher (0.1 per cent) and solvent (1.0 per cent) sectors; and

(d) The breakdown of HCFC use by manufacturing versus servicing sectors in countries covered by UNDP's surveys are country dependent as shown below:

[4] Including 1,213.9 ODP tonnes (22,071 metric tonnes) consumed by Republic of Korea, Singapore and United Arab Emirates.
[5] An additional 16 countries Article 5 countries had reported HCFC-22 consumption in 2005. Republic of Korea, Singapore and United Arab Emirates are excluded from the analysis.
[6] UNEP/OzL.Pro/ExCom/51/Inf. 3.
[7] UNEP/OzL.Pro/ExCom/51/Inf. 2.

Country	Manufacturing (%)	Servicing (%)
Argentina	38.0	59.0
Brazil	45.0	52.0
Colombia	59.0	31.0
India	79.0	20.0
Indonesia	56.0	44.0
Iran	83.0	17.0
Lebanon	31.0	69.0
Mexico	64.0	35.0
Venezuela	21.0	77.0

II.4 HCFC technology in Multilateral Fund projects

9. Since the inception of the Multilateral Fund in 1991, the Executive Committee has approved 858 stand-alone investment projects in 47 Article 5 countries where HCFCs have been selected as the technology to replace CFC consumption, partially or totally[8]. Additionally, sectoral phase-out plans in the foam and refrigeration sectors and the conversion of CFC-12 compressors to HCFC-22-based systems have also been approved by the Executive Committee in a few Article 5 countries. The sectoral distribution of the stand-alone projects is presented in Table II.3 below:

Table II.3 Sectoral distribution of Multilateral Fund stand-alone projects with HCFC replacement technology

Sector	Projects	Countries
Foam	491	31
Refrigeration(*)	364	44
Solvent	3	2
Total	**858**	

(*) Compressor projects converted to HCFC-22 technology are not included.

10. Over 40,000 ODP tonnes of CFCs have been replaced by HCFC technologies, mainly HCFC-141b in foam applications including foam insulation in domestic refrigerator manufacturing enterprises, and HCFC-22 as a refrigerant and to a lesser extent as a foam blowing agent. The total amount of HCFC-141b and HCFC-22 consumption phased in through projects using HCFCs as a replacement of CFC-11 and CFC-12 amounts to over 3,700 ODP tonnes[9], as shown in Table II.4 below.

[8] Inventory of Approved Projects, including projects approved at the 53rd Meeting of the Executive Committee.

[9] This analysis has not included the amounts phased in from refrigeration manufacturing enterprises and a few foam enterprises covered under multi-year national phase-out plans since composite phase-out data for these plans are not yet available, although it is to be expected that the conversion technologies and their outcomes will be similar to those of the projects implemented as individual, umbrella projects or specific sector plans. It is also expected that these figures are relatively small.

Table II.4 Amounts of HCFC consumption phased-in through approved projects (ODP tonnes)

Country	CFC phased out in projects using HCFC technologies	HCFC phased in
Algeria	54.2	5.4
Argentina	817.4	79.0
Bahrain	15.3	1.5
Bolivia	11.0	1.1
Bosnia and Herzegovina	29.1	2.9
Brazil	4,830.8	476.1
Chile	236.5	20.2
China	14,078.4	1,168.4
Colombia	644.9	63.9
Costa Rica	33.1	3.3
Cuba	0.8	0.1
Dominican Republic	135.3	13.4
Egypt	484.4	37.4
El Salvador	18.3	1.8
Guatemala	45.4	4.5
India	4,463.8	432.6
Indonesia	2,839.7	281.4
Iran	1,045.5	103.6
Jordan	330.3	32.7
Kenya	22.8	2.3
Lebanon	81.0	8.0
Libya	61.5	6.1
Macedonia, FYR	75.1	7.4
Malaysia	1,226.5	118.5
Mauritius	4.2	0.4
Mexico	2,106.3	193.6
Morocco	118.0	11.7
Nicaragua	8.0	0.8
Nigeria	487.5	48.3
Pakistan	781.1	77.4
Panama	14.4	1.4
Paraguay	66.5	6.6
Peru	146.9	14.6
Philippines	518.9	51.4
Romania	192.0	19.0
Serbia	44.2	4.4
Sri Lanka	7.2	0.7
Sudan	4.4	0.4
Syria	628.4	62.3
Thailand	2,015.8	199.3
Tunisia	234.9	20.3
Turkey	372.2	36.9
Uruguay	98.1	9.7

Country	CFC phased out in projects using HCFC technologies	HCFC phased in
Venezuela	699.1	69.3
Vietnam	44.4	4.4
Yemen	9.7	1.0
Zimbabwe	11.3	1.1
Total	**40,194.6**	**3,706.6**

ANNEX III

INCREMENTAL COSTS FOR PHASING OUT HCFC CONSUMPTION IN THE FOAM SECTOR

1. To date, over 89,370 ODP tonnes of CFCs used by Article 5 foam manufacturing enterprises have been phased out through Multilateral Fund individual and umbrella projects and sectoral phase-out plans, comprising 80,370 ODP tonnes of CFC-11 from the rigid polyurethane foam including domestic and commercial refrigeration, and integral skin foam sectors, and 9,000 ODP tonnes of CFC-12 from the extruded polystyrene and polyethylene foam sector. Out of this amount, some 34,000 ODP tonnes of CFC-11 were replaced by HCFC-141b, 760 ODP tonnes were replaced by HCFC-22[1] and about 280 ODP tonnes by HCFC-22/HCFC-142b[2], with a phase-in of some 3,380 ODP tonnes of HCFC-141b and 42 ODP tonnes of HCFC-22. The latest (2006) HCFC-141b consumption reported by Article 5 countries under Article 7 of the Montreal Protocol is about 12,200 ODP tonnes. The differences in the consumption levels may possibly be attributed to growth in the consumption of HCFC-141b resulting from industrial expansion in the foam sector already supported by the Multilateral Fund and installation of new capacity.

Size of Multilateral Fund projects

2. An analysis of 657 Multilateral Fund foam projects approved as individual projects for 38 Article 5 countries to phase out CFC-11 using HCFC-141b technology showed the following:

(a) About 50 per cent of the enterprises were small scale enterprises with CFC consumption below 20 ODP tonnes, 20 per cent were medium scale with CFC consumption ranging from 20 to 40 ODP tonnes, while 30 per cent had consumption above 40 ODP tonnes. Thus, nearly 70 per cent of all the enterprises were small and medium scale foam producers;

(b) Only 20 per cent of the enterprises had CFC consumption over 60 ODP tonnes and could have cost-effectively used hydrocarbon-based technology;

(c) Nearly 80 per cent of the foam enterprises converting to HCFC-141b technology were located in seven of the 38 Article 5 countries (i.e., Brazil, China, India, Indonesia, Malaysia, Mexico and Thailand). In these countries 80 per cent of the enterprises had consumption below 40 ODP tonnes per year.

3. An additional analysis of 454 Multilateral Fund projects approved for 48 Article 5 countries to phase-out CFC-11 using HCFC-141b technology and CFC-12 using alternative refrigerants in the domestic and commercial refrigeration sector, showed that:

(a) Over 75 per cent of the enterprises were small and medium scale producers with

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[1] HCFC-22 was used as a substitute for CFC-11 in rigid and integral skin foam projects only in the early stages of project funding in only one country under a special programme. Over 80 ODP tonnes of CFC-11 funded to be phased out using HCFC-22/HCFC-142b was phased out using HCFC-141b.

[2] These consumption data under the Multilateral Fund are based on baseline data reported in project proposals at the various times of their approval and do not factor in any growth in consumption.

annual CFC consumption below 40 ODP tonnes (over 60 per cent of the enterprises consumed less than 20 ODP tonnes);

(b) Nearly 14,300 ODP tonnes of CFCs used as blowing agent (i.e., over 63 per cent of the total consumption) were replaced by cyclopentane (63.5 per cent of the total) in only 119 enterprises (26 per cent). The other 335 enterprises (74 per cent) selected HCFC-141b technology;

(c) The selection of cyclopentane technology by 26 per cent of the enterprises was mainly related to the production capacity (size) of the enterprises and the products being manufactured.

4. Cyclopentane technology was selected by 26 refrigeration manufacturing enterprises with CFC-11 consumption below 20 ODP tonnes per year. The cyclopentane technology was feasible for these low volume CFC consuming enterprises since the projects were funded under the refrigeration manufacturing sub-sector where foam and refrigerant components were treated as one project, with cost-effectiveness thresholds of US $13.76/kg for domestic refrigeration and US $15.21/kg for commercial refrigeration. However, with a sub-sector cost-effectiveness threshold of US $7.83/kg, among rigid foam enterprises not manufacturing refrigeration equipment, only those with CFC consumption of over 40 ODP tonnes could select hydrocarbon-based technologies as a replacement of CFCs, .

5. From the above analysis and from a review of the baseline equipment described in Multilateral Fund project documents, the foam sector in many Article 5 countries comprises a large number of small scale units which are technically and chemically unsophisticated. Many of the enterprises usually manufacture within the same facility different combinations of foam products. For example, insulated panels for truck bodies could be produced in the same facility as block foam and moulded pipe sections, while at the same time doing spray foam at different sites using the same type of blowing agent. Some enterprises also manufacture both rigid foam and integral skin foam products in the same facility, using the same dispenser and hand mixing and the same type of blowing agent.

Selection of alternative technologies

6. Given the limited technical capabilities of many enterprises, the selection of alternative technology to CFC-11 has been driven by the need to have a technology which would not only resemble CFC-based technology (virtual drop-in) but would also be locally available to ensure readily available technical support from material suppliers (i.e., systems houses). Depending on the products being manufactured, the production volume and the baseline equipment, several alternative technologies were chosen by Article 5 countries. Specifically, methylene chloride and liquid carbon dioxide technologies were selected for polyurethane flexible slabstock foam; water/carbon dioxide technology for flexible moulded polyurethane; hydrocarbons (butane/LPG) for polystyrene and polyethylene foam and pentane/cyclopentane/isopentane for relatively large rigid and some integral skin foam operations.

7. For a large number of foam enterprises manufacturing rigid polyurethane and integral skin polyurethane foam enterprises, HCFC-141b met the needs of both small scale and medium

scale enterprises. HCFC-141b-based systems were technically mature and commercially available. They also provided relatively the most acceptable insulation value and energy efficiency, and the lowest investment and operating costs vis-à-vis other options. No major changes in the auxiliary equipment/tooling in the production programme, such as jig or mould redesign, were needed. According to information in approved project documents and enterprise commitment letters submitted with them, enterprises understood the transitional nature of HCFC-141b and expected the final replacement for it to have similar characteristics that would meet their production demands. Accordingly, the use of HCFCs as alternative blowing agent accounted for about 34 per cent of all CFCs phased out. Table III.1 below provides detailed breakdown of alternative blowing agents to CFC-11 used in approved Multilateral Fund rigid and integral skin polyurethane foam projects.

Table III.1. CFC replacement technologies in rigid and integral skin polyurethane foam projects

Replacement	**ODP tonnes**	**% of subtotal**
Rigid polyurethane foam		
50% reduced CFC	46.0	0.2%
HFC-134a	57.8	0.3%
HCFC-22	542.2	2.4%
Water/carbon dioxide	904.8	4.1%
Pentane/cyclopentane	4,036.2	18.2%
HCFC-141b	16,630.9	74.9%
Sub-total rigid polyurethane	**22,217.9**	**100.0%**
Rigid polyurethane (insulation refrigeration)		
Water/carbon dioxide	93.0	0.4%
50% reduced CFC	450.0	1.8%
HCFC-141b	9,255.7	36.6%
Pentane/cyclopentane	15,472.0	61.2%
Sub-total rigid (insulation ref.)	**25,270.7**	**100.0%**
Integral skin		
DOP (di-octyl-phtalate)	8.6	0.2%
Methylene chloride	8.8	0.2%
HCFC-22	60.0	1.5%
Pentane/cyclopentane	164.6	4.0%
Hexane	255.0	6.2%
HCFC-141b	837.6	20.4%
Water/carbon dioxide	2,766.6	67.5%
Sub-total integral skin	**4,101.2**	**100.0%**
Multiple-subsectors (*)		
HCFC-22	157	4.6%
Water/carbon dioxide	1,031	30.2%
HCFC-141b	2,231	65.2%
Sub-total multiple-subsectors	**3,419**	**100.0%**
Total	**55,008.8**	

(*) Enterprises producing a mix of several products either within or across foam sub-sectors, e.g., rigid polyurethane pipe sections, panels and flexible polyurethane moulded and integral skin foams.

Baseline equipment upgrades for conversion to HCFC-141b and other alternatives

8. Equipment baseline information provided in project documents showed invariably that existing equipment in many enterprises consisted of low pressure foam dispensers several of them home-made, with simple open top pre-mixers or mechanical drill and bucket for premixing foam chemical components and pouring into moulds and/or cavities by hand. Better equipped enterprises predominantly had low pressure foam dispensers with mechanical mixing heads while relatively small number had high pressure dispensers.

9. After extensive technical review and discussions among the Fund Secretariat, the implementing agencies, experts from the foam industry and representatives of equipment and chemical manufacturers, it was concluded that HCFC-141b-based foam would have poorer quality of insulation (e.g., increased thermal conductivity) than that produced with CFC-11, which was being replaced. It was also concluded that this problem could be mitigated by producing foam of fine cell structure which is achieved by impingement mixing of high pressure dispensers.

10. As a consequence, financial assistance was provided from the Multilateral Fund through approved projects to enterprises manufacturing rigid polyurethane foam for insulation applications as follows:

(a) Low pressure foam dispenser that existed in the baseline was replaced with a new high pressure dispenser of equivalent effective capacity;

(b) High pressure dispensers already existing in the baseline were retrofitted to enable them to accommodate the new formulations and mixing ratios, by changing the pump kits, the parts vulnerable to the solvent action of HCFC-141b and by recalibration;

(c) Where no dispenser existed in the baseline (i.e., manual operation), a high pressure dispenser meeting the product output requirements of the enterprise was provided with 50 per cent contribution from the enterprise towards the cost of the new machine. Where the enterprise could not afford the contribution required to be made for a high pressure machine, a low pressure machine was provided with a much lower agreed contribution from the enterprise (usually between 25 and 35 per cent depending on the size and capacity of the machine). It was understood by recipient enterprises that the equipment provided under such arrangement was sufficient for handling the next stage of phasing out the HCFC;

(d) Additional pieces of equipment were provided, mainly polyol pre-mixers, if they were used with the CFC-based foam production.

11. In the integral skin and flexible moulded foam sub-sector most enterprises had low pressure machines that could process CFC-based formulations. Since the insulation property of the foam is not an issue in these applications, the replacement of the low pressure dispenser with a high pressure dispenser was not justified except when hydrocarbon-based technologies were selected. Partial funding was provided for low pressure dispensers as described above for those

enterprises that did not have a foam dispenser in the baseline (i.e., SMEs with hand-mixing operations). The weaknesses in the baseline dispensers, both low and high pressure, were addressed through several retrofits, including variable drive pump motors to control the ratio of the dispenser; heat exchangers for controlling material temperature; refrigeration unit (chiller) to properly control the reactivity of the water blown foams in a hot environment; barrier coat system to replicate the thick skin of the CFC-11 blown foams as closely as possible; power washer for product finishing operations; mould ovens for preheating of the moulds for the water-blown integral skin foam and for drying the barrier coat; and/or suitable moulds where baseline moulds are of glass fibre.

12. In one country, to cover polyurethane foam production for insulating products using HCFC-22 as a blowing agent in rigid polyurethane foam thermoware products, funding was provided to replace existing low-pressure with high-pressure foaming dispensing units as well as on-site pre-mixers since polyol blends with HCFC-22 were not available. For production of extruded polystyrene foam sheets using HCFC-22/HCFC-142b as a blowing agent, funding was provided for installation of a gas storage facility, replacement of the existing extruder with a new extruder and auxiliary equipment.

Items of incremental operating costs paid for CFC phase-out

13. The level of incremental operating costs or savings of Multilateral Fund foam projects depend on several factors, including the nature of the new formulations that would produce foam of a similar quality as in the baseline, the relative prices of chemicals required for the manufacturing of foams; cost penalty resulting from increase in the density of the foam (applicable mainly to rigid insulation polyurethane foam); the cost of incremental maintenance, incremental insurance (estimated to be 5.5 per cent of net incremental cost of equipment) and incremental energy usage when selecting hydrocarbon-based technologies; and the cost of in-mould coating chemical in integral skin foam products.

14. The incremental operating cost associated with foam density can be as high as 60 per cent of the total incremental operating cost of the project. Since the duration of incremental operating cost for rigid foam projects is two years, calculation of the component of incremental operating cost associated with increase in foam density is based on “initial density increase” for the first year and “mature density increase” for the second year. Incremental operating costs of high density rigid insulation foams (above 45 kg/m^3), such as pipe-in-pipe foam (density: 70-80 kg/m^3) and spray foam for roofs (density: 48-50 kg/m^3) are not affected by foam density increase, all other applications are affected with increases in density ranging from 4-16 per cent for the first year and 3-13 per cent for the second year. Pentane and cyclopentane-based foam for boards and domestic refrigeration have the highest increase respectively of 16 and 13 per cent and 16 and 10 per cent in the first and second years.

15. The Secretariat and the implementing agencies have worked on and agreed the baseline densities and mature densities during conversion from CFC-11 to HCFC-141b technology. These mature densities could consequently become the baseline densities for the second stage conversion from HCFC-141b to non-ODS alternatives. However, information obtained on conversions using the new generation of alternative blowing agents, particularly HFC-245fa and methyl formate indicate that increase in foam density after conversion would not be an issue as

lower foam densities than that obtained with HCFC-141b could be achieved. It is, therefore, necessary to revisit the issue of changes in foam density in order to more accurately account for the required level of incremental operating costs.

Alternative blowing agents to HCFCs

16. The choice of substitute blowing agent and its associated conversion technology had to meet the following criteria which are equally applicable to conversion from HCFC-based technology:

(a) Proven and reasonably mature technology;

(b) Critical properties to be maintained in the end product;

(c) Cost effective conversion and local availability of substitute, at acceptable pricing;

(d) Support from the local systems suppliers; and

(e) Meeting established standards on environment and safety.

17. Information available from project documents and confirmed by project completion reports, the TEAP Foam Technical Options Committee and other sources point to the following technologies as potential alternatives to HCFCs in foam blowing.

Water-based (water/CO_2)

18. Water-based systems, where the blowing agent is carbon dioxide generated during the foaming process, became available in some Article 5 countries during the conversion from CFC-11 in rigid integral skin foams, rigid foams with relatively less critical insulation applications such as in-situ foams, surf boards, low density packaging foams, and thermoware and spray foam, initially with the use of HCFC-141b. Water-based systems, particularly for rigid foams, are up to 50 per cent more expensive than other CFC-free technologies since the technology is associated with reductions in insulation value and lower cell stability. The problem is addressed by adding more material (up to 50 per cent) to increase foam thickness, where feasible, with resulting increase in cost. Thus, the use of water-based technology in pour-in-place for insulation applications, while in principle feasible, would require an increase in thickness, which is not always practical or cost-effective.

19. Rigid integral skin foams have almost universally converted to all-water-based systems. In most of these applications, skin formation is triggered through densification (mould pressure) rather than condensation. Accordingly, subsequent coating may be required and densities can be increased. However, since densities in this application are already relatively high, (e.g. 60 kg/m3) this is not a major issue. This is not the case for flexible and semi-flexible integral skin foams. The related cost penalty arising from significantly increased densities and the poor skin formation associated with water blown systems has made the use of pentane, hexane and HFCs attractive in non-Article 5 countries and has caused almost universal conversion to HCFC-141b

in Article 5 countries. Under the Multilateral Fund also projects have been approved for 23 shoe sole (semi-flexible integral skin) manufacturers, mainly in Brazil, Indonesia, Mexico and Pakistan. About 60 per cent of the enterprises employed water/CO_2 technology while 40 per cent used hexane.

20. In one Article 5 country, with the assistance from the Multilateral Fund some enterprises converted their integral skin foam production to water-blown technology without increase in foam density to achieve a surface finish of the product using water-based cross-linked in-mould coating. This required inexpensive modifications to their manufacturing equipment. However, the incremental operating cost was still higher than that of using HCFC-141b due to the higher cost of the coating. Water-based systems have zero ODP. Water vapour is a major greenhouse gas; however, new emissions do not affect global warming because it is already at a saturation point in the atmosphere. CO_2 has a GWP of 1.

Hydrocarbons

21. Hydrocarbons as foam blowing agents have been proven commercially in both non-Article 5 and Article 5 countries. Pentanes, namely n-, iso-, and cyclopentane or their blends, have emerged as the most favoured blowing agents among the hydrocarbons, because the level of their use needed to achieve the same foam density is substantially lower than that for other blowing agents such as HCFC-141b. They constitute a permanent final technology, and their relatively low prices compared to other blowing agents make them economically attractive. However, in several projects approved under the Multilateral Fund claims for costs associated with increase in foam density or dimensional stability, incremental maintenance, incremental energy usage and incremental insurance have often resulted in substantial incremental operating costs.

22. Hydrocarbons are the preferred conversion technology for large and organized foam producers, where the safety requirements can be complied with and investments can be economically justified. Hydrocarbons have zero ODP and a relatively low GWP (maximum 25).

HFCs

23. HFCs have a higher insulating value than other foam blowing alternatives at operating temperatures for applications such as walk-in coolers and cold storage areas. They are mainly used where end product fire performance is an issue with insurers or where investment costs for hydrocarbon-based technology are prohibitive mainly for SMEs. The three main HFCs currently used in foam applications are HFC-134a, HFC-245fa and HFC-365mfc (and its blend with HFC-227ea).

(a) HFC-245fa (marketed primarily by Honeywell as Enovate 3000) is currently available across most, if not all, non-Article 5 countries although only currently manufactured in the United States and, to a smaller extent, in Japan (Central Glass). It has been used to replace HCFCs in most rigid foam applications, including domestic refrigeration, spray foam, and metal faced sandwich panels. Feedback from users underlines the excellent flow properties of systems containing HFC-245fa, good solubility in polyol, possible foam density reductions and reduced panel waste due to ease of processing. In most cases it can be processed with the same spray foam and pour in place dispensers used for HCFC-141b. HFC-245fa is typically used as co-blowing agent with CO_2/water in order to gain from the thermal performance, while limiting the cost impact. However, HFC-245fa poses some technical challenges to formulators due to its low boiling point and its lower fire-resistance properties relative to HCFC-141b. It currently has limited commercial availability in Article 5 countries due to lack of demand. It has a high price, currently costing over US $10.00/kg for bulk containers. HFC-245fa has zero ODP value and a GWP of 1,020.

(b) HFC-365mfc and its blend HFC-365mfc/HFC227ea (marketed almost exclusively by Solvay Fluor as Solkane-365 and Solkane-365/227, respectively), is currently available in most, if not all, non-Article 5 countries with the exception of the Canada and the United States, where patents prevent its use in foams. HFC-365mfc-blown foams have a fine cell structure with good insulation properties and good compressive strength. These foams are good for insulation purposes, where a non flammable liquid foaming agent with low thermal conductivity is needed, but does have a lower blowing efficiency than some other alternatives. For several applications, HFC-365mfc is blended with HFC-227ea to overcome a minor flammability issue. It has also a high price ranging from US $4.50 to US $5.00/kg. HFC-365mfc has zero ODP and GWP of 610. HFC-227ea has a much higher GWP value (2,900), however, it is used in relatively small proportions;

(c) HFC-134a has been used widely in Multilateral Fund projects as a refrigerant in refrigeration projects. However its use as a foam blowing agent has been very minimal due to processing difficulties, the fact that its pre-blends cannot be made available, and high production costs owing to the need for on-site pre-mixer which would limit its application by SMEs. Therefore it does not appear to have the potential as alternative blowing agent in Article 5 countries. HFC-134a has zero ODP and GWP of 1,300.

Methyl formate

24. Methyl formate (marketed primarily by Foam Supplies/BOC as Ecomate), is an emerging technology that could be of interest in Article 5 countries due to its reported high efficiency and low cost. Information available from the suppliers indicates that methyl formate seems an ideal replacement for HCFC 141b in integral skin foams because it has a desirable combination of boiling point and solubility to mimic those of HCFC-141b. Its boiling point just above ambient, allows good skin formation without expensive cooling. Spray and pour foams made with methyl formate have good physical properties, good fire resistance and good stability. It is reported to be currently supplied to some countries in Asia, Africa, Europe and Latin American. Some concern over dimensional stability has been reported in some applications, presumably arising from high solubility. The price of methyl formate worldwide is reported to be in the same range as of the

price of pentanes but not affected by to the price pressures of crude oil on pentanes. Methyl formate has zero ODP and relatively low GWP[3], likely to be similar to other hydrocarbons.

Range of incremental capital costs for phasing-out HCFCs

25. For purposes of funding the phase-out of HCFCs, the recipient enterprises may be put into the following categories, namely

(a) Enterprises that have converted their foam production from CFC-11 to HCFC-141b with the financial and technical assistance of the Multilateral Fund;

(b) Enterprises that that have converted their foam production from CFC-11 to HCFC-141b through their own resources and/or enterprises that might have established new foam production plants or installed new foaming equipment based on HCFC-141b.

26. The second category of enterprises consists of the following:

(a) Enterprises that established CFC-based foam production facilities after the cut-off date of 25 July 1995 using low pressure machines and have subsequently converted to HCFC-141b-based production by replacing the low pressure machines with high pressure ones and enterprises that established CFC-based foam production facilities after the cut-off date of 25 July 1995 using high pressure machines and have converted to HCFC-141b;

(b) Enterprises that established CFC-based foam production facilities after the cut-off date of 25 July 1995 using low pressure machines and have subsequently converted to HCFC-141b-based production on the same machines or enterprises that established HCFC-141b-based production on low pressure machines and continue to produce on the same machine;

(c) Enterprises that have converted part of their CFC-based foam production to HCFC-141b with the assistance of the Multilateral Fund while the other part on low pressure foaming capacity established after the July 1995 cut-off date did not receive assistance but continues to be used to produce HCFC-141b-based foam without any changes.

27. Against the background of the technical upgrades of enterprises that received assistance from the Multilateral Fund and of the discussion above regarding categories of enterprises that may potentially receive assistance from the Fund, the Secretariat made two parallel incremental capital cost estimates based on retrofit of existing equipment or replacement of existing equipment. The following considerations informed the calculations of the incremental capital cost:

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[3] The supplier's claim of zero GWP is based on the US EPA SNAP evaluation which described the GWP of methyl formate as 'likely to be negligible'. However, no actual testing was carried out to support this. Indeed, there is no chemical reason why the value should not be similar to that of other hydrocarbons.

(a) Conversion from HCFC-141b to liquid blowing agents, such as HFC-245fa, HFC-365mfc, HFC-365mfc/HFC-227ea blend, water/CO_2 or methyl formate, should be based on retrofits of the production equipment in the baseline. Replacement of existing production equipment should be fully demonstrated and considered on a case-by-case basis;

(b) Conversion to hydrocarbon technology should be based on retrofit or replacement of existing foam dispenser and pre-mixers as technically required. Additional equipment for storage of hydrocarbon and for safety is included.

28. Thus the incremental capital costs were determined on the basis of the following:

(a) Calculations were based on a unit operation (i.e., one dispenser and associated manufacturing equipment);

(b) The majority of enterprises rely on premixed systems instead of premixing in-house for each application segment. The cost of a new premixer or retrofit of existing premixer was included in the list of equipment for those enterprises that do not rely on premixed systems;

(c) The minimum cost was based on retrofit of all required equipment items except when an item has to be replaced for technical reasons such as the conversion to hydrocarbon-based blowing agent. The maximum cost was based on installation of new equipment or replacement of old equipment with new ones without any deductions for counterpart contribution. Also, the minimum and maximum cost levels represent the absolute levels;

(d) The cost of technology transfer, training and trials were estimated at a higher level than the levels during the transition from CFC to HCFCs due to anticipated need for more activities for finessing foam formulations with potentially higher cost of trials than was the case with transition to HCFC-141b;

(e) The incremental capital costs for integral skin foam sub-sector were calculated based on retrofits only except in the conversion from HCFC-141b to hydrocarbon-based technology where new production equipment is required.

29. Detailed calculations and breakdown for the various segments are provided in Appendix I.

Range of incremental operating costs

30. The level of incremental operating costs or savings for conversion from HCFCs to non-ODS-based technologies would depend on the nature of the new formulations that would produce foam of a similar quality as in the baseline formulation, the relative prices of chemicals required for the manufacturing of the foam; the expected increase in foam density; potential incremental maintenance, insurance and energy usage costs when using hydrocarbon-based

technologies; and the price and quantities of in-mould coating chemicals when used during production of water-blown integral skin foam.

31. The proportions of the main chemical ingredients in foam formulations (namely blowing agent, the polyol and MDI) and their prices are the key determinants of the level of incremental costs or savings. From an analysis of several Multilateral Fund projects, it was observed that small changes in material ratios and/or price differential could result in substantial incremental operating costs for one enterprise but incremental operating savings for another enterprise for the same type and amount of foam produced. Increase in foam density which translates into the cost of additional foam material also has a significant impact on incremental operating cost and savings, representing in some cases 50 per cent or more of the total operating costs. The levels of increase in foam densities associated with different foam applications were approved at the 31st Meeting of the Executive Committee (decision 31/44) with the view to revisit the issue in future and make modifications where necessary. The increases in foam densities were based on the transition from CFC-11 to HCFC-141b and need to be revisited for the transition from HCFC-141b to other alternative technologies, especially since there are indications that for some of the alternatives increase in foam density following conversion may no longer be the case.

32. Cost ranges of incremental operating costs were calculated for the following alternative technologies: water-based systems, hydrocarbons, both pentane and cyclopentane, HFC-245fa and methyl formate, on the basis of the following assumptions and considerations:

(a) Prices of chemicals for pentane and water-based technologies for which the Secretariat has extensive experience and a large body of information from project completion reports, prices were derived from project completion reports completed between 2000 and 2006. The information was complemented with information on prices provided by some Ozone Units through bilateral and implementing agencies;

(b) Prices of HFC-245fa and methyl formate were obtained from the relevant companies (Honeywell and Foam Supplies Inc.);

(c) Calculations were based on the relationship between HCFC-141b and the replacement chemicals based on ratios of 1:0.50 and 1:0.75 for HFC-245fa and 1:0.50 for methyl formate consistent with information obtained from the suppliers; 1:1.5 for water-based systems; 1:0.5 for pentane and cyclopentane in rigid foam; and 1:0.75 for integral skin foam according to methods used in approved projects;

(d) Given the limited time available for the preparation of this paper, the direct association between increases in foam density from HCFC-141b to other technologies for the various rigid polyurethane insulation foam application segments could not be subject to a thorough review. Therefore, no increase in density was factored into the calculation for HFC-245fa and methyl formate. However, as stated earlier, increase in foam density may not be a factor in reality. Based on observations made upon review of calculations of the incremental operating costs of hydrocarbon-based projects a 10 per cent increase in foam density was factored into the calculations for pentane and cyclopentane-blown foams;

(e) The cost of in-mould coating chemical was included in the calculations for the integral skin foam as it is a component of the foam processing chemicals accounting for up to about 70 per cent of the total incremental operating cost;

(f) Costs associated with incremental maintenance, insurance and energy usage of hydrocarbon-based technologies were also included in the calculation for integral skin foam consistent with the practice in approved projects.

33. The incremental operating costs were calculated for enterprises with HCFC-141b consumptions of 5, 25, and 75 metric tonnes (0.55, 2.75 and 8.25 ODP tonnes) to represent the rigid foam sub-sector and enterprises with consumptions of 10 and 30 metric tonnes (1.1 and 3.3 ODP tonnes) for the integral skin foam sub-sector. Calculation per kg of HCFC-141b eliminated was also made. The calculations were checked against approved projects to ensure consistency and accuracy of the methodology.

34. The detailed calculations as well as its application to typical consumption levels as indicated above for rigid and integral skin foams can be found in Appendix 1.

Strategies for viable and sustainable HCFC conversion in the foam sector

35. In rigid and integral skin polyurethane foam production, most enterprises rely on polyols commercially premixed with the blowing agent and other essential ingredients (premixed polyols)[4] that are provided by companies known as systems houses. While enterprises with pre-mixers on site have the flexibility to vary their foam formulations to meet their customers' end-product requirements, SMEs have to rely on systems houses to meet their customers' requirements. In that regard access to a systems house becomes critical to the competitiveness and/or productivity of a foam producer and above all the sustainability of the conversion programme overall. During the first phase of CFC phase-out, systems houses played a key role in the market penetration of HCFC-141b in Article 5 countries.

36. Eleven group projects involving 290 SMEs centered around local indigenous systems houses were approved in four countries at a total cost of US $7.2 million. The direct impact of involvement of the systems houses was a phase-out of over 1,300 ODP tonnes of CFC-11. Table III.2 provides basic information on the systems houses assisted through the Multilateral Fund.

Table III.2. Systems house activities in the phase-out of CFCs

Country	Systems house	Number of enterprises	Sector/sub-sectors	Project cost (US$)	Impact (ODP tonnes)	Substitute blowing agent
Brazil	JNP	25	Rigid PU, integral skin/ flexible molded PU	636,400	80.3	HCFC-141b

[4] Data on approved CFC-based integral skin and rigid foam projects shows that about 80 to 85 per cent relied on premixed polyol. Also, over 60 per cent of foam enterprises relying on premixed polyol were SMEs consuming between 0.2 and 20.0 ODP tonnes CFC-11 per year.

Country	Systems house	Number of enterprises	Sector/sub-sectors	Project cost (US$)	Impact (ODP tonnes)	Substitute blowing agent
Brazil	Plastquim	50	Rigid PU, integral skin/ flexible molded PU	721,500	153.4	HCFC-141b
Brazil	Polsul	14	Rigid PU	536,892	55.0	HCFC-141b
Colombia	GMP	29	Rigid PU	449,130	56.6	HCFC-141b
India	Polymermann	80	Rigid PU	1,403,921	290.0	HCFC-141b
India	Shevathene Linopack	28	Rigid PU	699,139	105.7	HCFC-141b
Mexico	Comsisa	20	Rigid PU, integral skin	424,055	68.7	HCFC-141b
Mexico	Orca	11	Integral skin shoe sole	1,321,500	190.0	Hexane
Mexico	Productos Eiffel	10	Rigid PU spray foam	345,000	100.0	Water/CO2
Mexico	Pumex	19	Rigid PU spray foam	519,750	167.7	HCFC-141b
Mexico	Valcom	5	Rigid PU spray foam	122,440	44.3	HCFC-141b
Total		291		7,179,727	1,311.7	

37. In collaboration with implementing agencies' experts, systems houses not only provided suitable foam systems to their customers but also they undertook technology transfer and training of the downstream foam enterprises as technology partners.

38. The infrastructure already put in place at some system houses should be utilized, built upon and expanded to enable systems houses in Article 5 countries both indigenous and transnational to continue to facilitate the next stage of ODS phase-out. Through the development and optimization of formulations suited to their local markets and possibly neighboring countries where low levels of HCFC consumption would not make a systems house operation feasible, system houses could contribute to the sustainability of the HCFC phase-out. This includes the critical issue of the development and application of hydrocarbon-based premixed polyols that could accelerate the move away from HFCs in Article 5 countries.

Appendix I

INCREMENTAL CAPITAL AND OPERATING COSTS CALCULATIONS

Incremental capital cost ranges for conversion of panels, pipe in pipe foam, thermoware* domestic refrigerators (US $)

Equipment item	**HFC-245fa**		**Water/CO2**		**Pentane**	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Production						
Replacement of low pressure with high pressure dispenser (60 kg/min-100 kg/min)	80,000	120,000	80,000	120,000	90,000	170,000
Retrofit of high pressure dispenser	-	15,000	-	15,000	60,000	100,000
Additional mixing head	15,000	30,000	15,000	30,000	20,000	40,000
Retrofit of pre-mixing unit (where eligible)	-	10,000	-	10,000		
Replacement of pre-mixing unit	20,000	65,000	20,000	65,000	55,000	85,000
Modification of press					15,000	25,000
Hydrocarbon tank and accessories (piping and pumps, ventilation)					30,000	55,000
Buffer tank for polyol					10,000	15,000
Nitrogen supply system					10,000	40,000
Plant safety						
Ventilation and exhaust system (fans, piping, ductworks, grounding, electrical boards/connections)					15,000	85,000
Heating, ventilation and enclosure for cabinet plant (domestic refrigeration)					40,000	50,000
Heating, ventilation and enclosure for door plant (domestic refrigeration)					40,000	50,000
Gas sensors, alarm, monitoring system for entire plant					25,000	50,000
Fire protection/control system for the plant					-	10,000
Lightning protection and grounding					15,000	25,000
Antistatic floor					-	5,000
Safety audit/Safety inspection & certification					10,000	25,000
Stand-by electric generator					-	15,000
General works						
Civil work/plant modifications					20,000	25,000
Technology transfer/training	10,000	20,000	5,000	10,000	20,000	30,000
Trials and commissioning	10,000	15,000	10,000	20,000	10,000	20,000
Total						
Total retrofit	20,000	60,000	15,000	55,000	375,000	710,000
Total replacement	135,000	250,000	130,000	245,000	405,000	780,000

The use of hydrocarbon-based blowing agent might be limited in this application.

Incremental capital cost ranges for conversion of spray foams and discontinuous block foam (US $)

Equipment item	Min.	Max.	Min.	Max.
	Low-output dispenser		**High-output dispenser**	
Production: Spray foam (*)				
Replacement of low pressure with high pressure spray foam dispenser (7 kg/min) (with standard accessories)	15,000	20,000		
Replacement of low pressure with high pressure spray foam dispenser (12-15 kg/min) (with standard accessories) (***)			25,000	40,000
Retrofit of high pressure spray foam dispenser	-	15,000	-	15,000
Replacement of pre-mixing unit (where eligible)	20,000	40,000	20,000	40,000
Retrofit of pre-mixing unit (where available)	-	10,000	-	10,000
DISCONTINUOUS BLOCKS (**)	**Dispenser option**		**Boxfoam option**	
Production: Discontinuous blocks (**)				
Replacement of box foam (handmix) with large output low pressure dispenser	50,000	70,000		
Replacement of box foam with semi-automatic boxfoam unit			50,000	65,000
Retrofit of low pressure dispenser	-	15,000	-	-
Retrofit of semi-automatic boxfoam unit			-	10,000
Replacement of pre-mixing unit (where eligible)	20,000	40,000		
Retrofit of pre-mixing unit (where available)	-	10,000	-	-
General works				
Technology transfer and training	5,000	10,000	5,000	10,000
Trials and commissioning	10,000	20,000	10,000	20,000
Total				
Total retrofit spray foam	15,000	55,000	15,000	55,000
Total replacement spray foam	50,000	110,000	60,000	110,000
Total retrofit discontinuous blocks foam	15,000	55,000	5,000	40,000
Total replacement discontinuous blocks foam	85,000	140,000	65,000	95,000

* Hydrocarbon technology not included.
** Hydrocarbon technology not included as availability in this segment is uncertain.
*** For SMEs having spray foam and pour-in-place operations.

Incremental capital cost ranges for integral skin foams (US $)

Equipment item	**HFC-245fa**		**Water/CO2**		**Pentane**	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Production						
Retrofit of dispenser for refrigerated thermal control	10,000	15,000	10,000	15,000		
Retrofit of dispenser for variable ratio control	10,000	15,000	10,000	15,000		
Penta-foam dispenser					90,000	120,000
Premixer with polyol and buffer tank					65,000	85,000
Pentane tank (500-1,000 l) with auxiliaries					25,000	35,000
In mold coating high-volume low-pressure spray system			10,000	15,000		
Mold preheating oven	5,000	10,000	5,000	10,000		
Infrared coating drying system			10,000	15,000		
In mold coating exhaust booth			10,000	15,000		
Plant safety						
Process ventilation					20,000	30,000
Electrical grounding					5,000	10,000
Pentane monitoring/alarm system					20,000	40,000
General works						
Technology transfer/training (foam)	5,000	10,000	5,000	10,000	10,000	30,000
Technology transfer, training (coating)			5,000	10,000		
Trials and commissioning	10,000	20,000	10,000	20,000	5,000	10,000
Safety audits					10,000	20,000
Miscellaneous local works					15,000	25,000
Total						
Retrofit	40,000	70,000	75,000	125,000	265,000	405,000

Incremental operating costs: Rigid polyurethane foam (US $)

Chemical	**Prices US $/kg**		**Ratio (*)**	**Consumption (metric tonnes)**		
	High	**Low**		**Plant 1**	**Plant 2**	**Plant 3**
HCFC-141b	1.40	3.50	1.00	5.00	25.00	75.00
HFC-245fa(**)	10.40	12.00	0.50	2.50	12.50	37.50
HFC-245fa (**)	10.40	12.00	0.75	3.75	18.75	56.25
Methyl formate	2.20	3.20	0.50	2.50	12.50	37.50
Water-based systems	1.50	3.50	1.50	7.50	37.50	112.50
Pentane	0.50	2.50	0.50	2.50	12.50	37.50
Cyclopentane	0.80	3.30	0.50	2.50	12.50	37.50
MDI (pentane)	1.50	3.50	1.10	5.50	27.50	82.50

(*) Ratio between HCFC-141b and the alternative blowing agent
(**) The lower and higher prices represent bulk price and small package price allowing for 15% difference.

Description	**Plant capacity: 5 tonnes**		**Plant capacity: 25 tonnes**		**Plant capacity: 75 tonnes**	
Before conversion						
HCFC-141b	7,000	17,500	35,000	87,500	105,000	262,500
After conversion						
HFC-245fa (50%)	26,000	30,000	130,000	150,000	390,000	450,000
HFC-245fa (75%)	39,000	45,000	195,000	225,000	585,000	675,000
Water-based system	11,250	26,250	56,250	131,250	168,750	393,750
Methyl formate	5,500	8,000	27,500	40,000	82,500	120,000
Pentane	9,500	25,500	47,500	127,500	142,500	382,500
Cyclopentane	10,250	27,500	51,250	137,500	153,750	412,500
One year IOC						
HFC-245fa (50%)	19,000	12,500	95,000	62,500	285,000	187,500
HFC-245fa (75%)	32,000	27,500	160,000	137,500	480,000	412,500
Water-based system	4,250	8,750	21,250	43,750	63,750	131,250
Methyl formate	(1,500)	(9,500)	(7,500)	(47,500)	(22,500)	(142,500)
Pentane	2,500	8,000	12,500	40,000	37,500	120,000
Cyclopentane	3,250	10,000	16,250	50,000	48,750	150,000
Two year IOC						
HFC-245fa (50%)	33,060	21,750	165,300	108,750	495,900	326,250
HFC-245fa (75%)	55,680	47,850	278,400	239,250	835,200	717,750
Water-based system	7,395	15,225	36,975	76,125	110,925	228,375
Methyl formate	(2,610)	(16,530)	(13,050)	(82,650)	(39,150)	(247,950)
Pentane	4,350	13,920	21,750	69,600	65,250	208,800
Cyclopentane	5,655	17,400	28,275	87,000	84,825	261,000

Notes
1. For pentane projects to the incremental operating costs should be added the following costs:
   (a) Incremental maintenance of 5% of net incremental investment
   (b) Incremental insurance of 0.5% of net incremental investment
   (c) Extra power of 5 kW/dispenser, 10 kW for premixer, 10 kW for ventilation for 2,000 hr/year at 0.10/kW
2. The prices of HFC-245fa and methyl formate are global prices as provided by manufacturers

Incremental operating costs: Integral skin foam (US $)

Chemical	Prices US $/kg		Ratio (*)	Consumption (metric tonnes)	
	High	Low		Plant 1	Plant 2
HCFC-141b	1.40	3.50	1.00	10.00	30.00
HFC-245fa(**)	10.40	12.00	0.50	5.00	15.00
HFC-245fa (**)	10.40	12.00	0.75	7.50	22.50
Methyl formate	2.20	3.20	0.50	5.00	15.00
Water-based systems	1.50	3.50	1.50	15.00	45.00
Pentane/Isopentane	0.50	2.50	0.75	7.50	22.50
In-mold coating	1.20	2.10			

(*) Ratio between HCFC-141b and the alternative blowing agent
(**) For water-based systems.

Description	Plant capacity: 10 tonnes		Plant capacity: 30 tonnes	
Before conversion				
HCFC-141b	14,000	35,000	42,000	105,000
After conversion				
HFC-245fa (50%)	52,000	60,000	156,000	180,000
HFC-245fa (75%)	78,000	90,000	234,000	270,000
Water-based system	49,500	162,750	148,500	488,250
Methyl formate	11,000	16,000	33,000	48,000
Pentane	21,139	42,684	28,639	80,184
One year IOC				
HFC-245fa (50%)	38,000	25,000	114,000	75,000
HFC-245fa (75%)	64,000	55,000	192,000	165,000
Water-based system	35,500	127,750	106,500	383,250
Methyl formate	(3,000)	(19,000)	(9,000)	(57,000)
Pentane	7,139	7,684	(13,361)	(24,816)
Two year IOC				
HFC-245fa (50%)	66,120	43,500	198,360	130,500
HFC-245fa (75%)	111,360	95,700	334,080	287,100
Water-based system	61,770	222,285	185,310	666,855
Methyl formate	(5,220)	(33,060)	(15,660)	(99,180)
Pentane	12,421	13,370	(23,249)	(43,180)

Notes;

1. For pentane conversion projects to the IOC should be added the following operating costs:
   Incremental maintenance & insurance (minimum) = 5.5% of 85% of $265,000
   Incremental maintenance & insurance (maximum) = 5.5% of 85% of $405,000
   Incremental energy @ 25kW for 2000hrs/year (US $0.1/kWh)
2. For water-based systems the cost of in-mold coating is 1.2 to 2.1 times the cost of MDI, depending on whether in-mold coating is used before and after conversion or only after conversion with water-blowing. Price of in-mold coating taken as US $10.0/kg.