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REVISED ANALYSIS OF RELEVANT COST CONSIDERATIONS SURROUNDING THE FINANCING OF HCFC PHASE-OUT (DECISIONS 53/37(I) AND 54/40)

EXECUTIVE SUMMARY

Overview of HCFCs and HCFC funding issues

1. As of April 2008, the Multilateral Fund has approved projects and activities, which when fully implemented are expected to phase-out some 250,000 ODP tonnes of consumption of ODSs. While, in comparison to this, the 25,765 ODP tonnes of Article 5 HCFC consumption appears modest, this ODP consumption translates into almost 363,400 metric tonnes, making the HCFC phase-out to be addressed seem larger than that achieved by the Fund to date.

2. Currently, three chemicals, 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 used mainly in the manufacturing of foam products and refrigeration equipment and in the refrigeration servicing sub-sector. The remaining consumption of HCFCs is used in specialized applications in the aerosol, fire extinguisher and solvent sectors. While there is not yet sufficient data to ascertain precise numbers, it is clear that about 90 countries consume only HCFC 22 for servicing existing refrigeration and air conditioning equipment, while 50 or so Article 5 countries have, in addition, enterprises that use HCFCs in manufacturing. Therefore, the refrigeration servicing sector will play an important role in complying with the 2013 freeze and 2015 reduction, particularly in those 90 or more countries without HCFC-based manufacturing enterprises. Given the experience of the Fund to date, it is likely that those countries that use HCFCs solely for servicing will be able to effectuate a phase-out through the use of an HPMP and related activities such as technician training, recovery and recycling, and conversion incentive programmes, while those countries which use HCFCs in the manufacturing sector will have to augment HPMP activities with sectoral or national investment components.

Existing policies for phasing out HCFCs

3. In line with decision 53/37(i), viable substitute technologies for phasing out HCFCs have been identified in the foam and refrigeration sectors, and their corresponding indicative ranges of costs have been estimated. Specifically, the incremental capital cost (ICC) of converting manufacturing firms to alternatives, and the incremental operational costs (IOC) associated with funding the new alternative have been estimated. That said, the cost ranges currently available do not at this stage provide a basis for recommending project conversion templates or establishing funding thresholds for certain types of conversions, but rather demonstrate the relative levels of capital costs and operational costs associated with conversions so as to better inform the on-going discussion of the Executive Committee. On the basis of this understanding, the Fund Secretariat believes there is an adequate basis for the preparation, review, consideration and approval of initial stand-alone HCFC conversion projects in line with decision 54/39 (d)[1]. However, in regard to sectoral or national HCFC phase-out plans, the Secretariat is not confident that it has the ability to provide informed recommendations to the Executive Committee on the appropriate cost of such plans. Instead, the Secretariat believes that it may be necessary to first develop a cost framework for HCFC phase-out projects on the basis of experience gained

[1] For countries that chose to implement investment projects in advance of completion of the HPMP: (i) the approval of each project should result in a phase-out of HCFCs to count against the consumption identified in the HPMP and no such projects could be approved after 2010 unless they were part of the HPMP; and (ii) if the individual project approach was used, the submission of the first project should provide an indication of how the demonstration projects related to the HPMP and an indication of when the HPMP would be submitted.

through review of a limited number of stand-alone HCFC conversion projects as well as HCFC phase-out management plan (HPMPs) to be prepared by Article 5 countries[2].

4. As noted above, funding of Multilateral Fund projects has been based on the assessment of eligible ICC and IOC. The ICC has been determined on the basis of the cost of equipment necessary to effectuate the conversion. In contrast, the IOC, which, in concept, has paid for the difference between the cost of the use of, for example, CFCs and the HFCs that have replaced them, has been paid for a duration determined by the Executive Committee. That duration has varied between sectors, and has ranged between 0 to 4 years. In some cases, such as in the aerosol sector, where the cost of the alternative is lower than that of the chemical it is replacing, the lower IOC has resulted in a reduction of the funds available to cover the capital cost of the conversion, making conversions more difficult. As it relates to HCFCs, at the present time and with the current stage of commercialisation of new technologies in Article 5 countries, there is a high degree of uncertainty regarding the precise quantification of the cost parameters that comprise IOC in HCFC phase-out projects. However, if the current policies and criteria for funding ODS phase-out remain unchanged, the IOC in HCFC phase-out projects could, depending on the alternative selected take a larger share of total project costs than was typical for similar CFC phase-out projects. The IOC, which are paid in cash, have provided an incentive to firms to undertake early conversion during the CFC phase-out. However, and given the higher cost of alternatives such as HFC-245fa, and the lower cost of zero global warming potential (GWP[3]) alternatives such as hydrocarbons, it appears that the current IOC system could result in a perverse incentive for firms to request conversion to higher priced but higher GWP alternatives, a result that would not appear consistent with the spirit or terms of decision XIX/6 of the Meeting of the Parties. Accordingly, this issue is ripe for in depth consideration by the Executive Committee, and it might be appropriate for some initial stand alone projects to be submitted with the relevant information needed to assess the IOC, which would enable the Committee to consider the issue on the basis of more accurate data.

5. Pending determination of the eligibility of funding for replacement of HCFC-based equipment that had been installed with assistance from the Multilateral Fund (second conversions) it would not be possible for stand alone projects for HCFC phase-out in enterprises that employed such equipment to be submitted. Resolution by the Executive Committee by its 57th Meeting in early 2009 of issues concerning second conversions and installation cut-off date for equipment to be funded for replacing HCFCs would be essential to permit consideration of stand-alone conversion projects to proceed without significant delay.

Foam sector technologies and costs

6. As noted above, approximately 50 Article 5 countries use HCFCs for manufacturing. In that context, the largest use area is the use of HCFC-141b in the production of foams. Luckily, there are a wide variety of alternatives available to replace the use of HCFCs in the foam sector. In this sector, water-based chemicals and hydrocarbon blowing agents have already been proven and are widely applied in Article 5 countries as non-HCFC alternatives to CFCs and will

[2] Funding for the preparation of HPMPs in more than 115 Article 5 countries has been submitted for consideration by the Executive Committee at its 55th Meeting.

[3] 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.

continue to be also applied as alternatives to the use of HCFC-141b. The safety requirements associated with hydrocarbons provide operational challenges for very small enterprises; however similar challenges have been overcome for hydrocarbon technology in the aerosol sector. Newer HFC-based technologies are also available and in regular use in non-Article 5 countries. These, however, are yet to be introduced commercially in Article 5 countries. The HFC options have a higher GWP than the HCFCs they replace. Another option, methyl formate technology, has a low GWP, and may meet the needs of Article 5 country enterprises in the production of integral skin foam sub-sector and in some applications in the rigid foam sub-sector, and at lower costs. However, methyl formate cannot yet be considered a mature technology for some applications. The alternatives just described represent all the technology choices that will be available to Article 5 Parties to address the 2013 and 2015 control targets.

7. The document provides a preliminary estimate of the ICC and IOC of conversion from the use of HCFCs in foam enterprises. The magnitude of ICC in the foam sector will be dependent mainly on the choice of technology. On the positive side, ICC will be modest for enterprises that installed new equipment to convert from CFC-11 to HCFC-141b, either on their own or with Multilateral Fund resources. Similarly, water-based technology can, in general, be implemented using HCFC-based process equipment. Related costs needed by these enterprises to effectuate the conversion from HCFCs would mainly consist of technical assistance for training and the trial of new chemical formulations. It is thought that related costs would need to be set at a higher level of funding than in the transition from CFCs to HCFCs. Costs related to conversion of HCFC–based enterprises to hydrocarbon technology relate to the provision of new processing and safety equipment at a similar cost to the equipment supplied for the hydrocarbon technologies used for CFC phase-out. However, as in the CFC phase-out, the capability of small enterprises to absorb the hydrocarbon-based technology is likely to be limited.

8. Although the ICC for conversion in the foam sector appear modest, the IOC will be significant, in particular, for HFC-based solutions, mainly due to the higher cost of the replacement chemicals. If IOC were paid for similar transitional periods to those that had been used in the foam sector for conversion from CFCs, the total funding level for future projects using HFC technologies would be dominated by these costs, that is, the cost paid for operational cost would be much higher than the capital cost of converting the firm to enable the use of HFCs. For hydrocarbon technology, while the precise levels of IOC cannot be fully quantified prior to the review and evaluation of actual projects, the application of current rules and policies would be expected to yield some savings. However, information from one Article 5 country indicates that in some production circumstances, conversions to HCs could be associated with some operational costs.

9. While the above discussion has focused on a more project specific view, experience with CFC phase-out in the foam sector has demonstrated the important role played by the chemicals suppliers and systems houses[4] in tailoring the chemical systems[5] used to manufacture foam to meet the needs of local markets and conditions (climatic and otherwise). These intermediaries, which are well known to many foam manufacturers, are capable of formulating foams systems to

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[4] Systems houses are chemical companies that are engaged in the business of bulk pre-blending of foam systems for distribution and sale to foam manufacturers. The pre-blending obviates the need for investment in expensive in-house premixing stations and bulk purchase of several chemical components that are blended in the system.

[5] Foam chemical systems are mixtures of chemical ingredients specially formulated and blended to meet specific foam processing conditions and product quality.

meet the specific needs of end users. In that light, it is believed that commercialisation and penetration in Article 5 countries of both HFC and low-GWP technologies (i.e., hydrocarbons, methyl formate), would be assisted through the forward funding and implementation of projects that target the optimization and validation for Article 5 conditions of foam chemical systems to minimise production costs. Such projects would be directed towards supporting the work of systems houses to facilitate the supply of new, non-HCFC chemical systems to foam producing enterprises.

Refrigeration sector technologies and costs

10. Use of HCFCs in the refrigeration sector is dominated by the use of HCFC 22. In the refrigeration sector the situation regarding replacement of HCFC-22 used in manufacturing has some similarities to the foam sector. Both HFC and hydrocarbon replacements are available to Article 5 countries. While in broad terms each technology has already been used in Multilateral Fund projects, the specific applications and sub-sectors differed significantly.

11. In this context, the possible adoption of low GWP technologies in Article 5 countries, in particular in the refrigeration and air conditioning sub-sectors, is of high priority. The Executive Committee might wish to consider whether to call for some demonstration projects in this sector. This would aim at demonstrating the specific steps and evaluating specific costs associated with the conversion to low GWP technologies.

12. Most HFC alternatives currently available for use in the refrigeration sector have a higher direct GWP than the HCFCs they would replace. On the other hand, the use of low GWP substances, in particular hydrocarbons, involves safety issues. Safety can be readily addressed but results in incremental capital costs similar to those arising in the foam sector, with the added challenge of ensuring safety in servicing activities. HFC and HC technologies represent all the technology choices that are likely to be available to enable Article 5 Parties to address the 2013 and 2015 control targets. It remains unclear if, when, and for what applications low GWP refrigerants with no flammability and low toxicity will become available at a later time. The document provides a preliminary estimate for incremental capital costs and incremental operational costs for the conversion of enterprises using HCFCs in refrigeration manufacturing.

13. With regard to the refrigeration servicing sub-sector, noting the limited information currently available about HCFC use in many Article 5 countries, preliminary estimates of phase-out costs to meet the 2013 and 2015 control measures have been based on Multilateral Fund experience with the range of individual activities funded to achieve CFC phase-out in refrigeration servicing.

14. It is likely that HCFC-22 is used by the service sector of essentially every Article 5 country and that a large number of Article 5 countries will have HCFC consumption almost exclusively in the service sector. In contrast to the situation for CFC phase-out, when in many countries at least some manufacturing 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 the majority of Article 5 countries. 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 provision of funding for training in good practices and the provision of tools and equipment. 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.

15. In examining the servicing sector the Secretariat notes that the current and future demand for HCFC-22 for servicing is proportional to the size of the installed base of HCFC-22 air-conditioning equipment in the consuming country. The amount of installed equipment is being constantly enlarged through imports of HCFC-22-based refrigeration equipment. Accordingly, in order to expedite the achievement of future reductions of consumption in the refrigeration servicing sector of Article 5 countries, and to provide a stronger incentive for air conditioner manufacturers to convert from the use of HCFCs, the possibility of introducing early national control schedules on imports of HCFC-22 equipment might be considered. This might influence the demand for Multilateral Fund conversions of HCFC-22 air conditioner manufacturing facilities.

Environmental issues

16. Consistent with decision XIX/6, the Secretariat has examined options on how the Executive Committee could give priority to cost-effective projects and programmes for HCFC phase-out, which minimise other impacts on the environment, particularly with respect to climate, including both GWP and energy use. As a starting point, the Secretariat has explored three basic methodologies, namely, a methodology based solely on GWP; a methodology based in Life Cycle Climate Performance (LCCP) and a methodology based on a 'functional unit' approach to life cycle evaluation.

17. In its initial review, the Secretariat did not consider that a methodology based solely on GWP would wholly address the mandate of decision XIX/6, since it would be unable to account for 'energy use' as required within the decision. The development of a formal LCCP is data-intensive and requires the input of a substantial number of variables, not all of which might be known, either to the enterprise or a country, at the time of the funding application. With the GWP and LCCP approaches representing the two extremes of the spectrum, the Secretariat has been assessing intermediate options which might overcome the disadvantages of each. This has resulted in the initial evaluation of a 'functional unit'[6] approach which offers the robustness of a simplified and less data-intensive methodology, while ensuring that the key criteria outlined in decision XIX/6 can be taken into account. The primary output of this methodology would be a comparative assessment of lifecycle climate impacts taking into consideration the GWP of the substitute, the amount of substance used, the energy consumed in operation, and the emission functions through the life-cycle.

18. This approach needs further development and evaluation across a wider range of sectors to provide assurance that the basic methodology can be applied more widely. With this in mind, the Secretariat is seeking the views of the Executive Committee as to whether it wishes the Secretariat to continue further developing this methodology in order to report in a more detailed fashion at a subsequent Executive Committee meeting.

[6] The 'functional unit' approach focuses on a typical use of the substance in a sector, called 'element', in order to characterise the impacts related to that 'element' throughout its lifecycle. The purpose is not to calculate the precise climate impact for each and every application, but to characterise these impacts so they can be used for comparing technologies.

Co-financing

19. The Multilateral Fund experience to date, principally in the chiller sector, suggests that significant time is needed to prepare, approve and implement projects co-funded by different entities. Given the time based reduction commitments of the Montreal Protocol, it is difficult for countries to risk having their projects delayed for the uncertain prospect of co- funding. Accordingly, if the slow rate of support by other funding entities were to continue, it would call into question the possibility of using other institutions to support Multilateral Fund activities. In order to reduce this obstacle, it would be possible for the Fund Secretariat to approach other institutions to see if clear methodologies and more streamlined mechanisms can be developed to enable the other institutions to top up Multilateral Fund ozone funding in order to achieve additional climate benefits. Exchange with other institutions could commence once discussion in the Executive Committee has progressed regarding certain issues raised in this document, in particular relating to cut-off date, second conversion and how to minimise other impacts on the environment.

20. In any event, through the preparation of HPMPs, countries and bilateral and implementing agencies have been encouraged to explore potential financial incentives and opportunities for additional resources to maximize the environmental benefits pursuant to paragraph 11(b) of decision XIX/6. Accordingly, the objectives of co-financing and a preliminary framework for such projects as might be applied to HCFC projects that could facilitate cooperation with possible co-financing entities, could be considered at a future meeting. It would be important for a preliminary framework to encompass guidance for projects where the additional benefits created through support by the Fund might, either now or in the future have a certain value, for example 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.[7]

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)).[8]

4. The Secretariat introduced the paper requested under decision 53/37(i) to the Executive Committee at its 54th Meeting. In the ensuing discussion, several issues were raised by the Committee, inter alia, the need to act immediately on HCFC phase-out, and to ensure that it would result in benefits in accordance with paragraph 11(b) of decision XIX/6; the calculation of IOC as a major component of the overall cost of phase-out projects; the cut-off date for newly established manufacturing enterprises; and the eligibility of second conversions. Mention was also made of the need to minimize the environmental impact of HCFC phase-out activities and to consider using other environmental indicators in addition to ODP, to take account of the cost implications of phase-out for LVC countries, and to ensure that HCFC phase out was integrated as much as possible with CFC phase-out. Several views were expressed in regard to co-financing issues, namely, that seeking co-financing possibilities probably should be an option; the need to gather information concerning sources of funding that were additional to the Global Environment Facility (GEF), whose timelines were considered by some to be too long; that co-financing should bring additionality, and that the main source of funding should remain the Fund itself.

5. After hearing a statement from the facilitator of the contact group that was established by the Executive Committee to consider the guidelines for the preparation of HPMPs and relevant cost considerations surrounding the financing of HCFC phase-out, the Committee decided to

[7] UNEP/OzL.Pro/ExCom/53/60.
[8] 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.

consider at its 55th Meeting a revised version of document UNEP/OzL.Pro/ExCom/54/54 which would take into account any comments that Members had submitted to the Fund Secretariat by the end of April 2008 (decision 54/40).

I.2 Scope of the paper

6. Decision 53/37(i) provides that the existing policies and guidelines of the Multilateral Fund would be applicable to the funding of HCFC phase-out unless otherwise decided. Accordingly, the following underlying principles were used for the analysis:

(a) Assumptions in this paper regarding the extension of existing policies are without prejudice to any future policy discussion of the Executive Committee on funding guidelines;

(b) Analysis of eligibility issues, such as the question of whether to fund a second conversion (i.e., replacement of HCFC-based equipment that had been installed with assistance from the Multilateral Fund) or funding of manufacturing capacity established after a certain cut-off date, is not considered part of the mandate of this paper. Based on decision at the 54th Meeting (decision 54/5 (iii)) funding for preparation of HCFC phase-out projects could not be considered for approval until the 56th Meeting and the consequent projects are unlikely to be submitted in advance of the 58th Meeting. Resolution of the policy for establishing a cut-off date for equipment installation by the 57th Meeting in early 2009, should the Executive Committee wish to do so, would permit stand-alone phase-out projects to be considered with little if any delay; and

(c) Preparation of this paper has been undertaken without prejudice to 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 and without prejudice to the preparation of that study.

7. The paper covers the following main content:

(a) A summary of policies for funding HCFC phase-out, 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. The cost analysis benefited from the experience gained in the Multilateral Fund after reviewing over 1,000 investment projects for phasing out CFCs used as blowing agents. Representative samples of projects were selected from the Secretariat’s inventory of approved projects database[9] for review with a view to identifying the nature, the extent of application and the main characteristics of various alternative technologies to CFC-11 and their applicability to conversions from HCFCs to a final technology. The ICC and IOC of the selected samples of projects were also reviewed against the background of information provided in project completion reports since some of them could be also applied to the phase-out of HCFCs[10]. The prices of equipment and chemicals were examined to determine whether significant differences existed between those at the time of project approval and at the time the project completion report was submitted three to four years later. Price and other relevant project information was extracted from project completion reports submitted between late 1998 and mid 2006. Prices of chemicals were compared with those provided by a selected number of Ozone Units in their progress reports on the implementation of the country programmes as well as by manufacturers of alternative blowing agents. The information obtained from the analysis was used as a starting point for estimating the possible incremental costs for phasing out HCFCs. In order to provide the necessary background information, including prices of conversion technologies which are currently mature in non-Article 5 countries, published information was reviewed and experts with knowledge of these technologies were consulted. The total information obtained provided the basis for estimating indicative incremental capital and operating cost ranges;

(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. The cost analysis could not be based on existing experience to the same degree as in the foam sector. While Multilateral Fund experience in conversion of mass production of refrigeration equipment is available, HCFC-based equipment is manufactured for different market segments, and has different sizes and is produced in different quantities than previous projects. In addition, there is no experience with most of the non-ODS refrigerants, which are likely alternatives to HCFC-22. Since existing experience relating to project cost could not be translated directly, the Secretariat used information in the HCFC studies already presented, in particular that on HCFCs in China. The experience in project assessment was transferred to the new sectors, input collected from experts and production equipment manufacturers, and used the approach of defining model companies to define the related conversion cost. A different analysis is presented for the service sub-sector, which is based on the extensive Multilateral Fund experience that started in 1991. Special consideration has been given to refrigerant management plans (RMPs) approved under decision 31/48 and to terminal phase-out management plans (TPMPs) approved under decision 45/54;

(d) Environmental issues, in particular the necessary steps to operationalize

[9] The inventory of approved projects is the Secretariat's main database on projects funded under the Multilateral Fund, providing records of all projects approved by the Executive Committee, including, among many others, the conditions of approval, conversion technology, incremental capital and operating costs, completion date.

[10] Project completion reports submitted by implementing agencies provide records of implementation of all approved projects, including information on actual expenditure of the approved incremental capital costs and actual prices of the blowing agents used before and after conversion of the projects, actual technology used, and lessons learned from the use of the technology.

decision XIX/6 in the Multilateral Fund context, supported by Annex V;

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

(f) Recommendations.

8. In preparing this paper, consideration was given to the input received from Executive Committee Members as requested by decisions 53/37(l) and 54/40. In regard to decision 54/40, comments were received from the Governments of China, the Dominican Republic, Germany and Lebanon and from UNDP. A number of the comments relate to detailed incremental cost issues. These will be relevant to the consideration of stand alone projects in due course, in particular during the Secretariat's project review process. Comments also relate to policy issues such as the treatment of IOC for HCFC conversion projects, resolution of which has not been specifically proposed in this paper. Other comments have been taken into account in the preparation of the paper as appropriate. The comments are reproduced in full in Annex VI to the present paper.

I.3 Policies 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.[11] 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. In the principal sectors of foam and refrigeration, policies have been tailored to projects for CFC phase-out. Projects for the phase out of HCFCs have similarities, but some important differences that require reconsideration and possible amendment of existing rules.

10. Funding of Multilateral Fund projects has been based on the assessment of eligible ICC and IOC. ICC 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. 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).[12]

11. As the number of phase-out projects increased, capital costs became well known and generally decreased over time. The input data for calculation of IOC always contained uncertainties that frequently did not lend themselves to prior verification. However the very large number of projects reviewed in the principal sectors enabled the emergence of broad norms with

[11] Appendix 1 of decision II/8 (Financial Mechanism).
[12] The duration of IOC 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.

which requested IOC could be compared. Costs for sector and national phase-out plans were subsequently reviewed with the benefit of this experience.

12. At the present time and with the current stage of commercialisation of new technologies in Article 5 countries, there is a high degree of uncertainty regarding the precise quantification of the cost parameters that comprise IOC in HCFC phase-out projects. For example the quantities and proportions of chemicals in new foam formulations and the prices and availability of these in Article 5 countries, particularly HFCs. However, if the current policies and criteria for funding ODS phase-out remain unchanged, IOC in HCFC phase-out projects in both the foam and refrigeration sectors would take a larger share of total project costs than was typical for similar CFC phase-out projects. IOC, being the only support actually paid in cash, have provided an incentive to enterprises during the CFC phase-out. However the maximum financial incentive is obtained by selecting the least economically sustainable technology option, that is, the option with the highest IOC. The analysis undertaken in this document attempts to show the implications of these cost components on Multilateral Fund funding obligations. However, it would be difficult to provide appropriate technical guidance to the Executive Committee on the costs of sectoral or national phase-out plans related to the conversion of manufacturing capacity without project-by-project cost assessment experience.

13. Special funding options have been agreed by the Executive Committee for funding projects from low-volume consuming (LVC)[13] countries with manufacturing facilities by establishing a special funding window for investment projects where the cost-effectiveness threshold values[14] would not apply. However, for the phase-out of HCFCs, Article 5 countries have been categorized in two groups, namely countries with HCFC consumption in the refrigeration servicing sector and countries with HCFC consumption in both the manufacturing and refrigeration servicing sectors[15]. 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.

14. As HCFCs[16] are controlled substances under the Montreal Protocol, 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 decisions 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 analysis of prospective non-HCFC alternatives. Furthermore, it had to be made clear that the enterprises concerned had agreed to

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[13] 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.

[14] 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.

[15] The guidelines for the elaboration HPMP as agreed by the Executive Committee at its 54th Meeting are based on this classification of Article 5 countries.

[16] 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.

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.

15. 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). Pending determination of the eligibility of funding second conversion projects, it would not be possible for stand alone projects for HCFC phase-out in enterprises that had received Multilateral Fund funding for conversion to HCFCs to be submitted. However with a minimum of 65 percent of current HCFC consumption in the foam sector estimated to be associated with enterprises that have not so far been supported by the Multilateral Fund, there is scope for stand-alone projects to be prepared and submitted prior to reconsideration of policies related to second conversions.

16. Subsequently, at its 54th Meeting, the Committee adopted guidelines for countries to develop a staged approach to the implementation of their HPMP through developing over-arching plans to achieve total phase-out of HCFCs. Depending on the availability of resources, countries should employ these guidelines to develop, in detail, stage one of the HPMPs, which would address how countries would meet the freeze in 2013 and the 10 per cent reduction in 2015, with an estimate of related cost considerations. Accordingly, countries with HCFC use only for servicing refrigeration systems would be required to develop an HPMP with activities similar to those being required for RMPs and TPMPs, while countries with HCFC-based manufacturing enterprises would develop activities in the context of national or sector performance- based plans. The guidelines also allow countries that choose to implement investment projects in advance of completion of the HPMP to do so, provided that the approval of each project results in a phase-out of HCFCs that counts against the consumption identified in the HPMP as a starting point for aggregate reductions, and that no such projects could be approved after 2010 unless they were part of the HPMP. If the individual project approach was used, the submission of the first project should provide an indication of how the demonstration projects related to the HPMP and an indication of when the HPMP would be submitted (decision 54/39)[17].

17. This discussion paper has therefore also been prepared against the background of the policies and guidelines related to HCFCs as outlined above and in Annex I of the document.

I.4 Overview of HCFC uses

18. The total consumption of HCFCs of 363,372 metric tonnes in all Article 5 countries in 2006 is more than two times the CFC consumption of 178,144 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., 25,765 ODP tonnes in total) is lower than that of CFCs (176,405 ODP tonnes) due to their lower ozone depleting potential[18].

[17] The full text of decision 54/39 is presented in Annex I to the present paper.

[18] These figures do not include consumption of ODS by the Republic of Korea, Singapore and United Arab Emirates (i.e., Article 5 countries that have not received assistance from the Multilateral Fund).

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

(a) Consumption of HCFC-141b, HCFC-142b and HCFC-22[19] represented more than 99 per cent of total HCFC consumption. Small levels of HCF-123 and HCFC-133 (0.6 per cent) have been reported in very few countries;

(b) HCFC consumption in 71 countries was below 360 metric tonnes. Twenty nine other countries[20] either reported zero consumption or did not report any consumption;

(c) HCFC-141b was used in 40 Article 5 countries[21], 20 of which had a consumption below 10 ODP tonnes (91 metric tonnes), while HCFC-142b was used only in 19[22] Article 5 countries, 18 of which had a consumption below 10 ODP tonnes (154 metric tonnes);

(d) Seventy[23] of the 117 Article 5 countries that reported consumption of HCFC-22[24] had consumption below 10 ODP tonnes (182 metric tonnes); and

(e) HCFCs were 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 were also used in the aerosol (0.2 per cent), fire extinguisher (0.1 per cent) and solvent (1.0 per cent) sectors.[25]

20. These data indicate that there are 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.

21. Taking into consideration that about 99 per cent of HCFC consumption occurs in the foam and refrigeration sectors, this paper addresses only these two sectors in order to gain experience and achieve early results in reducing HCFC consumption at the national level. However in due course it will be necessary to develop a similar understanding of technology and cost structures in the remaining sectors where HCFCs are consumed.

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[19] The ODP values of HCFC-141b is 0.11, of HCFC-142b is 0.065 and of HCFC-22 is 0.055.
[20] Twenty seven of the 29 countries are currently classified as LVC countries.
[21] Excluding 1,028.7 ODP tonnes (9,352 metric tonnes) consumed by Republic of Korea, Singapore and United Arab Emirates.
[22] Excluding 126.7 ODP tonnes (1,949 metric tonnes) consumed by Republic of Korea and Singapore.
[23] Excluding 1,213.9 ODP tonnes (22,071 metric tonnes) consumed by Republic of Korea, Singapore and United Arab Emirates.
[24] An additional 16 Article 5 countries had reported HCFC-22 consumption in 2005.
[25] HCFC surveys conducted by UNDP for 12 selected Article 5 countries (UNEP/OzL.Pro/ExCom/51/Inf. 2).

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

22. 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 sheets and nets. 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[26].

23. 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

24. 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 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

25. 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.

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

(a) Based on existing policies, no additional capital costs for replacing existing equipment will be required by all the rigid polyurethane and integral skin foam

[26] 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.

enterprises that upgraded their production facilities to allow for the interim use of HCFC blowing agents with assistance from the Multilateral Fund, except where such a need is technically justified and fully demonstrated[27]. 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 or replaced their CFC-based equipment for use with HCFCs without assistance from the Multilateral Fund, since such enterprises would 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 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.

27. 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. However, recent developments in the hydrocarbon technology and equipment design would appear to make the application of the technology more cost-effective for medium scale foam producing enterprises (Appendix 2 of Annex III).

28. 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 ICC, were estimated at a higher level than for the transition from CFCs to HCFCs due to an anticipated need for more

[27] 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.

activities and higher amounts of chemicals to optimise foam formulations resulting in potentially higher cost of trials than was the case with transition to HCFC-141b.

29. 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 incremental capital cost 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 and domestic and commercial refrigeration						
Retrofit	30,000	60,000			375,000	710,000
Replacement	100,000	195,000			385,000	780,000
Pipe in pipe and thermoware (*)						
Retrofit	30,000	60,000	25,000	55,000	375,000	710,000
Replacement	100,000	195,000	95,000	180,000	385,000	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

(*) Water-based systems would have limited application in pipe in pipe while pentane would have limited applications in thermoware.
(**) 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

30. The levels of incremental operating costs 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.

31. The proportions of main chemical ingredients in foam formulations, namely the blowing agent, the polyol and the isocyanate (or MDI[28]) 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

[28] MDI: methylene di-phenyl di-isocyanate.

phase-out of CFCs, this situation could result in substantial incremental operating costs 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. The use of relative foam system prices (for HCFC and alternative blowing agent) instead of the prices of individual chemicals where enterprises use premixed systems could help to mitigate some of the discrepancies in chemical prices.

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

Chemical	**Prices US $/kg**	
	Low	**High**
HCFC-141b	2.50	3.80
MDI	3.00	3.50
Pentane	1.90	2.50
Cyclopentane	2.10	3.30
HFC-245fa	10.40	12.00
Methyl formate	2.20	3.20

32. Increase in foam density, which is a cost penalty resulting from the cost of additional foam material, has a significant impact on the IOC, representing 50 per cent or more of the total operating costs in some cases.[29] The levels of increases in foam density used in calculating incremental operating costs 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.

33. 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 mainly on the functional proportions of main chemical ingredients in the foam formulations[30], their prices[31] and, where applicable, factors that impact the level of the given IOC. The calculations were checked against approved projects to ensure consistency and accuracy.

[29] 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.

[30] The proportions are based on the functional relationships between the molecular weights of HCFC and the alternative chemical and, where available, any known mitigating factors (e.g. resulting from potential optimization).

[31] 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 as well as information provided in comments received in response to Decision 54/40. 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.

Table II.3: Summary of annual incremental operating cost ranges for various foam applications per metric kilogram of HCFC-141b phased-out (US $/kg)[32]

Blowing agent	Rigid foam		Integral skin foam	
	Low	**High**	**Low**	**High**
HFC-245fa	2.20	5.30	0.40	1.14
Methyl formate	(1.40)	(2.20)	1.00	1.66
Water-based systems	1.45	2.00	7.40	12.48
Pentane	(1.25)	(2.20)	(1.84)	(2.84)
Cyclopentane	(1.15)	(1.80)	(0.76)	(1.41)

34. To demonstrate the scope of incremental operating costs at the enterprise level, the average unit incremental costs shown in the above table was 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 incremental operating costs 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%)	19,140	23,490	95,700	117,450	287,100	352,350
HFC-245fa (75%)	45,240	46,110	226,200	230,550	678,600	691,650
Water-based system	12,615	17,400	63,075	87,000	189,225	261,000
Methyl formate	(12,180)	(19,140)	(60,900)	(95,700)	(182,700)	(287,100)
Pentane	(10,875)	(19,140)	(54,375)	(95,700)	(163,125)	(287,100)
Cyclopentane	(10,005)	(15,660)	(50,025)	(78,300)	(150,075)	(234,900)

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

(a) Significant reductions in incremental operating costs 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;

(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[33];

(c) For rigid foam applications converting to pentane-based technologies has in the past (transition from CFC-11) resulted in significant incremental operating costs, even though the blowing agent had a relatively lower price as well as a lower usage rate of about half that of the HCFC-141b it would replace. This was

[32] 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.

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

attributed to an increase in foam density, and additional maintenance, insurance and energy costs. However, the overall conversion for rigid foam applications from HCFC-141b to pentane based technologies still resulted in operating savings even after taking into consideration a 10 per cent increase in foam density and additional maintenance, insurance and energy costs, consistent with the methods of calculating the IOC of Multilateral Fund projects in this sector; 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.

36. Under continuation of current policies for calculation of incremental operating costs in this sector, IOC will be a major component of the overall cost of projects to phase out HCFCs and 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

37. 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. The cost-effectiveness thresholds in domestic and commercial refrigeration sub-sectors consists of integrated values covering ICC and IOC in both foam and refrigeration manufacturing processes at an enterprise level.

38. 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 will need to be addressed under the foam sector since there is no refrigeration component.

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

39. 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 insulation foam boardstock in the construction industry. Such HCFCs have been phased out in the majority of these countries[34].

[34] 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.

40. 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[35]. 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

41. In rigid and integral skin polyurethane foam production, most enterprises rely on chemicals 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.[36] 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).

42. 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 may need to 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.

43. 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 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.

44. 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.

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[35] 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).

[36] 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.

Systems house project to validate HCFC alternative foam systems

45. It is deemed essential for a successful Multilateral Fund financed HCFC phase-out programme that cost-effective, environmentally sound phase-out technologies that have been validated for application in Article 5 countries be available in a timely manner. Thus, the objective of the programme is to engage selected systems houses in Article 5 countries to validate new or considerably revised technologies for use in HCFC-phase-out projects. It is essential that the investigation time should match that needed to prepare the first HPMPs so that investment projects can benefit immediately from the validation exercise. Therefore the programme should start as soon as possible and include: emerging technologies that are non-ODS/low GWP as well as low cost options for conventional, non ODS/low GWP technologies.

46. Only the ICC of the participating downstream enterprises in the programme is proposed to be approved up-front as the IOC will be part of the investigations and paid during or following implementation of the programme. The cost of the project per system house is estimated to be in the range of US $145,000 and US $210,000 for work on non-flammable blowing agents and US $200,000 and US $320,000 for flammable blowing agents. The ICC range for each downstream enterprise converting to non-flammable blowing agent is estimated to be US $13,000 to US $20,000 and US 79,000 to US $165,000 for conversion to flammable blowing agent. The breakdown of the ICC is provided in Appendix II of Annex III to this document.

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

47. 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[37]. 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

48. 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

[37] 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.

applications in industry. The air conditioning sector is dominated by large industries with centralised manufacturing facilities.

49. 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 to some extent 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 infrastructure available for air conditioning servicing. These companies simplified their operations significantly by using the same refrigerant for both the service of air conditioning systems as well as for the assembly, charging and servicing of commercial refrigeration equipment.

III.2 Alternatives

50. 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, i.e. which might be relevant for Multilateral Fund projects related to the 2013 freeze or the 2015 consumption reduction step. These alternatives are essentially HFC refrigerants, hydrocarbons and ammonia. A detailed description of alternative technologies can be found in Annex IV.

51. 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 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. Most of these were actually introduced more than 12 years ago during the replacement of CFCs. Only HFC-134a has a lower GWP than HCFC-22 and is presently being used in particular for small 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.

52. Hydrocarbons and ammonia are low-GWP refrigerants, which have continuously been used for many years. Both face safety related challenges. While the necessary technology to safely handle these refrigerants is well known, these characteristics lead to a higher incremental

capital cost at the time of conversion, as well as restrictions regarding the use of the related equipment. The main issues are:

(a) Hydrocarbons, in particular iso-butane, propane and propylene are, like HCFC-22, excellent refrigerants. Their flammability requires safe handling in manufacturing and during servicing, limits the amount of hydrocarbons charged per equipment and could impose restrictions with regard to the location of production facilities (e.g. outside residential areas) and, for larger systems, the equipment installed (e.g. ventilation requirements, separation from public). Hydrocarbons have been successfully used in refrigerators, where they are a fully established and widely used technology, as well as in 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. Similar to larger hydrocarbon systems, ammonia is typically restricted in terms of the location of equipment installed.

53. 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.

54. 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. Research regarding the development of low GWP refrigerants for the MAC sector with no flammability and low toxicity are reported, but presently it is unclear if and when they will be commercialised. More importantly, their applicability for HCFC-22 using sub-sectors is unclear, since these pose specific challenges for a replacement. CO_2 has been under development as an alternative refrigerant for the last 20 years, and is presently used in demonstration trials. Its main applications are small commercial systems and, in large, centralised supermarket systems, use for low temperatures. In small systems CO_2 requires a fundamentally different design and components, and has, due to its high pressure in this particular application, very different service characteristics than other refrigerants. In addition, the energy efficiency in comparison to HCFC-22 suffers significantly at high outdoor temperatures. It remains unclear if and under what circumstances the technology will be developed sufficiently to break out of its present niche market. For large low temperature systems, the technology used is only a relatively small variation of commonly employed technology, but the number of applications in Article 5 countries where it can be used to replace HCFC-22 is likely to be very limited.

III.3 Specific challenges in the service sector

55. Air conditioning systems are used throughout the world for comfort cooling. In some countries this might be restricted to uses like hotels and hospitals, in others include offices, and

domiciles might also be included. HCFC-22 is likely to be used in virtually all air conditioning systems from very small window units to 500 kW capacity systems. Given the need for servicing of these systems, it is likely that HCFC-22 is used by the service sector in essentially every Article 5 country.

56. 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 widespread use of HCFC-22 in commercial refrigeration is further boosting service demand. The general 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.

57. Since HCFC-based manufacturing in the foam and refrigeration sectors as well as solvent use of HCFC appears to be limited to a small number of countries, it is likely that a large number of Article 5 countries will have HCFC consumption almost exclusively in the service sector. This would include 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. During CFC phase-out it became evident that it is not possible to address and monitor the service sector on an enterprise-by-enterprise basis, chiefly because of the number of enterprises involved, their small size and their often informal structure. 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.

58. The demand for HCFC-22 in the servicing sector is related to the import of HCFC-22 air conditioning equipment by Article 5 countries, which subsequently creates a demand for HCFC-22 in the service sector. 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.

59. 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.

III.4 Cost considerations

60. In order to develop an understanding of the possible costs related to HCFC phase-out in the refrigeration manufacturing 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 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.

61. The approach of using a "typical" enterprise for the determination of incremental costs for manufacturing enterprises limits the uncertainty in estimating incremental capital 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.

62. The cost calculations for different model enterprises in the refrigeration manufacturing sector lead to the results presented in Table III.1. The operating cost are shown on an annual basis. If the Executive Committee would decide e.g. on a four-year duration, the values for the incremental operating costs shown in the table would increase accordingly. The calculation demonstrates that incremental operating costs of HCFC phase-out often take a larger share of the incremental cost than was typical for CFC-phase-out projects. It should be noted that those operating costs, being the only support under the Fund actually paid in cash, provide significant incentives to enterprises to convert their production early. On the other hand, the present way of the IOC provides an incentive to select the least economically sustainable technology, i.e. the option with highest per unit cost increase. The risks of problems during implementation, or of subsequent problems or retro-conversion to HCFC-22 is particularly high in such cases.

Table III.1: Incremental capital and incremental operating cost forecast for selected project templates in the refrigeration manufacturing sector[38]

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	10,000	66,000	66,000	140,000	66,000	66,000	110,000	320,000,	320,000	230,000
Stand-alone units: vending machines	10,000							500,000	800,000	150,000
Condensing units	5,000	55,000	60,000	390,000	55,000	60,000	310,000			

63. The Secretariat has also attempted a preliminary estimate on the incremental costs for the service sector. The exact nature and volume of interventions in the service sector remains to be discussed, *inter alia* on the basis of the experience with RMPs and TPMPs. It 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. The cost estimate assumes that it is necessary to provide additional funding for reviewing ODS legislation, as well as training programmes at a level of funding estimated according to the level of HCFCs consumption in the year 2006. The costs until 2015 were estimated to be between US $110,000 for the lowest consuming and US $13,940,000 for the highest consuming countries. The details of this estimate are presented in Annex IV.

IV. ENVIRONMENTAL ISSUES

IV.1 Decisions leading to the prioritisation of environmental issues

64. 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." It also provides direction to the Executive Committee that when developing criteria for the selection of projects and programmes to be funded it "gives priority to cost-effective projects and programmes which focus on *inter alia*, 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"

65. The nature of the term 'gives priority' could allow for a number of interpretations, including priority in timing, in absolute technology selection or in funding provision. Priority in terms of timing could be taken as a 'given' assuming that climate beneficial technologies are already available. However, there are foreseeable conflicts if measures to address the 'worst first' requirements of decision XIX/6 in the context of ODS phase-out are less climate beneficial (or even result in a climate dis-benefit) than other options available.

[38] This table provides the incremental operating cost as per presently available data. It should be noted that there is not only a potential of variation of incremental operating cost, but also that the different technologies have different susceptibility for such changes. Consequently, the cost ratio between the different technologies will likely shift.

66. Where climate neutral or climate beneficial technologies exist which are affordable, it might be in the interests of the Executive Committee to discourage the adoption of technologies that lead to a climate dis-benefit by determining not to provide Multilateral Fund funding support at all. There are previous precedents within the Multilateral Fund history. However, such an approach would need to leave the enterprise or country with a sufficient number of funded technology choices available. In preparing this paper, the Secretariat believes that it needs further guidance from the Executive Committee about whether this type of prioritisation is appropriate at this point in time.

67. In this present analysis, no further consideration has been given to the treatment of ‘other environmental impacts’ which are inferred in decision XIX/6. In principle, these could include such items as VOC emissions leading to the formation of low level ozone. However, since these are often localised factors, it is expected that they will be applied at that level and will be part of the beneficiaries technology selection.

68. Since this paper is set in the context of a consideration of costs, the work reported herein relates primarily to how the funding approach of the Executive Committee might be used to encourage the adoption of technologies with maximum climate benefits. Decision XIX/6 itself notes the need to take into account “global warming potential, energy use and other relevant factors”. In assessing these indicators, the Secretariat has been keen to develop an approach that is sufficiently robust to act as a basis for a funding assessment, while ensuring that it is sufficiently sensitive to make meaningful climate comparisons. Additional information can be found in Annex V. Three basic methodologies have emerged:

(a) The adoption of a methodology based solely on global warming potential (GWP);

(b) The adoption of a methodology based in Life Cycle Climate Performance (LCCP); and

(c) The adoption of a ‘functional unit’ approach to life cycle evaluation.

69. In its initial review, the Secretariat did not consider that a methodology based solely on GWP would wholly address the mandate of decision XIX/6, since it would be unable to account for ‘energy use’ as required within the decision. In addition, the approach would need to account for differences in life-cycle containment practices and recovery options if it was to properly reflect a fair technology comparison. This would, by definition, bring it into the assessment of life cycle components.

70. As with all Life Cycle Assessment (LCA) processes, the development of a formal LCCP is data-intensive and requires the input of a substantial number of variables, not all of which might be known, either to the enterprise or a country, at the time of the funding application. Even if they were available, it would be a substantial and potentially impractical task for the Secretariat to cross-reference and verify that these assumptions were appropriate. The LCCP methodology is therefore seen as unsuitable as a basis for a funding assessment.

71. With the GWP and LCCP approaches representing the two extremes of the spectrum, the Secretariat has been assessing intermediate options which might overcome the disadvantages of each. This has resulted in the initial evaluation of a ‘functional unit’ approach which offers the robustness of a simplified and less data-intensive methodology, while ensuring that the key

criteria outlined in decision XIX/6 (GWP, energy use and other relevant factors) can all be taken into account. It should be stressed that the evaluation to date has been limited to only one sector and requires further methodological development to ensure applicability across the range of projects and programmes envisaged under decision XIX/6. Nevertheless, the Secretariat believes it appropriate to set out the basic methodology at this stage, and the funding options that could be derived from it, in order to received early feedback from the Executive Committee on the proposed approach.

72. The 'functional unit' approach focuses on a typical use of the substance in a sector, called 'element', in order to characterise the impacts related to that 'element' throughout its lifecycle. For example, the contribution of a foam to energy efficiency can be quantified per unit area for a typical building maintaining an average 10^0C temperature differential (thermal gradient) across a building element. This typical application is then used as a 'proxy' for the total activities in a sector. The purpose is not to calculate the precise climate impact for each and every application, but to characterise these impacts so they can be used for comparing technologies. In practice, the primary output would be a comparative assessment of lifecycle climate impacts taking into consideration the GWP of the substitute, the charge size, the energy used in operation, and the emission functions through the life-cycle. Alternative technologies can be evaluated against the benchmark of the most cost effective technology which completely phases out ODS and leads to a similar climate impact as the original HCFC technology.

73. This approach needs further development and evaluation across a wider range of sectors to provide assurance that the basic methodology can be applied more widely. The Secretariat therefore seeks the mandate to continue this work on the current path or, as revised by the Executive Committee, in order to present a more concrete set of proposals at the 57th Meeting.

V. INCENTIVES AND OPPORTUNITIES FOR CO-FINANCING

74. In preparing this paper, 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. In the meantime, the 54th Meeting of the Executive Committee decided to adopt in its decision 54/39 guidelines for the preparation of HPMPs. These guidelines encourage countries and agencies to explore potential financial incentives and opportunities for additional resources to maximize the environmental benefits from HPMPs. Co-financing can be levied either on the level of individual projects or national plans, or on an aggregated level, or both. Decision 54/39 establishes the requirement to look into co-financing associated with individual projects or programmes.

75. For the purpose of this paper, the issue of environmental benefits is understood to refer to climate change and the mitigation of greenhouse gas emissions. Phase-out projects under the Multilateral Fund create mitigation of the emission of greenhouse gases on different levels. The reduction of the production of HCFC-22 will lead to subsequent reductions in the co-production of HFC-23, a potent greenhouse gas. The reduction of the production and consumption of HCFCs will lead to a subsequent reduction in emission of these substances which also have relatively high GWPs. The replacements used in the same applications would also be emitted, some of which might be potent greenhouse gases. Finally, HCFC use as a refrigerant and, to a certain extent as a foam blowing agent, are closely related to energy consumption, being in turn linked to carbon emissions.

76. For phase-out projects implemented under the Multilateral Fund to attract co-financing will require, as a minimum, a climate-relevant indicator as proposed in section V of this paper. This should provide a good starting point to assess the possible contribution of projects under the Multilateral Fund to the objectives of other funding mechanisms.

77. A number of such funding mechanisms exist which might be suitable to provide co-funds for Multilateral Fund projects. Among them are funds from beneficiaries, mechanisms based on traditional funding models, national energy efficiency projects from governments or from industry, and market based mechanisms. These currently represent the most likely sources of co-financing.

78. Traditional funding models include funds which are in their structure similar to the Multilateral Fund, i.e. a number of donors provide funding, which is available to a group of recipients, according to the definitions developed by a controlling entity. The GEF falls into this group, as well as other climate or environment related funds on an international, regional, and individual donor country level. At present, this group of funds is rapidly growing both in terms of volume as well as in the number of mechanisms. The criteria and access modalities to some of these funds might not be compatible with the objectives of the Multilateral Fund.

79. In some countries, governments or electricity suppliers are operating energy saving funds. Typically, such funds can be expected to be compatible with Multilateral Fund projects, but they do not appear to be common in Article 5 countries.

80. The market based mechanisms issue carbon credits or carbon emission rights that are meant to offset carbon emissions occurring elsewhere by emission reductions achieved under certain well defined projects. The income generated from such undertakings is dependent on the market price for such rights or credits at the moment of sale. These mechanisms work on the basis of actual emission reductions, and require environmental additionality, i.e., the projects must lead to emission reductions that would not have occurred otherwise. Activities to maximize the environmental benefits could be interpreted as being additional.

81. There is already experience regarding co-financing of individual projects or programmes available within the Multilateral Fund and its implementing agencies. Almost all Multilateral Fund projects have been approved as grants to beneficiary enterprises and institutions in Article 5 countries, with the exception of 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 costs have been paid, in many instances, by the beneficiary enterprises, sometimes with the assistance of cash funding provided through payment of incremental operating costs.

82. Examples of non-incremental costs paid by the enterprises are: construction costs associated with plant conversion and capacity increase or technology upgrades beyond the baseline level[39]. In addition, there is a large number of incentive programmes in the refrigeration servicing sector, which 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-

[39] These non-incremental costs have not been assessed and recorded by the Secretariat, and therefore quantitative information cannot be provided other than through the compilation of such additional information as might have been included in project documents.

based system to alternative refrigerants. These constitute examples for what could be seen as beneficiary co-funding in Multilateral Fund projects[40].

83. The centrifugal chiller replacement programme based on a funding window established by the Executive Committee at its 45th Meeting was approved on the understanding that there would be multiple benefits from replacing old CFC-based chillers by chillers with alternative technologies, and that funding would be disbursed only when co-financing had been assured[41]. Chiller projects were approved by the Committee at its 46th and 47th Meetings. A number of the projects were dependent on high beneficiary contributions, creating in essence an implementation facility similar to the incentive programmes mentioned above. Other projects were seeking to use other funding mechanisms such as the GEF, other environmental funds or funds from electricity companies associated with energy conservation. Funding from environmental funds started to materialise only 18 month after project approval, and are still not fully available. Funds from international finance instruments and electricity companies have not been available up to date, despite significant efforts.

84. It is likely that the projects would need to incorporate activities that might not be eligible under the present guidelines of the Multilateral Fund, while being funded from part of the co-financing received. This might, for example, be a technical upgrade of the technology used in air conditioners in order to achieve a higher energy efficiency. Similarly, restrictions might be imposed, e.g. in the sourcing of equipment, use of specific technologies, etc. It will be necessary to carefully assess, in light of the overall mandate provided by the Parties, under which conditions the amount of co-financing expected is significant enough to undertake the additional effort needed to fulfil these requirements.

85. In agreeing to the HCFC guidelines, the Executive Committee has already requested information regarding national or regional funding mechanisms that might be applicable. The premise of co-financing for individual projects and plans is therefore established.

86. From an assessment of the project process, it became clear that HCFC phase-out projects would need to be developed and implemented between 2009 and 2013 to achieve the 2013 and 2015 HCFC compliance targets. The experience in the implementation of chiller projects, with an important co-financing component, suggests that significant delays in HCFC phase-out projects are likely if they are conditional upon co-financing from regional or multilateral sources, creating potentially large challenges in achieving the compliance targets in 2013 and 2015. Given the time based reduction commitments of the Montreal Protocol, it is difficult for countries to risk having their projects delayed for the uncertain prospect of co- funding. Accordingly, if the slow rate of support by other funding entities were to continue, it would call into question the possibility of using other institutions to support Multilateral Fund activities.

87. Co-financing could also be accessed globally, i.e. beyond the co-financing of individual projects or programmes. For this purpose, both market based mechanisms as well as climate or environmental funds could be used. There might be some advantages to a parallel global approach, such as simplifying procedures and centralising the effort to leverage co-financing. In

[40] Under other funding mechanisms these costs are seen as “counterpart funding” or “co-funding”.
[41] To allow the review of chiller projects under this funding window, the Secretariat undertook in documents ExCom/46/37, ExCom/47/20 and ExCom/47/21 an analysis of important aspects and relevant experience on co-financing that could be also valid for the mandate for this paper.

order to reduce the issue of project delay due to exploring co-financing possibilities, it would be possible for the Fund Secretariat to approach other institutions to see if clear methodologies and more streamlined mechanisms can be developed to enable the other institutions to top up Multilateral Fund ozone funding in order to achieve additional climate benefits. Exchange with other institutions could commence once discussion in the Executive Committee has progressed regarding certain issues raised in this document, in particular relating to cut-off date, second conversion and how to minimise other impacts on the environment.

88. Such activities might consist of the following:

(a) Identification of suitable and compatible regional or multilateral funding mechanisms;

(b) Assessment of the operational requirements associated, such as need for monitoring, requirements for additional activities or restrictions;

(c) Development of possible operational concepts for co-operation and necessary adjustments in project assessment, implementation, monitoring and evaluation.

89. The above points form a preliminary list, and would require close co-operation of the Secretariat and implementing agencies, under the continuous guidance and supervision by the Executive Committee. The Executive Committee might therefore wish to consider whether it wishes to further explore possibilities for co-financing.

VI. RECOMMENDATIONS

90. The Executive Committee might wish to:

(a) Take note of the discussion paper providing analysis of relevant costs considerations surrounding the financing of HCFC phase-out,

(b) Note the limited introduction of several of the HCFC alternative technologies available to date in Article 5 countries, the need to validate and optimize them to local conditions prevailing in Article 5 countries, and the wide variation in costs of replacement equipment and raw materials and, accordingly:

(i) Request the Secretariat to gather technical information related to HCFC phase-out in the aerosols, fire extinguishers and solvents on an on-going basis, to review any project in these sectors when submitted and to refer them as appropriate, for individual consideration by the Executive Committee; and

(ii) Consider the deferral to its first meeting in 2010 of any decision it might wish to take on policies for the calculation of incremental operating costs or savings from HCFC conversion projects, as well as the establishment of cost-effectiveness thresholds, in order to benefit from the experience gained through review of HCFC phase-out projects prior to that meeting;

(c) Agree that the technical information contained in document UNEP/OzL.Pro/ExCom/55/47, is sufficient to enable preparation, review and submission on a case-by-case basis of a number of stand alone projects (4 per region) for HCFC phase-out in the foam, refrigeration and air conditioning sectors with the aim of demonstrating the applicability of alternative technologies and facilitating the collection of accurate data on incremental capital costs and operating costs or savings as well as other data relevant to the application of the technologies, as per paras (d) and (e) below;

(d) Invite bilateral and implementing agencies, as a matter of urgency, to prepare and submit a limited number of time specific project proposals involving interested systems houses and/or chemical suppliers for the development, optimization and validation of chemical systems for use with non-HCFC blowing agents on the following basis:

    (i) As part of the projects, following the development and validation process, the collaborating systems houses would provide technology transfer and training to a selected number of downstream foam enterprises to complete the phase-out of HCFCs in these enterprises;

    (ii) Agencies are to collect and report accurate project cost data as well as other data relevant to the application of the technologies;

    (iii) In order to be of benefit to the preparation and implementation of the HPMPs, as well as any stand alone projects these specific projects will be completed within a period not exceeding 18 months and a progress report on each of the two implementation phases as outlined in paragraphs (i) and (ii) above, will be made available to the Executive Committee;

    (iv) Bilateral and implementing agencies and relevant collaborating systems houses are encouraged to addresses the technological issues surrounding preparation and distribution of premixed polyols containing hydrocarbon blowing agents;

(e) Consider inviting bilateral and implementing agencies to submit a limited number of demonstration projects for the conversion of HCFC projects in the refrigeration and air conditioning sub-sectors to low-GWP technologies to identify all the steps required and assess their associated costs;

(f) Continue its deliberations on policy relating to second stage conversions and determination of the cut-off date for installation of HCFC-based manufacturing equipment after which incremental costs for the conversion of such equipment will not be eligible for funding, with the view to concluding its considerations prior to submission of stand-alone projects which could commence at the 56th Meeting;

(g) Consider whether an approach of the type outlined in document UNEP/OzL.Pro/ExCom/55/47 provides a satisfactory basis for the prioritisation of HCFC phase-out technologies to minimise climate impacts as originally envisaged in decision XIX/6, and whether it wishes the Secretariat to continue with its evaluation in order to report in a more detailed fashion at a subsequent Executive Committee meeting;

(h) Consider the possibility for the Secretariat to approach other institutions with the objective of identifying suitable and compatible regional or multilateral funding mechanisms as sources for co-financing to top up Multilateral Fund ozone funding in order to achieve additional climate benefits and to provide a further report to a future meeting;

(i) Consider whether it wishes to examine, at a future meeting, options for giving priority to Multilateral Fund support for equipment replacement at a time when such equipment is reaching the end of its useful life to avoid premature retirement and destruction of expensive, fully functional infrastructure once the 2013 and 2015 compliance targets have been addressed.

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.

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

(b) Incremental operating costs reflect changes in costs attributable to the conversion 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]. Since the adoption of cost-effectiveness thresholds, the cost-effectiveness of projects have been assessed against the threshold value, with projects above this threshold receiving lower funding priority or partial funding.

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-

[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).

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 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.

Forty-second Meeting of the Executive Committee (April 2004)

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.

Forty-third Meeting of the Executive Committee (July 2004)

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.

Fifty-third Meeting of the Executive Committee (November 2007)

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 55th 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 54th 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.

Fifty-fourth Meeting of the Executive Committee (April 2008)

32. The fifty-fourth Executive Committee decided to adopt the following guidelines (decision 54/39):

(a) Countries should adopt a staged approach to the implementation of an HCFC phase-out management plan (HPMP), within the framework of their over-arching-strategy;

(b) As soon as possible and depending on the availability of resources, countries should employ the guidelines herein to develop, in detail, stage one of the HPMPs, which would address how countries would meet the freeze in 2013 and the 10 per cent reduction in 2015, with an estimate of related cost considerations and applying cost guidelines as they were developed;

(c) The elaboration of stage one of the HPMP and subsequent stages should be developed as follows:

(i) For countries with consumption in the servicing sector only:

a) To be consistent with existing guidelines for the preparation of RMPs/RMP updates pursuant to decisions 31/48 and 35/57; and, if applicable, with the preparation of TPMPs pursuant to decision 45/54;

b) To contain commitments to achieve the 2013 and 2015 HCFC control measures and include a performance-based system for HPMPs based on the completion of activities in the HPMP to enable the annual release of funding for the HPMP;

(ii) For countries with manufacturing sectors using HCFCs, HPMPs should contain a national performance-based phase-out plan (NPP) with one or several substance or sector-based phase-out plans (SPP) consistent with decision 38/65 addressing consumption reduction levels sufficient to achieve the 2013 and 2015 HCFC control measures and provide starting points for aggregate reductions, together with annual reduction targets;

(d) For countries that chose to implement investment projects in advance of completion of the HPMP:

(i) The approval of each project should result in a phase-out of HCFCs to count against the consumption identified in the HPMP and no such projects could be approved after 2010 unless they were part of the HPMP;

(ii) If the individual project approach was used, the submission of the first project should provide an indication of how the demonstration projects related to the HPMP and an indication of when the HPMP would be submitted;

(e) Consideration should be given to providing funding for assistance to include HCFC control measures in legislation, regulations and licensing systems as part of the funding of HPMP preparation as necessary and confirmation of the implementation of the same should be required as a prerequisite for funding implementation of the HPMP;

(f) In cases where there were multiple implementing agencies in one country, a lead agency should be designated to coordinate the overall development of stage one of the HPMP;

(g) HPMPs should contain cost information at the time of their submission based on and addressing:

(i) The most current HCFC cost guidelines at the time of submission;

(ii) Alternative cost scenarios based on different potential cut-off dates for new capacity if a specific cut-off date had not yet been decided, for funding eligibility of manufacturing facilities as specified in decision 53/37(k), as well as the current policy for a 25 July 1995 cut-off date;

(iii) Alternative cost scenarios for the operational and capital costs for second conversions;

(iv) The incremental costs of regulating import and supply to the market of HCFC dependent equipment once proven alternatives were commercially available in the country and describing the benefits to the servicing sector of associated reduced demand;

(v) Cost and benefit information based on the full range of alternatives considered, and associated ODP and other impacts on the environment including on the climate, taking into account global-warming potential, energy use and other relevant factors;

(h) Countries and agencies were encouraged to explore potential financial incentives and opportunities for additional resources to maximize the environmental benefits from HPMPs pursuant to paragraph 11(b) of decision XIX/6 of the Nineteenth Meeting of the Parties;

(i) HPMPs should address:

(i) The use of institutional arrangements mentioned in decision 53/37(e) and (f);

(ii) The roles and responsibilities of associations of refrigeration technicians and other industry associations and how they could contribute to HCFC phase-out; and

(j) HPMPs should, as a minimum, fulfil the data and information requirements, as applicable, listed in the indicative outline for the development of HPMPs, as set out in Annex XIX to the present report.

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 excluding Republic of Korea, Singapore and United Arab Emirates, amounted to 178,144 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 40 and 19 Article 5 countries[2] respectively in 2006. Twenty[3] of the 40 countries reported consumption of HCFC-141b consumption below 10 ODP tonnes (91 metric tonnes). Similarly, 16[4] of 19 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] Excluding Republic of Korea, Singapore and United Arab Emirates.
[3] Excluding 1,028.7 ODP tonnes (9,352 metric tonnes) consumed by Republic of Korea, Singapore and United Arab Emirates.
[4] Excluding 126.7 ODP tonnes (1,949 metric tonnes) consumed by Republic of Korea and Singapore.

6. Seventy[5] of the 114 Article 5 countries that reported consumption of HCFC-22[6] 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	3	1	40
HCFC-142b**	17		1		1	19
HCFC-22(*)	73	20	7	13	1	114

(*) 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[7] and UNDP for 12 selected Article 5 countries[8]. 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:

---

[5] Excluding 1,213.9 ODP tonnes (22,071 metric tonnes) consumed by Republic of Korea, Singapore and United Arab Emirates.
[6] 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.
[7] UNEP/OzL.Pro/ExCom/51/Inf. 3.
[8] 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[9]. 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[10], as shown in Table II.4 below.

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

[10] 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
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

[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. Where cost limitations precluded provision of high pressure foam dispenser, the existing low pressure unit was replaced with a low pressure dispenser with variable ratio and heating/coating facility;

(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 had the capability to process CFC-based formulations while those that were inadequate were upgraded through retrofits. 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 technology was 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 IOC paid for CFC phase-out

13. The level of IOC 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. Experience from approved foam projects shows that the IOC associated with foam density could be as high as 60 per cent of the total IOC of the project. Since the duration of IOC for rigid foam projects is two years, calculation of the component of IOC associated with increase in foam density is based on “initial density increase” for the first year and “mature density increase” for the second year. IOC 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 might not be an issue as lower foam densities than that obtained with HCFC-141b could be achieved although 1 to 2 per cent increases in density could occur particularly with methyl formate which could be mitigated with time through formulation optimization. It may, therefore, be necessary to revisit the issue of changes in foam density in order to more accurately account for the required level of IOC.

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.

<u>Technologies already in use in Article 5 countries</u>

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, 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 IOC 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 IOC.

22. Hydrocarbons have been the preferred conversion technology for large and organized foam producers, where the safety requirements could be complied with and investments could be economically justified. However, small-sized enterprises in non-Article 5 Parties have been unable to adopt hydrocarbon technologies to any significant extent due to the investment need in new equipment[3]. Most of these enterprises have selected HFC-based technologies despite the higher system costs. Where insulation requirements are less stringent, greater use of CO2 (water) has also occurred.

23. Recent developments in equipment and technological processes appear to have made it possible for the investment costs as well as safety concerns associated with the technology to be considerably reduced. These late developments would appear to make the conversion to hydrocarbon technology more affordable and feasible to enterprises with low to medium level of HCFC consumption. Furthermore, the role of systems houses in optimizing formulations for SMEs has been particularly important. Hydrocarbons have zero ODP and a relatively low GWP (maximum 25).

[3] TEAP Progress Report, May 2008.

Technologies with limited application/use in Article 5 countries

HFCs

24. 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.

25. 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. New formulations for replacing

HCFCs in the manufacture of extruded polystyrene boards in North America are almost certain to relay on HFC-134a as a large component of the final blowing agent[4]. HFC-134a has zero ODP and GWP of 1,300.

26. In order to optimise the cost-effectiveness of HFC-based systems, foam formulators have developed products containing levels of co-blowing agents higher than have traditionally been used with HCFC-based formulations. The most prevalent co-blowing agent used is CO2 (water) and to a lesser extent hydrocarbons, CO2 (LCD), methyl formate, alcohols, and others. In many applications where limited space prevents an increase in insulation thickness (i.e., domestic and commercial refrigerators, closed cell spray foam insulation for existing building envelopes, building panels, and insulated transport containers), HFCs are selected as the blowing agent in order to provide the best available energy efficiency. In many cases the energy efficiency requirements are dictated by regulation, building codes or voluntary programmes[5].

Methyl formate

27. Methyl formate marketed by Foam Supplies Inc. (FSI) of the United States 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 are also said to have good physical properties, good fire resistance and good stability[6]. However, other market information appears to contradict some of the supplier information indicating that while Ecomate technology is interesting and promising it does not appear to be proven for many foam applications and at this stage could be more expensive than HCFC-141b, although it could be more cost competitive in the long run. Activities to optimize the technology for use in Multilateral Fund projects would be desirable.

28. The chemical is considered “extremely flammable but not explosive”. FSI indicates that process emissions from Ecomate systems are so low as not to require special precautions in the manufacturing area. As Ecomate is normally sold as a system to foam producers, any flammability issues would be restricted to the systems supplier. Shipping of the systems is possible without “flammable” tags.[7]

29. Ecomate is exclusively licensed to Purcom[8] for Latin America, to BOC Specialty Gases for the United Kingdom and Ireland and to Australian Urethane Systems for Australia, New

[4] TEAP Progress Report. May 2008.

[5] Several analyses have been carried out on these applications that demonstrate that the Life Cycle Climate Performance (LCCP) associated with the use of HFCs is, in many cases, favourable and no worse than neutral in others compared to low GWP alternatives, even when all of the blowing agents contained in the foams are deemed to be emitted over the lifecycle. The situation is further improved when measures can be adopted to minimise emissions, particularly at end-of-life.

[6] Dennis Jones, BOC Ltd., Ecomate – A Revolutionary yet Economical New Blowing Agent.

[7] John Murphy, Mark Schulte, Buck Green, Ecomate® Foam Blowing Agent, API Polyurethanes 2005 Technical Conference, 10/18/2005 (page 302ff); John Murphy – Foam Supplies, Inc and Dennis Jones, BOC Ltd. Ecomate - The Revolutionary New Blowing Agent for Europe, Utech 2006, Paper #18, March 28, 2006.

[8] Juan Valásquez - São Paulo – Brazil. International Gazeta, Purcom acquires foam suppliers license (Mjzanon’s IP Newsletter - September 2005).

Zealand and the Pacific Rim. The price of methyl formate worldwide is reported to be in the same range as of the price of pentanes but not affected by the price pressures of crude oil on pentanes. Methyl formate has zero ODP and relatively low GWP[9], likely to be similar to other hydrocarbons.

Other technologies

30. Other alternatives technologies to HCFC-141b have been introduced in non-Article 5 countries[10], including:

(a) Super-critical CO_2 spray foam technology. This technology has been established mainly in Japan with a market penetration of no more than 10 per cent. The technology is yet to make any significant market penetration beyond Japan. The Green Procurement Law has also promoted the greater uptake of CO_2 (water), which is particularly suited to the Japanese market and growth of this technology has exceeded that of super-critical CO_2;

(b) A new low-GWP blowing agent, HBA-1, has been launched (Honeywell), where hydrocarbons cannot be used to replace HFC-134a for one-component foams for safety and performance reasons. This blowing agent will be commercially available in July 2008, in time to enable compliance with the requirements of the European F-Gas Regulation;

(c) The use of not-in-kind technologies such as fibrous insulation has increased in insulation markets as a result of the greater thermal efficiency of foam insulation and improvements in fire performance (greater use of polyisocyanurate technologies);

(d) The alternative technologies for HCFCs by extruded polystyrene board producers in the United States are likely a combination of HFCs, CO_2, hydrocarbons and/or water.

Costs associated with the financing of HCFC phase-out in the foam Sector

31. The costs associated with the financing of HCFC phase-out in the foam sector would include:

(a) Initiation costs: Costs associated with preparatory/enabling activities such as formulation validation activities and other initiatives to demonstrate the feasibility, performance and acceptability of alternative technologies, and investigate and establish inherent costs of conversion;

(b) Investment costs: ICC and IOC , including technical assistance and training, site preparation, trials, testing, installation and commissioning; and

[9] 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.
[10] TEAP Progress Report, May 2008.

(c) Management costs: Costs for supervision, monitoring, reporting, evaluation, verification, agency coordination, as a component of the overall HCFC management plan.

32. As the management costs are expected to be addressed as part of the preparation of the various HCFC management plans (HPMPs) only the initiation and investment costs are discussed in this paper. As the initiation activities are precursors to the investment activities the associated costs have been addressed as a whole. The main initiation activity under the HCFC phase-out programme is the validation of HCFC alternative foam formulations involving systems houses and foam chemical suppliers. The cost of this activity has been estimated and is attached as Appendix II to this Annex. The components of the investment cost, namely ICC and IOC are discussed below.

Range of ICC for phasing-out HCFCs

33. 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 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.

34. 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.

35. 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 ICC estimates based on retrofit of existing equipment or replacement of existing equipment. The following considerations informed the calculations of the ICC:

(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 existing foaming machine in the baseline. The need for replacement of existing production equipment should be technically demonstrated and considered on a case-by-case basis[11];

(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.

36. Thus the ICC 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. Thus, 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 ICC 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.

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

[11] 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.

Range of IOC

38. The level of IOC 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.

39. 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 IOC, 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.

40. Cost ranges of IOC were calculated for the following alternative technologies: water-based systems, hydrocarbons, both pentane and cyclopentane, HFC-245fa and methyl formate. The precise levels of IOC can only be fully quantified when all the cost elements are known, including the cost of all the component chemicals (polyol, isocyanate, blowing agents), formulation ratios, foam densities. This information is available only at the time of review and evaluation of actual projects. Thus in the absence of actual projects the IOC were estimated 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 1:0.3 for integral skin foam similar to the method 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 IOC 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 IOC;

(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.

41. The IOC 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.

42. 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

43. 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)[12] 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.

44. 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.

[12] 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.

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
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	

45. 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.

46. The infrastructure already put in place at some system houses should be utilized to continue to facilitate the phase-out of HCFCs, through the development, optimization and validation of formulations with non-HCFC blowing agents suited to their local markets and possibly neighboring countries where low levels of HCFC consumption would not make a systems house operation feasible. This validation should include checking processing characteristics; product performance; commercial availability; safety; environmental performance; and related incremental costs. The estimated costs of the proposed validation range from US $145,000 to US $210,000 per systems house project for non-flammable blowing agents technology and from US $200,000 to US $320,000 per systems house for flammable blowing agents technology. Once the validation process has been completed and new non-HCFC based pre-blended polyols are developed, systems houses would provide technology transfers and training for a selected number of downstream foam enterprises (i.e., no more than 10 enterprises per systems house and should include, if possible, different foam applications). Based on the experience gained in the introduction of the new non-HCFC based polyols, actual ICC and IOC for the conversion of foam enterprises could then be fully assessed. A detailed analysis of the costs can be found in Appendix II to this Annex III.

Appendix I

ICC CALCULATIONS

ICC ranges for conversion of panels, pipe in pipe foam, thermoware, domestic refrigerators (US $)

Foam application	Alternative technology
Panels	HFC-254a, pentane
Pipe-in-pipe	HFC-254a, water (limited applications), pentane
Thermoware	HFC-254a, water, pentane (limited application)
Domestic refrigerator	HFC-254a, pentane

Equipment item	HFC-245fa		Water/CO2		Pentane	
	Low	High	Low	High	Low	High
Production						
Replacement of low pressure with high pressure dispenser	60,000	100,000	60,000	100,000	90,000	170,000
Retrofit of high pressure dispenser	10,000	15,000	10,000	15,000	60,000	100,000
Retrofit of pre-mixing unit (where eligible)	-	10,000	-	10,000		
Replacement of pre-mixing unit	20,000	60,000	20,000	60,000	55,000	85,000
Modification of press					15,000	25,000
Hydrocarbon tank and accessories (piping and pumps, ventilation)					20,000	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	30,000	60,000	25,000	55,000	375,000	710,000
Total replacement	100,000	195,000	95,000	180,000	385,000	780,000

ICC ranges for conversion of spray foams and discontinuous block foam (US $)

Equipment item	**Low**	**High**	**Low**	**High**
	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
Production: Discontinuous blocks (**)	**Dispenser option**		**Boxfoam option**	
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.

ICC ranges for integral skin foams (US $)

Equipment item	HFC-245fa		Water/CO2		Pentane	
	Low	High	Low	High	Low	High
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

IOC: Rigid polyurethane foam (US $)

Chemical	Prices US $/kg		Ratio (*)	Consumption (metric tonnes)		
	Low	High		Plant 1	Plant 2	Plant 3
HCFC-141b	2.50	3.80	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	3.00	3.50	1.50	7.50	37.50	112.50
Pentane	1.90	2.50	0.50	2.50	12.50	37.50
Cyclopentane	2.10	3.30	0.50	2.50	12.50	37.50
MDI (pentane)	3.00	3.50	0.10	0.50	2.50	7.50

(*) 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	12,500	19,000	62,500	95,000	187,500	285,000
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	22,500	26,250	112,500	131,250	337,500	393,750
Methyl formate	5,500	8,000	27,500	40,000	82,500	120,000
Pentane	6,250	8,000	31,250	40,000	93,750	120,000
Cyclopentane	6,750	10,000	33,750	50,000	101,250	150,000
One year IOC						
HFC-245fa (50%)	13,500	11,000	67,500	55,000	202,500	165,000
HFC-245fa (75%)	26,500	26,000	132,500	130,000	397,500	390,000
Water-based system	10,000	7,250	50,000	36,250	150,000	108,750
Methyl formate	(7,000)	(11,000)	(35,000)	(55,000)	(105,000)	(165,000)
Pentane	(6,250)	(11,000)	(31,250)	(55,000)	(93,750)	(165,000)
Cyclopentane	(5,750)	(9,000)	(28,750)	(45,000)	(86,250)	(135,000)
Two year IOC						
HFC-245fa (50%)	23,490	19,140	117,450	95,700	352,350	287,100
HFC-245fa (75%)	46,110	45,240	230,550	226,200	691,650	678,600
Water-based system	17,400	12,615	87,000	63,075	261,000	189,225
Methyl formate	(12,180)	(19,140)	(60,900)	(95,700)	(182,700)	(287,100)
Pentane	(10,875)	(19,140)	(54,375)	(95,700)	(163,125)	(287,100)
Cyclopentane	(10,005)	(15,660)	(50,025)	(78,300)	(150,075)	(234,900)

Notes
1. For pentane projects to the IOC should be added the following costs:
   (a) Incremental maintenance of 5 per cent of net incremental investment
   (b) Incremental insurance of 0.5 per cent 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

IOC: Integral skin foam (US $)

Chemical	Prices US $/kg		Ratio (*)	Consumption (metric tonnes)	
	Low	High		Plant 1	Plant 2
HCFC-141b	2.50	3.80	1.00	10.00	30.00
HFC-245fa(**)	10.40	12.00	0.35	3.50	10.50
HFC-245fa (**)	10.40	12.00	0.40	4.00	12.00
Methyl formate	2.20	3.20	0.30	3.00	9.00
Water-based systems	3.00	3.50	1.50	15.00	45.00
Pentane/Isopentane	1.90	2.50	0.30	3.00	9.00
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	25,000	38,000	75,000	114,000
After conversion				
HFC-245fa (50%)	36,400	42,000	109,200	126,000
HFC-245fa (75%)	41,600	48,000	124,800	144,000
Water-based system	99,000	162,750	297,000	488,250
Methyl formate	6,600	9,600	19,800	28,800
Pentane	23,089	31,434	34,489	46,434
One year IOC				
HFC-245fa (50%)	11,400	4,000	34,200	12,000
HFC-245fa (75%)	16,600	10,000	49,800	30,000
Water-based system	74,000	124,750	222,000	374,250
Methyl formate	(18,400)	(28,400)	(55,200)	(85,200)
Pentane	(1,911)	(6,566)	(40,511)	(67,566)
Two year IOC				
HFC-245fa (50%)	19,836	6,960	59,508	20,880
HFC-245fa (75%)	28,884	17,400	86,652	52,200
Water-based system	128,760	217,065	386,280	651,195
Methyl formate	(32,016)	(49,416)	(96,048)	(148,248)
Pentane	(3,326)	(11,425)	(70,490)	(117,565)

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.

Appendix II

SYSTEM HOUSES PROJECTS TO VALIDATE HCFC ALTERNATIVE FOAM SYSTEMS

Description	Low (US $)	High (US$)
I.1 Preparatory work		
Preparation cost (participants, profile, contacts, arrangements for workshops	20,000	25,000
Technology transfer*	40,000	50,000
Technical (training) workshop	30,000	50,000
Sub-total preparatory work	**90,000**	**125,000**
I.2 Items for non-flammable blowing agents technology		
Analytical equipment	10,000	15,000
Blending equipment	10,000	20,000
Trials	20,000	30,000
Sub-total non-flammable blowing agents	**40,000**	**65,000**
I.3 Items for flammable blowing agents technology		
Analytical equipment	10,000	15,000
Blending equipment	60,000	100,000
Packaging and distribution costs for pre-blended polyol	15,000	30,000
Trials	10,000	20,000
Sub-total flammable blowing agents	**95,000**	**165,000**
I.4 Summary cost for systems house		
ICC per systems house project for non-flammable blowing agents technology (I.1 + I.2) including contingency (at 10 per cent)	**145,000**	**210,000**
ICC per systems house for flammable blowing agents technology demonstration, (I.1 +I.3) including contingency (at 10 per cent)	**200,000**	**320,000**
II. Project cost for each participating enterprise		
II.1. ICC for non-flammable blowing agents		
Retrofit cost	10,000	15,000
Trials	2,000	3,000
Sub-total	12,000	18,000
Contingency (at 10 per cent)	1,200	1,800
Total ICC for non-flammable blowing agents	**13,200**	**19,800**
II.2 ICC for flammable blowing agents(**) with retrofit option for use of premixed polyol		
Retrofit of foaming machine (polyol side) (including mix head)	70,000	85,000
Trials	2,000	3,000
Subtotal	72,000	88,000
Contingency (at 10 per cent)	7,200	8,800
Total ICC for flammable blowing agents with retrofit option	**79,200**	**96,800**
II.3 ICC for flammable blowing agents(**) with equipment replacement option		
New production equipment	120,000	150,000
Trials	2,000	3,000
Subtotal	122,000	153,000
Contingency (at 10 per cent)	12,200	15,300
Total ICC for flammable blowing agents with equipment replacement option	**132,200**	**165,300**

(*) Does not include licensing fee, where such is required.
(**)Henncke-Krauss Maffei, Experiences and potentials in replacing rigid foam manufacturing equipment in Article 5 countries. Presented at the HCFC Technical Meeting, Montreal, 6 April 2008
IOC for the participating downstream enterprises will be based on relative systems costs. These will be calculated following the first stage of the project involving the systems formulations at the systems houses.