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# OVERVIEW OF APPROVED HCFC DEMONSTRATION PROJECTS AND OPTIONS FOR ADDITIONAL PROJECTS TO DEMONSTRATE CLIMATE-FRIENDLY AND ENERGY-EFFICIENT ALTERNATIVE TECHNOLOGIES TO HCFCs (DECISION 71/51(a))

## Background

1. Decision XXV/5 requested the Executive Committee to consider the information provided in the report on additional information on alternatives to ODS substances prepared by the Technology and Economic Assessment Panel (TEAP) pursuant to decision XXIV/7[1] of the Twenty-fourth Meeting of the Parties and other related reports, with a view to considering whether additional demonstration projects to validate low-global warming potential (GWP) alternatives and technologies, together with additional activities to maximize the climate benefits, would be useful in assisting Article 5 parties in further minimizing the environmental impact of HCFC phase-out.

2. During the discussion of this matter at the 71st meeting, it was mentioned that the Secretariat in consultation with bilateral and implementing agencies would be requested to prepare a discussion paper with a view to use the information contained in the document mentioned in the decision by the Parties, to decide whether to proceed any further and how to do so. It should also take into account documents UNEP/OzL.Pro/ExCom/71/6/Add.1[2] (Parts IX and XII) and UNEP/OzL.Pro/ExCom/71/56[3], on a number of initiatives related to the adoption of alternative technologies to ODS that were under way or had been introduced in several countries. Further to a discussion, the Executive Committee requested the Secretariat to prepare for the 72nd meeting:

(a) An overview of approved HCFC demonstration projects, including countries and regions

[1] Decision XXIV/7 requested the TEAP to prepare a report with updated information on alternatives and technologies in various sectors for consideration by the 25th Meeting of the Parties.
[2] Status reports and compliance.
[3] Discussion paper on minimizing adverse climate impact of HCFC phase-out in the refrigeration servicing sector.

covered, and technologies selected;

(b) A discussion paper, in consultation with the bilateral and implementing agencies, on options for a number of additional projects to demonstrate climate-friendly and energy-efficient alternative technologies to HCFCs, including not-in-kind technologies, taking into account discussion during the 71st meeting (decision 71/51(a)).

3. Pursuant to decision 71/51(a), the Secretariat has prepared this paper. The paper is based on the comprehensive assessment reports and progress reports prepared by relevant bilateral and implementing agencies on demonstration projects on HCFC alternatives technologies for the foam and refrigeration and air-conditioning manufacturing sectors, and the solvent sector. The Secretariat also discussed this issue during the Inter-agency coordination meeting held in Montreal from 11 to 13 February 2014. Subsequently, the Secretariat held discussions with some bilateral and implementing agencies. Implementing agencies also provided additional information, in some cases in the form of project concepts, as summarized in Annex I.

4. The discussion paper consists of the following parts:

Part I: Overview of approved HCFC demonstration projects

Part II: Impact of HCFC demonstration projects on the penetration of alternatives

Part III: Options for additional projects to demonstrate climate-friendly and energy-efficient alternative technologies

Part IV: Conclusions

Part V: Recommendations

5. The discussion paper also includes the following annexes:

Annex I: Information on additional or ongoing projects to demonstrate climate friendly and energy efficient technologies provided by implementing agencies

Annex II: Summary of results so far achieved from the approved HCFC demonstration projects[4]

Annex III: Potential framework conditions for demonstration projects

**Part I. Overview of approved HCFC demonstration projects**

Background

6. In the framework of the cost considerations surrounding the financing of HCFC phase-out, the Executive Committee decided at its 55th meeting *inter alia* to invite bilateral and implementing agencies to prepare and submit project proposals for HCFC uses in the foam sector including systems houses and/or chemical suppliers for the development, optimization and validation of chemical systems for use with non-HCFC blowing agents, and in the refrigeration and air-conditioning sub-sectors, so that the Executive Committee could choose those projects that best demonstrated alternative technologies and facilitated the collection of accurate data on incremental capital cost and operating costs or savings, as well as other data relevant to the application of the technologies (decision 55/43).

[4] This annex is an update of Annex V to document on the Criteria of funding HCFC phase-out in the consumption sector adopted by decision 60/44 (UNEP/OzL.Pro/ExCom/70/52).

7. Pursuant to decision 55/43, the Executive Committee has approved 14 demonstration projects, as summarized in Table 1. The projects below were approved between the 56th and 64th Executive Committee meetings for a total value of US $17,864,172 and an associated impact of 57.73 ODP tonnes. Annex II to this document includes a brief overview of the finding so far by each one of these projects.

**Table 1. HCFC demonstration projects approved by the Executive Committee**

| Sectors/projects | Agency | Country | ODS | Alternative technology | Final report |
|---|---|---|---|---|---|
| **PU foam manufacturing*** | | | | | |
| Validation of methyl formate as a blowing agent in the manufacture of PU foam (BRA/FOA/56/DEM/285) | UNDP | Brazil | HCFC-141b | Methyl formate | Dec-2010 |
| Validation of methyl formate in microcellular PU foam applications (MEX/FOA/56/DEM/141) | UNDP | Mexico | HCFC-141b | Methyl formate | Dec-2010 |
| Validation of methylal as blowing agent in the manufacture of PU foams (BRA/FOA/58/DEM/292) | UNDP | Brazil | HCFC-141b | Methylal | Apr-2012 |
| Conversion demonstration from HCFC-141b-based to cyclopentane-based pre-blended polyol in the manufacture of rigid PU foam at Guangdong Wanhua Rongwei Polyurethane Co. Ltd (CPR/FOA/59/DEM/491) | World Bank | China | HCFC-141b | Pre-blended cyclopentane | Expected Nov-2014 |
| Conversion of the foam part of Jiangsu Huaiyin Huihuang Solar Co. Ltd. from HCFC-141b to cyclopentane (CPR/FOA/59/DEM/492) | World Bank | China | HCFC-141b | Cyclopentane | Dec-2012 |
| Validation of the use of super-critical $CO_2$ in the manufacture of sprayed PU rigid foam (COL/FOA/60/DEM/75) | Japan/UNDP | Colombia | HCFC-141b | Supercritical $CO_2$ | Dec-2013 |
| Validation/demonstration of low cost options for the use of HCs** as foaming agent in the manufacture of PU foams (EGY/FOA/58/DEM/100) | UNDP | Egypt | HCFC-141b | HC** | Partially completed Apr-2012 |
| **XPS foam manufacturing***** | | | | | |
| Validation of the use of HFO-1234ze as blowing agent in the manufacture of XPS foam boardstock (TUR/FOA/60/DEM/96) | UNDP | Turkey | HCFC-22 /HCFC-142b | HFO-1234ze | Jun-2012 |
| Conversion from HCFC-22/HCFC-142b technology to $CO_2$ with methyl formate co-blowing technology in the manufacture of XPS foam at Feininger (Nanjing) Energy Saving Technology Co. Ltd. (CPR/FOA/64/DEM/507) | UNDP | China | HCFC-22 /HCFC-142b | $CO_2$/methyl formate | Expected Nov-2014 |
| **Industrial/food processing and storage refrigeration manufacturing** | | | | | |
| Conversion from HCFC-22 technology to ammonia/CO2 technology in the manufacture of two-stage refrigeration systems for cold storage and freezing applications at Yantai Moon Group Co. Ltd. (CPR/REF/60/DEM/499) | UNDP | China | HCFC-22 | Ammonia/$CO_2$ | May-2014 |
| **Air-conditioning component development** | | | | | |
| Conversion of room air-conditioning compressor manufacturing from HCFC-22 to propane at Guangdong Meizhi Co. (CPR/REF/61/DEM/502) | UNIDO | China | HCFC-22 | HC-290 | Dec-2013 |

| Sectors/projects | Agency | Country | ODS | Alternative technology | Final report |
|---|---|---|---|---|---|
| **Air-conditioning manufacturing** | | | | | |
| Conversion from HCFC-22 technology to HFC-32 technology in the manufacture of commercial air-source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd. (CPR/REF/60/DEM/498) | UNDP | China | HCFC-22 | HFC-32 | May-2014 |
| Conversion from HCFC-22 to propane at Midea Room Air-conditioning Manufacturing Company (CPR/REF/61/DEM/503) | UNIDO | China | HCFC-22 | HC-290 | May-2014 |
| **Solvents applications** | | | | | |
| Conversion from HCFC-141b based technology to iso-paraffin and siloxane (KC-6) technology for cleaning in the manufacture of medical devices at Zhejiang Kindly Medical Devices Co. Ltd. (CPR/SOL/64/DEM/506, CPR/SOL/64/DEM/511) | Japan/UNDP | China | HCFC-141b | Iso-paraffin/ siloxane (KC-6) | Expected Nov-2014 |

*PU: Polyurethane.
**HC: hydrocarbons.
***XPS: Extruded polystyrene.

8. Table 2 presents an overview of the demonstration projects approved, including the technologies selected and the geographical distribution.

**Table 2: Overview of HCFC demonstration projects approved**

| Parameters | PU foam | XPS foam | Food process and storage refrigeration | Compressor | Air-conditioning manufacturing | Solvents | Total |
|---|---|---|---|---|---|---|---|
| Number of projects | 7 | 2 | 1 | 1 | 2 | 1 | 14 |
| Cost (US $) | 4,072,904 | 2,138,300 | 3,964,458 | 1,875,000 | 5,255,843 | 557,667 | 17,864,172 |
| Impact (ODP tonnes) | 11.98 | 12.30 | 13.75 | N.A. | 16.60 | 3.10 | 57.73 |
| Technologies demonstrated | Methyl formate<br><br>Methylal<br><br>Pre-blended HCs<br><br>Supercritical $CO_2$ | HFO-1234ze<br><br>$CO_2$/Methyl formate | $NH3/CO_2$ | HC-290 | HC-290<br><br>HFC-32 | Iso-paraffin / siloxane (KC-6) | |
| **Regional distribution*** | | | | | | | |
| Africa | Egypt | | | | | | 1 |
| Asia and the Pacific | China (2) | China | China | China | China (2) | China | 8 |
| Europe and Central Asia | | Turkey | | | | | 1 |
| Latin America and the Caribbean | Brazil (2)<br>Colombia<br>Mexico | | | | | | 4 |

*No demonstration projects pursuant to decision 55/43 have been implemented in low-volume consuming (LVC) countries.

Status of implementation of the HCFC demonstration projects

9. Out of the 14 projects approved, so far seven have been completed and a final report has been submitted to the Executive Committee; three reports have been submitted to the 72nd meeting[5]; three reports would be submitted to the 73rd meeting, and one is partially completed with final completion subject to a change in current conditions in the country (i.e., Egypt).

10. The average time of completion of the projects was 38 months, the first one completed in December 2010 and the others between 2012 and 2014. The main reasons for the long implementation time are: the signature of project documents; delays in shipment of equipment; need to optimize the use of the technologies for better performance; and prioritization of compliance related projects over demonstration projects. In many cases, Article 5 countries did not have the results of the demonstration projects as they were not available by the time they were formulating stage I of their HPMPs. However, under the flexibility clause of their Agreements with the Executive Committee, they could consider and pursue changes of selected technologies wherever it becomes relevant.

11. Based on this past experience, the completion of a technology demonstration project in 18 months might have been under-estimated. Moreover, the preparatory phase would add at a minimum six months.

**Part II. Impact of HCFC demonstration projects on the penetration of alternatives**

12. Through the demonstration projects, alternative technologies have been independently assessed through an exhaustive analysis of their performance and costs under local conditions prevailing in Article 5 countries. The results of these demonstration projects have been documented in the final reports submitted to the Executive Committee, and also disseminated through workshops attended by governments and industry representatives from the regions where the demonstrations have taken place.

13. Several of the technologies that have been demonstrated have been incorporated into HPMPs as shown in Table 3. Some prominent examples are:

(a) The demonstration project for the use of methyl formate in several PU foam applications has led to the introduction of this technology in 12 Article 5 countries, involving more than 15 local systems houses and hundreds of downstream users with an aggregated consumption of approximately 5,000 metric tonnes (mt) of HCFC-141b. Other technologies in the foam sector have had lower penetration so far but their use is increasing, such as pre-blended HCs which will be used by systems houses in China, Egypt and Mexico;

(b) The demonstration project for room air conditioners using HC-290[6] (propane) has led to the use of HC-290 as a major alternative for HCFC-22 in the room air conditioner (RAC) sector plan of China, where currently nine conversion activities with an aggregated consumption of 3,741 mt are under implementation; in addition, three compressor manufacturers are currently being converted to HC-290 technology; and

(c) The demonstration project of HFC-32[7] has led to the introduction of this technology as an

[5] Demonstration sub-project for conversion from HCFC-22 to propane at Midea Room Air-Conditioner Manufacturer Company; demonstration project for HFC-32 technology in the manufacture of small-sized commercial air source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co., Ltd., and demonstration project for conversion from HCFC-22 technology to ammonia/CO2 technology in the manufacture of two-stage refrigeration systems for cold storage and freezing applications at Yantai Moon Group Co. Ltd. (UNEP/OzL.Pro/ExCom/72/11/Add.1).

[6] Demonstration sub-project for conversion from HCFC-22 to propane at Midea Room Air Conditioner Manufacturer Company, approved at the 61st meeting.

[7] Demonstration project for conversion from HCFC-22 technology to HFC-32 technology in the manufacture of commercial air-source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd., approved at the 60th meeting.

alternative for HCFC-22 in the industrial and commercial refrigeration and air-conditioning (ICR) sector plan of China, where conversions at six enterprises with an aggregated consumption of approximately 3,000 mt are under implementation. In addition, one compressor manufacturer is currently being converted to HFC-32 technology. A second compressor manufacturer and another six equipment manufacturers are expected to convert to HFC-32 technology in the future. HFC-32 has also been selected in Indonesia, where three refrigeration and five air-conditioning equipment manufacturers using more than 550 mt of HCFC-22 are currently converting to HFC-32; Algeria (8.3 mt of HCFC-22); and Thailand (1,036 mt of HCFC-22).

**Table 3: Penetration of technologies demonstrated**

| Sector | Technology | Countries with ongoing projects introducing the technology | Estimated HCFC phase-out (mt) |
|---|---|---|---|
| Foam | Methyl formate | Brazil, Bosnia and Herzegovina, Cameroon, the Dominican Republic, Egypt, El Salvador, Indonesia, Jamaica, Mexico, Nigeria, South Africa, Trinidad and Tobago | 5,000 |
| | Methylal | Brazil, Mexico | 300 |
| | Supercritical $CO_2$ | The Philippines | 43 |
| | Pre-blended HC | China, Egypt and Mexico | *n.a. |
| Refrigeration and air-conditioning | Ammonia/$CO_2$ | China, Indonesia | *n.a. |
| | HC-290 | Armenia, China, Serbia | 3,741 |
| | HFC-32 | Algeria, Indonesia, Thailand | 4,594 |
| Solvent | Iso-paraffin/ siloxane (KC-6) | China | *n.a. |

*Not yet available.

14. Independently of the final result of the technology assessments, the demonstration projects pursuant to decision 55/43 fulfilled the mandate of demonstrating alternative technologies and facilitating the collection of accurate data on costs and application of the technologies. None of the projects was cancelled. The projects offered increase in know-how in terms of alternative technologies, their concepts or approaches were concretely described and justified in the initial proposals, some of them were linked to further activities or had potential to be replicated in a significant amount of funded activities in the same sub-sector; and they were implemented in specific enterprises already identified and committed to undertake the assessment. For future planning, to ensure effective use of the funds, it is important to ensure that similar projects comply with all these parameters at minimum.

15. Some of the barriers encountered for a larger penetration of these technologies in the case of the foam sector include: the lack of clarity on the side of users about the ways to gain access to the technology and the associated costs (i.e. possible licenses, royalties or technology transfer fees); lack of know-how in the application of the technologies by many users; lack of availability of the alternative blowing agent and compatible components in the local market; and high operating cost of some alternative technologies. Furthermore, the lack of local systems houses in several Article 5 countries, mostly LVCs, makes it more difficult to introduce a viable technology that complies with availability, cost, performance, safety and environmental requirements, particularly with small and medium-sized enterprises (SMEs) and with spray foam applications. As a result, several of these countries have opted by postponing conversion of foam enterprises until such technologies are made available.

16. In the technologies demonstrated in the refrigeration and air-conditioning manufacturing sectors, one of the constraints is that the use of flammable refrigerants requires assessing procedures used for storage, transportation, service and disposal of refrigeration and air-conditioning systems, which are typically defined in standards[8]. The lack of standards on good practice for the use of flammable substances effectively blocks market access for systems based on those technologies. This is also the case for Article 5 countries which are not manufacturing air-conditioners but have indicated in their HPMPs that they would introduce low-GWP refrigeration and air-conditioning systems to replace HCFC-22-based systems. Manufacturers would only export equipment once the relevant standards are in place in the country.

Other projects

*Systems houses*

17. The Multilateral Fund has also approved several projects to assist systems houses customize formulations using new and emerging low-GWP alternative technologies (including HFOs, methyl formate and methylal) to supply a large number of downstream users, many of them SMEs.

18. Stage I of the HPMPs for Brazil, China, Egypt, India, the Islamic Republic or Iran, Malaysia, Mexico, Nigeria, Saudi Arabia, South Africa and Thailand have included projects to assist locally-owned systems houses to introduce low-GWP alternative formulations. Some of these projects include direct assistance to local downstream-users, as well as in other countries (e.g., Costa Rica, El Salvador, Jamaica and Trinidad and Tobago), to facilitate the transition to alternative technologies. For example, China will supply HC pre-blended polyols through systems houses to assist enterprises that cannot establish HC storage and pre-blending stations due to financial, safety and technical reasons. In Malaysia, four systems houses have already developed and tested one formulation based on methyl formate, while two of them have also developed one formulation based on HFO-1233zd. In Mexico, 10 local systems houses have already fully developed formulations based on methyl formate (and some on methylal and pre-blended HCs), which are being tested in downstream users and made commercially available. In South Africa, the first six downstream users supported by their system houses have been converted to methyl formate.

*Promoting low-GWP refrigerants for air-conditioning sectors in high-ambient temperature countries in West Asia*

19. This project intends to demonstrate potential low-GWP alternative technology for the air-conditioning sector in high-ambient temperature countries, where air-conditioning constitutes more than 50 per cent of the energy demand. This project is designed to address *inter alia:* challenges related to the availability of long-term low-GWP alternative refrigerants; technical issues including final products, components, and accessories; assess relevant energy efficiency standards and codes; and identify opportunities for facilitating the transfer of low-GWP technologies.

20. In order to address these issues, 65 prototypes are being built in association with seven local manufacturers, one global company manufacturing locally and seven technology providers (Daikin, Honeywell, DuPont, Emerson, GMCC, and Highly), for measuring different potential technologies. Local manufacturers will test four different HFOs, HFC-32 and HCs in window air-conditioning units, split units, ducted split units and packaged air-conditioning units. Prototypes are expected to be ready by the third quarter of 2014. The project will also prepare a study on long-term feasible technologies for air-conditioning in the region, including district cooling.

[8] This issue was discussed in the Secretariat’s document UNEP/OzL.Pro/ExCom/71/18.

*District cooling in Colombia and Maldives*

21. Two district cooling projects in Colombia and Maldives are associated to ODS phase out plans in these countries. The district cooling project in Colombia emerged from the demonstration project for integrated management of the centrifugal chiller sub-sector, focusing on application of energy-efficient CFC-free technologies for replacement of CFC-based chillers approved at the 47th meeting. The project is expected to generate at least 31 per cent of energy savings compared to standard centrifugal chillers and reduce about 35 per cent of $CO_2$-eq emissions per year. The project budget is US $13.4 million, of which US $0.5 million was provided by the Multilateral Fund. The process to develop the specific district cooling project and to secure the co-finance took more than two years, and another two years are expected to be needed for implementation. A description of the project is contained in Annex I.

22. The district cooling project in the Maldives, proposes to replace HCFC and HFC based air-conditioners by not-in-kind technologies, including vapor absorption systems, deep seawater cooling systems, tidal and other cooling systems, in a district/community cooling configuration. They can use different energy sources (e.g., waste heat, steam, direct heat, electricity) and are potentially more energy efficient and have an overall lower carbon footprint than HFC technologies. The feasibility study is funded by the Climate and Clean Air Coalition. More details are available in Annex II.

*Demonstration of HCFC alternative technologies addressed to service sector and end-users*

23. Several HPMPs proposed as part of their activities in the refrigeration servicing sector, pilot projects to demonstrate and assess the performance of emerging technologies in refrigeration and air-conditioning systems (e.g., Chile, Georgia, Kenya, Mexico (Stage II), Turkey), to facilitate production of alternatives (e.g., Nigeria), or to facilitate the development of standards for the use of flammable alternative technologies (Ghana, Georgia, Indonesia, Kenya, Kuwait, Mexico (stage II) and Oman). For example:

(a) Chile included in stage I of its HPMP a programme to demonstrate low-GWP and high energy efficiency technologies in the supermarket sector, which consumes 45 per cent of the total HCFC-22 used in servicing. The project will assist several supermarkets, which have already considered investing in these conversions, tackle technical and cost issues related to the lack of expertise and unavailability of components needed to implement these technologies;

(b) Mexico has proposed in stage II of its HPMP a demonstration project to distribute 1,000 new HC air-conditioning units on a pilot basis to specific users willing to assist the Government in collecting the necessary data on energy use and functioning of the system during a 12 month-period. Data on emission reductions and energy performance will be used for different purposes;

(c) Nigeria included in its HPMP a demonstration project that will establish a facility for locally produced refrigerant-grade HCs, demonstrate the technology at commercial refrigeration manufacturers and provide training to assure that the use of HC will occur in a safe way. Construction work at the facility has been finalized, product quality control established, a full safety audit was conducted and the facility is in trial and testing phase for full production in 2014; and

(d) Turkey included in its HPMP activities to demonstrate conversion of refrigeration systems in supermarkets to low-GWP technologies (i.e., $CO_2$ ammonia, HC) with the objective to gain commitments from larger end-users to stop using HCFC-22.

**Part III. Options for additional projects to demonstrate climate-friendly and energy-efficient alternative technologies**

24. Based on the analysis of the 14 demonstration projects so far approved and the information contained on the TEAP report pursuant to decision XXIV/7[9] the Secretariat arrived at the following observations:

Additional projects to demonstrate technologies in the foam sector

25. The TEAP report on additional information to alternatives on ODS, categorized alternative technologies in five groups: HCs; saturated HFCs; oxygenated HCs (HCOs); unsaturated HFCs (HFOs); and $CO_2$ based technologies.

26. The TEAP report concluded that HC technologies are dominant worldwide as several of their issues have been resolved; have been optimized for better thermal performance; and are proven and commercially available in most PU foam applications with the exception of spray foam where it is considered unsafe and integral skin where it is uneconomic for SMEs. Some of the issues that would prevent a larger penetration of HCs are their flammability risk associated to the production process, product installation and use, large capital investment cost on safety items, local health and safety regulations, regulations on volatile organic compounds and waste management issues. The Executive Committee has funded projects to demonstrate in two Article 5 countries cyclopentane based pre-blended polyols in the manufacturing of rigid PU foam. In addition, the Executive Committee has approved a larger number of projects in several countries that replaced CFC-11 and HCFC-141b foam blowing agents with HCs.

27. HFOs seem to offer a competitive level of performance with minimum or no capital investment. In particular, HFO-1234ze is seen as a promising alternative in the XPS foam manufacturing sector, which operates with gaseous blowing agents. However, the costs and global availability of HFOs in general are still unclear. The TEAP report indicates manufacturer’s information that HFOs would be commercially available between late 2013 and 2015, but assumes that their availability would be limited to specific applications in non-Article 5 countries. Even in these markets, it is expected that HFOs will be co-blended with other blowing agents to obtain better performance and/or reduce cost increase. The Executive Committee has already approved one pilot project to demonstrate the use of HFO-1234ze as blowing agent in the manufacturing of XPS foam boardstock. Several systems houses in a number of countries also received funding to develop formulations based on HFOs.

28. Methyl formate and methylal in the TEAP report are described as less flammable than HCs, clarifying that the significance of those differences can often depend on local product codes and the regulatory frameworks governing foam manufacturers. There is a growing tendency to use them as components of tailored blends where they can contribute to overall performance criteria. The Executive Committee has approved three projects to demonstrate methyl formate and methylal in the manufacturing of at least fifteen applications of PU foam, and one project to demonstrate the use of a blend containing $CO_2$ and methyl formate in the manufacturing of XPS foam. Since then, several foam enterprises in a number of Article 5 countries are introducing formulations based on methyl formate and/or methylal.

29. $CO_2$ based technologies are commercially available, have low GWP, are non-flammable and have low incremental capital cost for several applications. However, their use in PU foam is limited to some applications such as integral skin because of the moderate foam properties offered for other uses, including high thermal conductivity, high density and poor ageing. In the XPS sector $CO_2$ is the most cost-effective alternative but could not be used in all applications given process difficulties, thermal conductivity requirements, cost of conversion including licensing constraints resulting from patents, and

[9] TEAP Task force report on additional information to alternatives on ODS, September 2013

loss of processing flexibility. The Executive Committee approved a project to demonstrate the use of $CO_2$ in supercritical state in the manufacturing of PU spray foam, as $CO_2$ in this state can overcome the main limitations of $CO_2$ technology, namely poor dimensional stability, poor adhesion to substrates and high thermal conductivity.

30. Table 4 from the TEAP report summarizes the existing and emerging alternatives to HCFCs in the PU and XPS foam manufacturing sectors.

**Table 4. Existing and emerging alternatives in the foam sector***

<table>
<tr><th>Sector</th><th>HCFC</th><th>HFCs</th><th>HC</th><th>HCO</th><th>HFO</th><th>$CO_2$-based</th></tr>
<tr><td>PU appliances</td><td>HCFC-141b<br>HCFC-22</td><td rowspan="5">HFC-245fa (C)<br>HFC-365mfc/227ea (C)</td><td>Cyclopentane (C)<br>Cyclo-/iso-pentane (C)<br>Low cost options (D)</td><td>Methyl formate (D)</td><td rowspan="5">HFO-1233zd (U)<br>HFO-1336mzzm (U)<br>AFA-1 (undisclosed) (U)</td><td>$CO_2$ (water) (C)</td></tr>
<tr><td>PU board</td><td>HCFC-141b</td><td rowspan="2">n-pentane(C)<br>cyclo/iso-pentane (C)<br>Low cost options (D)</td><td></td><td></td></tr>
<tr><td>PU panel</td><td>HCFC-141b</td><td>Methyl formate (D)</td><td>$CO_2$ (water) (C)</td></tr>
<tr><td>PU spray</td><td>HCFC-141b</td><td></td><td>Methyl formate (D)</td><td>$CO_2$ (water) (C )<br>Supercritical $CO_2$(D)</td></tr>
<tr><td>PU in-situ/block</td><td>HCFC-141b</td><td>n-pentane (C)<br>cyclo/iso-pentane (C)</td><td>Methyl formate (D)</td><td>$CO_2$ (water) (C)</td></tr>
<tr><td>PU integral skin</td><td>HCFC-141b<br>HCFC-22</td><td>HFC-245fa (C)<br>HFC-134a (C)</td><td></td><td>Methyl formate (D)<br>Methylal (D)</td><td></td><td>$CO_2$ (water) (C)</td></tr>
<tr><td>XPS board</td><td>HCFC-142b<br>HCFC-22</td><td>HFC-134a (C)<br>HFC-152a (C)</td><td></td><td>DME (C)</td><td>HFO-1234ze (U)</td><td>$CO_2$ (C)<br>$CO_2$/ethanol (C)</td></tr>
<tr><td>Phenolic</td><td>HCFC-141b</td><td>HFC-245fa (C)<br>HFC-365mfc/227ea(C)</td><td>n-pentane (C)<br>cyclo/iso-pentane (C)</td><td></td><td>HFO-1233zd (U)<br>HFO-1336mzzm (U)<br>AFA-1 (undisclosed) (U)</td><td></td></tr>
</table>

*Source: TEAP report pursuant to decision XXIV/7; C: in use; D: demonstrated; U: commercial availability

31. The potential use of low-GWP HFCs (HFOs) is being discussed. Several countries (e.g., India, Malaysia and Saudi Arabia) have received under their HPMPs assistance for their local systems houses to develop and introduce formulations with HFO. UNDP submitted a concept note to the Secretariat for a possible demonstration project to investigate mixtures of HFOs with other blowing agents (details in Annex I). However, HFO blowing agents do not seem to achieve full commercial availability before 2015, according to the TEAP Task Force report. In addition, the acceptance of this technology in the different sub-sectors is currently unclear since benefits over available technologies have to be balanced with the presumed substantial increase in the cost for the blowing agent. On that basis, it does not appear meaningful at this point in time to actively pursue the development of demonstration projects, but such projects should be considered once the technology becomes commercially available.

*Refrigeration and air conditioning sector*

General remarks

32. Refrigeration and air conditioning units have a climate impact through emissions of their refrigerants during their lifetime as well as through their energy consumption, which typically causes the release of $CO_2$ e.g. in the burning of fossil fuels for electricity generation. While this document can provide sufficient information on issue of climate friendly alternatives with a low climate impact by the refrigerant, it cannot provide detailed information on the energy efficiency as improvement in energy efficiency of systems has not been considered as incremental cost in projects funded by the Multilateral

Fund. Generally, the different refrigerant technologies assessed have broadly similar energy efficiencies. Differences between different concepts are often more pronounced, e.g., very large refrigeration systems tend to be able to achieve higher energy efficiency as compared to smaller systems.

33. In the refrigeration and air-conditioning sector, a large number of sub-sectors are present[10]. The TEAP report on additional information to alternatives on ODS provides five categories of technologies to generate cooling: ammonia, $CO_2$, HC, medium and high-GWP HFCs, and low GWP HFCs (often referred to as HFOs). In addition to these technologies, which all belong to the group of refrigerants for vapour compression cycles, a number of other technologies have been developed; however only one has reached the level where market-acceptable products and/or production could be envisioned. This technology is lithium bromide/water absorption systems, where the energy is supplied by heat instead of by electricity and which is used for large and very large air-conditioning applications; each of these systems is used as an alternative to the use of one or several centrifugal chillers. Other technologies, such as air cycle, magnetic refrigeration, and sterling machines have so far not demonstrated that they would be able to replace a significant amount of HCFC-22 use in the foreseeable future.

34. While the methodology in the TEAP report focuses on all refrigeration and air-conditioning applications, in the context of this discussion paper only those are considered where typically HCFCs are being used. Tables 5 to 7 derived from the TEAP report[11] summarize the existing and emerging alternative technologies in the refrigeration and air-condition sectors.

**Table 5. Current use of alternatives in the air conditioning sector***

| GWP | 0 | 1 | 3 – 5 | 4 | 490 | 716 |
|---|---|---|---|---|---|---|
| Substance | R-717 (ammonia) | R-744 (CO2) | HC-290, HC-1270 | HC-600a | “L-41” | HFC-32 |
| Small self-contained | | L | C [D] | | | L |
| Mini-split (non-ducted) | | L | C, D | | L | C |
| Multi-split | | L | | | L | L |
| Split (ducted) | | | | | | L |
| Ducted split comm. & non-split | | | L | | | L, D |
| Hot water heating HPs | C | C | C | C | | L |
| Space heating HPs | C | L | C | L | | L, D |

*Source: TEAP report pursuant to decision XXIV/7. C: Commercial use; L: limited use; D: MLF demonstration projects; [D] Results of MLF demonstration project in different sub-sector potentially relevant

**Table 6. Current use of alternatives in the chiller sub-sector sub-sectors***

| GWP | 0 | 1 | 3 – 5 | 4 | 6 | 6 | 490 | 600 | 630 | 716 |
|---|---|---|---|---|---|---|---|---|---|---|
| Substance | R-717 (ammonia) | R-744 (CO2) | HC-290, HC-1270 | HFC-1234yf | HFC-1234ze(E) | HCFC-1233zd(E) | “L-41” | “N-13” | “XP-10” | HFC-32 |
| Positive displacement | C | C | C | L | L | | L | L | L | L, [D] |
| Centrifugal | | | L | L | L | L | | | | |

*Source: TEAP report pursuant to decision XXIV/7. C: Commercial use; L: limited use; D: MLF demonstration projects; [D] Results of MLF demonstration project in different sub-sector potentially relevant

[10] For the assessment of the need for demonstration projects the TEAP progress report uses a slightly different classification than the Multilateral Fund typically does

[11] The Secretariat removed from the Table provided in the TEAP report those substances which would not show either “C” or “L” as a category, to allow a better overview

**Table 7. Current use of alternatives in various refrigeration sub-sectors***

| GWP | | 0 | 1 | 3 – 5 | 4 | 4 | 630 | 1330 |
|---|---|---|---|---|---|---|---|---|
| Substance | | R-717 (ammonia) | R-744 ($CO_2$) | HC-290, HC-1270 | HC-600a | HFC-1234yf | "XP-10" | "N-40" |
| Commercial refrigeration | Stand-alone equipment | | C | C | C | L | | L |
| | Condensing units | | L | L | | | | L |
| | Centralised systems | L | C | L | | | L | L |
| Transport refrigeration | | | C | C | | | | |
| Large size refrigeration | | C | C, D | L | | | | |

*Source: TEAP report pursuant to decision XXIV/7. C: Commercial use; L: limited use; D: MLF demonstration projects; [D] Results of MLF demonstration project in different sub-sector potentially relevant

35. The Secretariat notes that a number of refrigerant blends are under development, often mixing medium or high-GWP HFCs with low-GWP HFCs (HFOs), resulting in GWPs between 490 and 1,330, with flammable blends starting at GWP below 500. Currently, no low-GWP HFC (HFO) has been developed as a direct replacement of HCFC-22, and there is currently no indication that a pure HFC with low-GWP (HFO) is being developed as a replacement for HCFC-22 or for use in applications where HCFC-22 is the prevalent choice of refrigerant.

<u>End users</u>

36. The Secretariat notes that activities addressing directly end users have in the past almost without exception not provided tangible benefits beyond the particular equipment converted or purchased. The demand from end users which could be generated through Multilateral Fund support is too small to cause manufacturers to develop new products with alternative refrigerants. The annual consumption these projects phase out is the annual service need of the particular equipment supported, which is typically very small as compared to the project costs.

37. A different type of end-user projects would address HCFC uses which are not directly linked to a product charged with HCFC which could be converted. Instead, a different type of equipment altogether might be used. This covers, e.g., the use of chillers and district cooling, which offer a possibility to reduce emissions of refrigerant and for the introduction of low-GWP refrigerants. The Multilateral Fund has in the past directly supported related efforts in larger equipment, in particular through the chiller demonstration projects, but also through the HPMP in Maldives. As part of the chiller demonstration projects, one district cooling application in Colombia was supported, and is currently operating. However, the experience in the chiller projects also suggests that this type of support is not suitable to provide for short-term feedback into the design of further HPMP related activities as described in several previous documents, e.g., UNEP/OzL.Pro/ExCom/71/6/Add.1 part IX: Progress report on the implementation of chiller projects. Support by the Multilateral Fund was at best a moderate component in the total funding of related projects. At this time, the most meaningful approach appears to be to closely monitor and document the already on-going activities of the Multilateral Fund, and to use them actively to showcase the benefits of secondary systems in district cooling and chillers. While it is conceivable that projects in the end user sector in general and for replacing large cooling facilities in particular might be meaningful in some cases, the Secretariat sees in the near-future no need for a demonstration project.

38. In reaction to discussion of demonstration projects at the Inter-agency co-ordination meeting, UNIDO has submitted two project concepts related to the end-user sector. One concept was suggesting a demonstration project of non-conventional technologies in central air conditioning applications in the buildings sector of the Middle East region, the other one a demonstration project for the retrofitting of HCFC-22 chillers to HC-290 in the hotel air conditioning sub-sector. A brief description of the concepts can be found in Annex I.

Air conditioning

39. In the air-conditioning sector, the use of propane (HC-290) has been demonstrated for the use in smaller split air conditioners, and could also apply for small self-contained air conditioners, i.e. mainly window air conditioners. These two uses are the largest consumers of HCFC in the sector. As an alternative for medium sized air-conditioning systems, the conversion to HFC-32 was subject of a demonstration project, which could also apply to a range of medium-size air-conditioning applications (e.g. multi-split, split applications, and small packaged air conditioners). The air conditioning demonstration projects also included air-to-air heat pumps. The Secretariat is not aware of a demand for heat pump projects in other applications than air-to-air, and is also uncertain whether such other applications would have the potential to be replicated widely in Article 5 countries. Heat pump systems using ammonia (for large systems) and HCs (for small systems) have already been commercialized.

40. In reaction to discussion of demonstration projects at the Inter-agency co-ordination meeting and with the background of the on-going UNEP/UNIDO project on promoting low GWP Refrigerants for air-conditioning sectors in high-ambient temperature countries, UNIDO has submitted one project concept related to the air conditioning manufacturing sector. It suggests a demonstration project on HFO technology in the A/C manufacturing industry in the Gulf region. A brief description of this concept can be found in Annex I.

Chillers

41. In the chillers sub-sector, the Secretariat is not aware of any Article 5 country based manufacturing of centrifugal chillers where a conversion project would be meaningful. However, there are a large number of manufacturers who produce water chillers of different types and sizes operated by screw or scroll compressors. Depending on the location of the equipment, ammonia and HCs can be and are widely used (ammonia has been used for large capacities in such applications for more than 100 years). The Secretariat is of the view that there is no need for demonstration projects in the chiller-sector to allow conversion to HC or ammonia technologies. However, activities to develop safety concepts for use of such equipment in particular in populated areas might be meaningful.

Large refrigeration systems and transport refrigeration

42. The replacement of HCFC-22 in large-size refrigeration has been demonstrated in one project using $CO_2$ and ammonia. It does not appear that in this sector additional demonstration projects would be needed. For the sub-sector of transport refrigeration, the Secretariat notes that no conversion projects have been submitted, and that HPMPs did not list manufacturing enterprises in the sector. In addition, it appears that this sub-sector introduces flammable low GWP refrigerants only at a later stage due to the more complex safety situation of transport refrigeration equipment. For a lack of suitable beneficiaries it does not appear meaningful to undertake demonstration projects in the transport refrigeration sub-sector. Any potential projects or activities which might be submitted could be considered on a case-by-case basis, without necessarily be considered as demonstration projects.

Commercial refrigeration

43. The Secretariat notes that virtually no projects have been submitted to the Multilateral Fund covering use of HCFC in manufacturing of commercial refrigeration system; furthermore HPMPs so far approved had not included a list of such enterprises. It appears that the manufacturers of commercial refrigeration equipment charged at the manufacturers' site, such as stand-alone equipment, are using either HFC-134a or HFC-404A as refrigerant, but not HCFCs. It also appears that a substantial amount of HCFC-22 is used in systems which are charged on-site, such as supermarkets and condensing units. However, since components of supermarket systems and condensing units are not being charged at a

manufacturing site, and therefore the related enterprises have no consumption in manufacturing. The Executive Committee could treat such a demonstration project similar to the demonstration project to convert a compressor manufacturer. However, currently the Secretariat is not aware of any plan for such a project, and exchanges with bilateral and implementing agencies, where the potential for such projects was discussed, have not resulted in any concrete example. Therefore there is no need to undertake demonstration projects in the commercial sub-sector. Any potential projects or activities which might be submitted could be considered on a case-by-case basis, without necessarily be considered as demonstration projects.

Servicing sector

44. It might be meaningful to also include in the scope of possible future demonstration projects activities in the servicing sector. If transition to low-GWP refrigerants in the manufacturing of refrigeration and air-conditioning equipment is considered, the servicing sector will, at some point in time, have to service such equipment. In addition, even if the most prevalent replacement for HCFC-22, i.e., HFC-410A, is used more widely, additional skills in the servicing sector might still be needed to minimize leakage of this high-GWP refrigerant caused by the high-working pressure. The Secretariat believes that the changes to the servicing of refrigeration and air-conditioning equipment in using either low-GWP solutions, which are mostly flammable and/or high-pressure refrigerants, require substantially more training in the refrigeration service sector than the previous transition away from CFCs. The main characteristic of CFC replacement was to have almost identical handling characteristics to the original refrigerant, which kept training needs at a moderate level. Training has now to address different issues related to safety, diligence, liability and quality of craftsmanship. This will probably lead to new approaches for the development of standards; adoption and enforcement of standards; development of good practices; development of training material and courses; and the necessity for adequate and sufficient training equipment, the substantial update of vocational schools capabilities and the possibility to teach not only theory but have people train practical work. The Secretariat believes that experience gained in the implementation of existing HPMPs should be collected in a separate effort and made available to the bilateral and implementing agencies. Currently and before such experience is available, there is no indication that beyond the collection of such information, any demonstration projects are necessary. This suggestion is partially covered by suggestions from UNEP at the 57th meeting, and also by concepts provided by UNIDO and the Government of Japan (see Annex I).

45. In reaction to discussion of demonstration projects at the Inter-agency co-ordination meeting, UNIDO has a project concept suggesting one demonstration project on the introduction and update of safety standards on refrigerants, related to the issue of flammable low-GWP refrigerants. UNIDO, on behalf of the Government of Japan, submitted a second concept regarding training on energy efficient and low-GWP alternative technologies to phase out HCFCs in the refrigeration, air-conditioning manufacturing and in the service sectors. A brief description of the concepts can be found in Annex I.

*Solvent sector*

46. The TEAP report on additional information to alternatives on ODS points to a number of alternatives to HCFCs which include not-in-kind technologies such as aqueous cleaning, semi-aqueous cleaning, HC and alcoholic solvents, and in-kind alternatives such as chlorinated, brominated and fluorinated solvents with various levels of acceptance. The report also points out that no single options seem well suited to replace HCFCs completely, and that HFO, HFOs which have both chlorine and fluorine, and other solvents are being under development. The report concludes that individual solutions need to be identified for individual replacement tasks, and that it remains uncertain whether all of them can have a low-GWP. One demonstration project was undertaken in the solvent sector, related to solvent use in the production of medical devices, particularly needles; it has been replicated in the solvent sector plan for China.

47. Currently there appears to be no information available suggesting that in any particular area of HCFC solvent use other than in medical devices there are a number of uses which are sufficiently similar to offer replication of the approach tried in a demonstration project. As a consequence, it might be meaningful to consider any potential projects which might be submitted for the solvent sector on a case-by-case basis, and not to foresee demonstration projects in the sector.

**Part IV: Conclusion**

48. The Secretariat has attempted to provide information in this discussion document which will enable the Executive Committee to have an informed discussion on possible options for additional projects to demonstrate climate-friendly and energy-efficient alternative technologies to HCFCs. The document shows that the demonstration projects undertaken on the basis of decision 55/43 have been very successful and have in their targeted approach yielded very valuable results. At the same time, the Secretariat came to the conclusion that there is only limited need for additional demonstration projects and similar activities of an enabling character at this point in time.

49. The Secretariat could envision that based on the still-to-be-submitted results of the project "Promoting low GWP refrigerants for air-conditioning sectors in high-ambient temperature countries" implemented by UNEP and UNIDO, a demonstration project for conversion of manufacturing capacity for manufacturing of air conditioners in high ambient temperature conditions might be meaningful.

50. It might also be meaningful to collect and assess experience from currently implemented activities contained in HPMPs or, where relevant, chiller projects, which relate to

(a) The flammability of refrigerants, such as safety standards, technician training for handling of flammable refrigerants, and developments of codes of good practices. Based on the outcomes of such an activity, the potential need for specific projects, whether a demonstration project, a global project or a different approach could be assessed;

(b) Collection, assessment and publication of the results of demonstration activities under the existing HPMPs; and

(c) Collection, assessment and publication of lessons learned from the district cooling projects in Colombia and the Maldives, and potential for further promoting the concept.

51. Should the Executive Committee consider to support the use of low-GWP replacements in the chiller sub-sector, where currently only ammonia is available, a study on existing safety concepts and meaningful approaches to ensure operational safety of ammonia refrigeration plants in heavily populated areas might be helpful to allow end-users to consider this option.

52. In case the Executive Committee would consider demonstration projects in the near future, the Secretariat has drawn some lessons from the information provided in this document as well as in Annex III to provide some generic criteria that might be applied to such projects as a pre-condition for their approval:

(a) The project offers a significant increase in current know-how in terms of an alternative technology, concept or approach or its application in a developing country, representing a significant technological step forward;

(b) The technology, concept or approach has to be concretely described, linked to other activities in a country and to have the potential to be replicated in the medium future (i.e., within five years) in a significant amount of funded activities in the same sub-sector;

(c) For conversion projects, an eligible company has been identified which is willing to undertake conversion of manufacturing process to the new technology, and has confirmed it will cease to use HCFC after the conversion;

(d) The reporting obligations of the demonstration project become part of the regular progress reporting under the HPMP, and fulfilment of these reporting obligations is required to allow submission of a tranche; and

(e) Funding requests for preparation projects should address the above criteria as well, and should provide reasonable assurance that they can be met as part of the project proposal.

**Part V: Recommendation**

53. The Secretariat recommends that the Executive Committee:

(a) Takes note of the overview of approved HCFC demonstration projects and options for additional projects to demonstrate climate-friendly and energy efficient alternative technologies to HCFCs (decision 71/51(a)), contained in document UNEP/OzL.Pro/ExCom/72/40; and

(b) Takes into account the information and suggestions provided in the present document in its further deliberation on options for additional projects to demonstrate climate-friendly and energy-efficient alternative technologies to HCFCs.

# Annex I

## INFORMATION ON ADDITIONAL OR ONGOING PROJECTS TO DEMONSTRATE CLIMATE FRIENDLY AND ENERGY EFFICIENT TECHNOLOGIES PROVIDED BY IMPLEMENTING AGENCIES

**UNDP**

Possible ideas on demonstration projects, including alternative technology, added benefit as compared to status quo, and how it would address something that the previous demonstration projects have not addressed

*Foam sector*

1. “A review of the effectiveness of HFCs in PU foams on global warming effect and formulation costs has not been funded by the ExCom. In the meantime successors for these substances, HFOs have been further developed into serious contenders in PU technology from around 2015 onwards and major chemical companies have decided to industrially develop these. While recent reports show very good physical performance, these chemicals are quite expensive. On the other side, studies and industrial trials on Methyl Formate (MF) and Methylal (ML) -- also called Oxygenated Hydro Carbons, HCOs -- show that there are flammability concerns at certain concentrations, when used as sole replacement for HCFCs, and problems in physical properties in the case of MF. Both considerations--high price of HFOs and lacking safety and or physical performance for low-density HCOs trigger interest into blends of both. Actually, there is already a work going on HFC/HCO blends but, due to the high GWP of the HFCs this cannot be a satisfactory end goal for the MLF. This work could be analyzed in close cooperation with the PU supplying industry and then extended to HFO/HCO blends, allowing one stage (HFO/HCO) or two stage HFC/HFO -> HFO/HCO)/projects thus assuring that the ExCom's goal of low GWP transformations will be met. The project will need thorough preparation to make sure that all existing development is adequately considered but would then be relatively low cost in actual execution. It is expected that the PU supplying industry is very interested in this exercise and therefore will assist in making current development work available and willing to take on any further development work if/when identified as needed. UNDP would function as a (1) clearing house thus avoiding legal concerns on anti-competitive behavior, (2) assuring that the focus will remain on cost-effective solutions in a developing country setting and (3) guiding industrial trials. The MFL costs could be restricted to the UNDP part.”

*Ongoing initiatives on district cooling being implemented by UNDP*

*District cooling in Colombia*

2. “The Ozone National Unit of Colombia (UTO), the Swiss government (through SECO) and “Empresas Públicas de Medellin” (EPM), the public utility of the Municipality of Medellin, are promoting the construction of a district cooling project for the Medellin’s Alpujarra administrative center as an alternative replacement of the old and inefficient individual CFC-based centrifugal chillers. This initiative was born in the EPM Gas Management, from programs to promote the use of natural gas, cross cutting with energy efficiency issues in commercial and industrial sectors. The main energy source to be used is natural gas. Combustion of natural gas will generate 600 kW installed capacity to supply electrical power to ensure the operation of the auxiliary devices (pumps, cooling towers, monitoring and control) and an ice maker equipment based on NH3. Waste hot air is to be used in an Indirect Heat Absorption chiller, which will serve the base load to provide cold water being distributed by underground pipes to 4 buildings of the administrative complex (in this 1st phase of the project). The project budget is USD 13.4

million, which are being co-funded as follows: USD 6.6 million from EPM, USD 5.8 million from SECO, USD 0.5 million by the MLF and USD 0.25 million by the Ministry of Environment and Sustainable Development of Colombia. This project is expected to generate at least 31% of energy savings compared to standard centrifugal chillers baseline application and reduce about 35% of $CO_2$-eq emissions per year.

3. All the co-finance has been secured and the implementation of the project is expected to be done in two years. It is important to mention that the process to develop the specific district cooling project and to secure the co-finance took more than two years"

*District cooling in Maldives*

4. "Not-in-kind technologies are technologies that substitute conventional technologies in air-conditioning sector. Not-in-kind alternatives include vapor absorption systems, deep seawater cooling systems, tidal and other cooling systems, etc. in a district/community cooling configuration. These systems do not use conventional refrigerants, such as HCFCs, HFCs and HCs. They can use multitude of energy sources such as waste heat, steam, direct heat, electricity, etc. These systems are potentially more energy efficient and have an overall low carbon footprint. They appear to be prima facie appropriate candidates for replacement of HCFC/HFC based air-conditioners. Thus, this presents an opportunity to utilize a climate-friendly district cooling approach, rather than transitioning to high-GWP HFC technologies in the Maldives.

5. For implementing such options, one needs to structure a viable business model involving various stakeholders (e.g., consumers of such equipment, service providers (existing / news), Government, technology operators etc.). In case of Maldives, this would include National Ozone Unit, Ministry of Economic Development, STELCO, Housing Development Cooperation, Male' City Council, Male; Water and Sewerage Company and FENAKA Cooperation, besides consumers. This would also involve a systematic phased approach for implementation as it necessitates investment in infrastructure at community level – thus necessitating step-by-step scaling up of such facilities and operations.

6. The project agreement draft was reviewed by UNDP and comments were sent to CCAC Secretariat. They were incorporated in the agreement. The final agreement is awaiting signature, following which next steps relating to project implementation will be undertaken by UNDP. The total funding through CCAC for the feasibility study is US $ 118,800. The project preparation activity should be completed over a period of 12 – 18 month.

7. During implementation, there would be a combination of funding sources e.g., Government, financial institutions, donor funds and funds from international institutions, for this project. It is too early to state anything concrete here. This can be done only when project preparation is at final stages. Project implementation schedule will be known after preparation."

## UNIDO

Possible ideas on demonstration projects, including alternative technology, added benefit as compared to status quo, and how it would address something that the previous demonstration projects have not addressed:

### *Project concepts shared, related to the refrigeration and air conditioning sector:*

*Demonstration project – Retrofitting of HCFC 22 chillers to HC 290 in the hotel air-conditioning sector (Colombia)*

8. A large number of hotels in tropical countries in Latin America depend on HCFC 22 chillers for their ambient cooling requirements, particularly in coastal areas, where a high percentage of thermodynamic load is destined to dehumidifying. These chillers may range between 25 TR and 200 TR. Even though there is a growing trend in hotel administrators, particularly in small to medium hotels, to increase dependency on using compact split units, it cannot be ignored that centralized water chilled system are more efficient, if properly maintained.

9. The objective is to demonstrate the correct use of hydrocarbons (HC-R290) as refrigerants in water chilled systems used for air conditioning in the hotel sector in Colombia in order to help defeat the barriers and obstacles that are preventing the adoption of this type of refrigerants as a viable alternative to HCFCs (R-22) and consequently generating technical strengths in the service companies that work with these systems.

*Demonstration project on HFO technology in the A/C manufacturing industry in Saudi Arabia*

10. In the Kingdom of Saudi Arabia, a new regulation requiring air-conditioning equipment to be energy efficient in order to enter the Saudi Arabian market will enter into effect as of 2015. The introduction of this new regulation increases the need to find alternatives in the short term.

11. The project “Promoting low-global warming potential refrigerants for air-conditioning sectors in high-ambient temperature countries in West Asia” (PRAHA), approved at the 69th meeting, assesses suitable alternative technologies for HCFC-22.

12. The use of HFOs as alternative technology to HCFC-22 for the conversion of refrigeration/air-conditioning equipment manufacturers is yet to be demonstrated. Prototype development for HFO technologies is currently under way within the PRAHA project’s framework. In the Kingdom of Saud Arabia some air-conditioning equipment manufacturers have opted for testing four HFO blends (DR3, DR5, L20, and L41) and the tests will be carried out in the course of 2014.

13. In this context, UNIDO propose to develop a demonstration project of the HFO technology in the air-conditioning sector in the Kingdom of Saudi Arabia. The proposed demonstration project will be based on the results of the above mentioned prototype testing and consist of a full conversion of the participating company’s assembly line currently using HCFC-22 to HFO.

*Demonstrating Non-conventional Technologies in CAC Applications in Buildings Sector at the Middle East Region (Bahrain, Egypt and Kuwait)*

14. Buildings Sector accounts for almost 40% of global energy consumption and are an equally important source of CO2 emissions. Currently, both-space heating and cooling as well as hot water are estimated to account for roughly half of global energy consumption in buildings. These end-uses represent significant opportunities to reduce energy consumption, improve energy security and reduce

$CO_2$ emissions due to the fact that space and water- heating provision is dominated by fossil fuels while cooling demand is growing rapidly in countries with very carbon-intensive electricity systems.

15. Therefore, the suggested project will try, while preparing the detailed proposal and implanting physical demos, to provide answers to economics of the technology; efficiency, availability of natural and/or renewable resources; availability of local/regional technical support and availability of national relevant supporting aiming at making the outcomes of the project feasible and appealing to governments and decision makers of the buildings sector. Accordingly, the project will basically examine the deployment the below technologies given their potentiality in the Middle East region.

16. There are several non-vapor compression technologies introduced over years in many locations around the world. However the adoption of any technology to widely contribute to the respective sectors relies on many factors.

17. The preparatory stage of the project will include assessing the feasibility of each technology in each country.

18. The aim of the Regional Demonstration Project is to open and promote window to further consider non-conventional technologies in the CAC applications in the buildings sector in a region that highly and extensively use such applications. Demonstrating non-conventional technologies in CAC will be with an objective of producing cases studies that can guide the buildings sector in at least 4 countries in the Middle East with a target to further expand the benefits and outcomes of the demos across the rest of countries in the Middle East given similarities in socio-economic and climatic conditions.

*Demonstration project on the introduction nd update of safety standards on refrigerants in Africa (Kenya, Uganda, Tanzania and Zambia)*

19. The availability on the market of many low-global-warming-potential alternatives and technologies is strictly linked to policies and initiatives related to the adoption and implementation of standards on safety and environmental requirements of refrigeration technologies.

20. The ISO standards related to the Designation and safety classification (ISO 817) and the Safety and environmental requirements (ISO 5149) have been updated to classify and norm the use of new low low-global-warming-potential alternatives, including standards on allowable amount of refrigerant, measures to adopt for larger charges and, as mentioned before, on the relaxation of requirements.

21. This demonstration project on the introduction of standards on safety and environmental requirements of refrigeration technologies is key in assisting Article 5 countries in fully adopting low-global-warming-potential alternatives and further minimizing the environmental impact of the hydro chlorofluorocarbon phase-out, as requested in by Decision XXV/5 and relevant Executive Committee decisions.

22. Indeed, the recent amendment of the ISO classification of refrigerant and relative adjustment on standard in safety handling of refrigerant has created the need for considering a revision of the relevant national standards. Indeed, some refrigerants classified ISO 2L are already commercially available and technology providers are ready to place products containing them on the global market. Therefore, refrigeration standard have to be amended and/or adapted in the coming years in order to allow full commercialization of refrigerants and products containing them, including those classified as ISO 2L.

23. In this framework, UNIDO proposes to carry out a demonstration project which aims is to provide technical, strategic and coordination support to relevant national authorities to implement these new ISO standard requirements and, eventually, more stringent measures. Appropriately guided by

UNIDO, national authorities, including NOUs and Bureau of Standards, should be able to complement, adopt and enforce a proper standard on refrigerants and their safe handling in their country.

24. The project expects to identify and overcome main barriers to commercialization of flammable refrigerants and technologies; have full access to new, low-GWP and energy efficient technologies once standards have been developed in those countries; create a common ground of the highest standard accessible to all the nations equally in the region; and link manufacturing, servicing and recycling sectors and prevent distortion in any level of the refrigerant cycle.

*Training on energy efficient and low-GWP alternative technologies to phase out HCFCs in the refrigeration, air-conditioning manufacturing and in the service sectors implemented by Japan with UNIDO as cooperating agency.*

25. The objective of this proposed training project is to support a number of ozone units and project management units in their efforts by providing updated information on low-GWP and energy efficient alternatives in the refrigeration and air-conditioning manufacturing sectors, which are available in Japan in response to Decision XXV/5.

26. Japan is of the view that this is the most appropriate time for such a proposal, when many Article 5 countries have progressed in implementation of their Stage I HPMPs and are in the process to start preparation of Stage II HPMPs. It is expected that Stage II HPMPs, contrary to Stage I HPMPs, will need to address the refrigeration and air-conditioning manufacturing sectors in order to control/reduce the number of new R22-based installations, which will have future demand for R22 in servicing. Furthermore, all A5 countries will have to undertake phase-out activities in the refrigeration service sector. Japan has a very effective, recovery and recycle infrastructure and through the training and study tours, Japan could provide very useful information on the Japanese system. A5 countries could adopt some or all of the good practices implemented in Japan.

27. The proposed activities will help NOUs and PMUs to develop proper Stage II HPMP strategies by introducing new, low-GWP, energy efficient alternatives and best practices in refrigeration servicing.

28. Associated social systems in Japan will be introduced to help Article 5 countries get an idea to conduct their own system in near future.

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# Annex II

## SUMMARY OF RESULTS SO FAR ACHIEVED FROM THE APPROVED HCFC DEMONSTRATION PROJECTS

1. In line with decision 55/43 on the submission of a limited number of projects that could best demonstrate alternative technologies to the use of HCFCs, the Executive Committee approved the following projects:

(a) Pilot project for validation of methyl formate (MF) as a blowing agent in the manufacture of polyurethane foam (UNDP) (BRA/FOA/56/DEM/285);

(b) Pilot project for validation of MF in microcellular polyurethane applications (UNDP) (MEX/FOA/56/DEM/141);

(c) Pilot project to validate methylal as blowing agent in the manufacture of polyurethane foams (UNDP) (BRA/FOA/58/DEM/292);

(d) Demonstration project to validate the use of super-critical $CO_2$ in the manufacture of sprayed polyurethane rigid foam (Japan) (COL/FOA/60/DEM/75);

(e) Validation/demonstration of low-cost options for the use of hydrocarbons as foaming agent in the manufacture of polyurethane foams (UNDP) (EGY/FOA/58/DEM/100);

(f) Conversion demonstration from HCFC-141b-based to cyclopentane-based pre-blended polyol in the manufacture of rigid polyurethane foam at Guangdong Wanhua Rongwei Polyurethane Co. Ltd (World Bank) (CPR/FOA/59/DEM/491);

(g) Conversion of the foam part of Jiangsu Huaiyin Huihuang Solar Co. Ltd. from HCFC-141b to cyclopentane (World Bank) (CPR/FOA/59/DEM/492);

(h) Validation of the use of HFO-1234ze as blowing agent in the manufacture of extruded polystyrene foam boardstock (UNDP) (TUR/FOA/60/DEM/96);

(i) Demonstration project for conversion from HCFC-22/HCFC-142b technology to $CO_2$ with MF co-blowing technology in the manufacture of extruded polystyrene foam at Feininger (Nanjing) Energy Saving Technology Co. Ltd. (UNDP) (CPR/FOA/64/DEM/507);

(j) Demonstration project for conversion from HCFC-22 technology to ammonia/$CO_2$ technology in the manufacture of two-stage refrigeration systems for cold storage and freezing applications at Yantai Moon Group Co. Ltd. (UNDP) (CPR/REF/60/DEM/499);

(k) Demonstration project for conversion from HCFC-22 technology to HFC-32 technology in the manufacture of commercial air-source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd. (UNDP) (CPR/REF/60/DEM/498);

(l) Demonstration sub-project for conversion of room air-conditioning compressor manufacturing from HCFC-22 to propane at Guangdong Meizhi Co. (UNIDO) (CPR/REF/61/DEM/502);

(m) Demonstration sub-project for conversion from HCFC-22 to propane at Midea Room Air-conditioning Manufacturing Company (UNIDO) (CPR/REF/61/DEM/503);

(n) Promoting low-global warming potential refrigerants for air-conditioning sectors in high-ambient temperature countries in West Asia (UNEP, UNIDO) (ASP/REF/69/DEM/56, ASP/REF/69/DEM/57); and

(o) Demonstration project for conversion from HCFC-141b based technology to iso-paraffin and siloxane (KC-6) technology for cleaning in the manufacture of medical devices at Zhejiang Kindly Medical Devices Co. Ltd. (UNDP) (CPR/SOL/64/DEM/511)

2. Several demonstration projects in the foam sector have been completed and comprehensive reports have been submitted to the Executive Committee. Other projects are under current implementation with final results expected soon.

3. Considering that several of the technologies included in the demonstration projects have already been selected in various Article 5 countries for replacing HCFCs used in the manufacturing sectors, and others could be introduced during the remainder of implementation of stage I or futures stages of the HPMPs, this annex includes a brief description of the results of the demonstration projects that have been completed.

**Methyl formate[1] as a rigid polyurethane (PU) foam blowing agent**

4. The use of methyl formate (MF)-based systems has been evaluated at Purcom Quimica[2] (Brazil) and Quimiuretanos Zadro[3] (Mexico) with the objective of assessing their performance compared to HCFC-141b-based systems, and establishing the feasibility of its use in Multilateral Fund projects.

5. Analysis of assessment outcomes led to the following conclusions:

(a) The use of MF as an alternative blowing agent to HCFC-141b in PU foam applications can be considered in flexible/integral skin foam applications and in a number of rigid foam applications. For certain rigid foam applications, mainly domestic appliances, the technology cannot be recommended at this stage because the density required for this application cannot be reached by MF at the current level of technology (i.e., further optimization of the technology is required). Other applications of the technology should be analyzed on a case-by case-basis and might require further optimization;

(b) To minimize safety risks for downstream-users, such projects should preferably be implemented through their system suppliers as fully formulated systems; and

(c) Project designers should ensure that chemical compatibility is verified; minimum packed density is observed; health, safety and environmental recommendations are incorporated; and implications related to acidity are taken into account.

6. The peer review concluded that many of the apparent shortfalls in MF's performance are very likely to be addressed by formulation optimisation. However, in the present case so far, this optimisation process has not been led by the global polyurethane systems houses, as was the case with earlier blowing

[1] UNEP/OzL.Pro/ExCom/62/9.
[2] At the time the project was approved by the Committee, Purcom was the only Article 5 licensee of the technology; for that reason, it was selected to implement the pilot project.
[3] To assess the use of MF for shoe sole systems.

agents. The peer review also highlighted the following areas that require further consideration: information on experience and MF usage per application (sub-sector); combustibility safety during foam processing and of the end product/foam in some cases; data on spray and shoe-soling elastomer applications; further and longer-term dimensional stability test data, particularly for rigid insulating foams; and longer-term thermal conductivity testing.

7. Several successful trials with methyl formate and methylal have been undertaken at the systems house level in Egypt, Mexico and Brazil, in spray foam applications in Egypt and Jamaica, and for insulation in water heaters in Egypt. Information at the foam enterprises level will be available towards the end of 2013, when methyl formate pre-blended polyol systems will be supplied to them. UNDP also noted that highly qualified technical assistance is needed in conducting trials with methyl formate as formulations need to be optimized. Therefore, costs associated with trials will remain until formulations are optimized for the various foam applications where methyl formate might be used.

**Methylal as a rigid PU foam blowing agent**

8. UNDP formulated a number of pilot projects to investigate the safe use of methylal to replace HCFC-141b in polyurethane (PU) foam applications. The use of methylal-based systems has been evaluated at Arinos Química, Ltd. (Brazil), with the objective of assessing its performance compared with HCFC-141b-based systems in order to establish whether the technology is feasible for use in Multilateral Fund projects. Sixteen PU foam applications using HCFC-141b as a blowing agent were evaluated for their potential to convert to methylal[4].

9. The results of the assessment indicated that methylal is better suited for integral skin and flexible foam applications. Taking into consideration that the comparison is being made between optimized HCFC-141b-based systems and recently developed methylal-based systems, the results for rigid (insulation) foam applications showed a penalty in insulation value of up to 10 per cent. Therefore, the use and further optimization of methylal systems in those applications should be evaluated individually by enterprises.

10. The technical reviewer concluded that “the use of methylal as a replacement for HCFC-141b systems in polyurethane foam manufacturing in Article 5 countries appears to be a feasible solution that meets the objectives of a cost-effective, zero-ODP, low-GWP replacement technology. Final foam properties are comparable to HCFC-141b-based foams”. The technical reviewer further recommended that the report should, *inter alia*, define the parameters of the test results to provide guidance about whether the density results are predictive of actual operating conditions; provide an estimate of the incremental operating costs based on the results obtained; continue with the long-term stability studies of foam properties, particularly dimensional stability; and include monitoring equipment as an integral component of each project to assure operational and personnel safety.

**Super-critical $CO_2$ technology in the manufacture of sprayed foam**

11. UNDP submitted to the 71st meeting an assessment report of the super-critical $CO_2$ technology in the manufacture of sprayed foam[5]. The performance of this technology, which has been used in Japan since 2004, was evaluated in Espumlatex, the largest locally-owned system house in Colombia. The supercritical $CO_2$ technology was assessed versus the HCFC-141b technology, in two different environmental conditions, namely at sea level (Barranquilla) and at an altitude of 2,600 m (Bogota). To

[4] UNEP/OzL.Pro/ExCom/66/17.
[5] UNEP/OzL.Pro/ExCom/71/6.

check processability of the foam, field in-door applications were done in industrial warehouses in both cities; and to determine the physical properties, test foam sprayed samples were prepared and analysed following ASTM[6] and JIS[7] standards in Achilles Corporation (the owner of the supercritical $CO_2$ patented technology and Espumlatex laboratories. In addition few samples (polyisocyanurate (PIR) and rigid polyurethane (PUR)) were made for E-84[8] fire performance testing at QAI laboratories in the United States.

12. Analysis of assessment outcomes led to the following conclusions:

(a) Supercritical $CO_2$ technology is non-flammable, and does not incur any incremental industrial hygiene and safety hazard. Under tropical weather conditions and various levels of altitude over sea level, the technology showed a similar processability to HCFC-141b-based systems currently used. Polyol and isocyanate components of both technologies were stable during the six months of project duration;

(b) In terms of physical properties of PU foam, the supercritical $CO_2$ technology showed: higher thermal conductivity but better aging (the difference in lambda value between the two technologies decreased with time); similar aging behaviour in compressive strength (values kept stable with time; similar dimensional stability performance at temperatures below 20 ºC; improved dimensional stability at 60 ºC and 96 per cent relative humidity; similar adhesion strength to galvanised steel);

(c) In terms of physical properties of PIR foam, the supercritical $CO_2$ technology showed: higher thermal conductivity but better aging; similar aging behaviour in compressive strength; similar dimensional stability performance at temperatures below 20 ºC; similar dimensional stability at 60 ºC and 96 per cent relative humidity in absolute values, however, while the supercritical $CO_2$ technology experienced a negative change in volume the HCFC-141b formulation had a positive one; and lower adhesion strength to galvanised steel;

(d) According to fire performance test ASTM E84-12c, run on just one sample per formulation, both the PU and PIR foams based on supercritical $CO_2$ technologies would be classified as class A and B respectively by the National Fire Protection Association (NFPA);

(e) The cost of the required retrofit of a typical spray machine to apply the supercritical $CO_2$ range between US $9,800 to US $13,700 for PU foam and from US $11,800 to US $15,700 for PIR foam; and

(f) The supercritical $CO_2$ technology is a patented technology owned by Achilles Corporation, and is based on proprietary polyol and isocyanate formulations. The free on board (FOB) price of supercritical $CO_2$ system is US $7.00/kg in Japan. The interested enterprises should come to an agreement with Achilles on technology fees.

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[6] ASTM International, formerly known as the American Society for Testing and Materials (ASTM), is a globally recognized leader in the development and delivery of international voluntary consensus standards.
[7] The Japanese Industrial Standards (JIS) specifies the standards used for industrial activities in Japan.
[8] ASTM E84 is the standard test method for surface burning characteristics of building materials

**Hydrocarbon-based pre-blended polyol systems**

13. UNDP submitted to the 66th meeting a technical report on low-cost options for the use of hydrocarbons in the manufacture of polyurethane foam[9]: During project implementation, UNDP identified options for cost reduction in pre-blending at the supplier level, which would avoid the need for a pre-blender plus ancillary equipment (e.g., storage tanks, piping); direct injection of hydrocarbons, which also removes the need for pre-blender systems; and the introduction of more recently developed hydrocarbon blends which would allow for lower foam densities.

14. The equipment selected was a three-module high-pressure dispenser capable of processing fully formulated systems, with direct injection of flammable as well as non-flammable blowing agents. In the trials it functioned well for HCFC systems (baseline), pre-blended systems and direct injection. In particular, the dispenser offered: excellent repeatability; acceptable three-stream blending (future adjustments may improve the performance); and high efficiency in blowing-agent containment, leading to lower foam densities.

15. Test results showed that: physical and chemical stability of cyclopentane systems under standard conditions for up to six months is confirmed; cost savings of around US $100,000 can be expected, as no pre-blender system is needed; although there are no savings in the cost of equipment for direct injection, the compact design could result in savings in layout and storage; operating savings of between 6 and 8 per cent (or 10 per cent with direct injection) can be expected as compared to HCFC-141b systems (however, transportation costs may increase); and a slightly higher k-factor[10] (between 5 to 8 per cent) and lower reactivity show that the mixer head impingement has suffered from the introduction of a third stream.

16. The technical reviewer concluded that the study has verified the acceptable physical properties of rigid foam products for commercial refrigeration, discontinuous panels and water heater applications using pre-blended hydrocarbon-based systems as well as direct metering of hydrocarbons. The study has also verified the stability of cyclopentane pre-blended systems for a 5-month period; studies are continuing to verify a minimum 6-month shelf life. It has also shown that n-pentane systems are not suitable for pre-blending due to instability (phase separation) of the blended product.

17. The study did not adequately verify the continued safety of operations of the new systems and equipment. Additional studies should be conducted to generate data clearly establishing that the three-component blending operation meets safety requirements, particularly for flammability, during the processing of both pre-blended systems and direct-metered hydrocarbons. Further information should be provided regarding the safety requirements for ventilation and monitoring during transportation and storage of the pre-blended polyol systems, including projected costs. An analysis of the projected costs for the conversion to these pre-blended/direct injection systems should be developed to establish the approximate usage level that will benefit from this technology refinement.

18. Based on preliminary cost analysis by UNDP, savings of approximately US $100,000 could be expected when using these systems, as no pre-mixing equipment and ancillary equipment will be required at the enterprise; although there are no savings in the cost of foam dispensers for direct injection, the compact design could result in savings in layout and storage. Operating savings of between 6 and 8 per cent (or 10 per cent with direct injection) can be expected as compared to HCFC-141b systems; however, transportation costs may increase.

19. The World Bank also implemented a demonstration for cyclopentane based pre-blended polyol in the manufacture of rigid polyurethane foam. The objective of the project is to demonstrate the feasibility of pre-blending polyol with cyclopentane, supplying the pre-blended polyol to foam producers and testing

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[9] UNEP/OzL.Pro/ExCom/66/17.
[10] The thermal conductivity for a unit thickness of material.

the approach in four foam producing enterprises[11]. The assessment of technical feasibility of the conversion to cyclopentane is considered particularly in terms of the compatibility of cyclopentane with polyether. The test on the stability of 16 representative grades of dry pre-mixed formulated polyols undertaken by the Jiangsu Research Institute of Product Quality Supervision and Inspection found that the majority of the polyols have good stability and good compatibility with cyclopentane. These results indicated that the domestic polyether suppliers have solved the compatibility issue of cyclopentane and polyether. Another critical component under evaluation is the flammability of the mixture, as it sets the requirements for transportation, storage and use within a company. Flash-point tests to assess the safety hazard of the 16 samples of pre-mixed formulated polyols with cyclopentane have demonstrated that the formulated polyols are categorized as class II flammable liquids; they can be transported over short and medium distances provided they meet the requirements of the specific transport regulations for dangerous goods.

20. As reported by the World Bank, delivering hydrocarbon pre-blended polyols in drums as compared to cyclopentane delivered in bulk results is capital savings as enterprises do not have to invest in cyclopentane storage tank and delivery systems (including pumps and piping) and safety equipment. Additional savings will be realized as enterprises do not need to invest in pre-mixing equipment and safety measures, and separate access for delivery of drums to the storage room (i.e., saving of over US $200,000 compared to a traditional cyclopentane-based foam project with blending *in situ* could be expected). In addition, hydrocarbon-based pre-blended polyols could be used by foam enterprises using much less than 5.5 ODP tonnes (50 mt) of HCFC-141b.

**HFO-1234ze used for XPS foams**

21. UNDP submitted to the 67th meeting a technical report on HFO-1234ze as a blowing agent in the manufacture of extruded polystyrene foam boardstock[12]. UNDP conducted a series of trials with different formulations of HFO-1234ze and dimethyl ether (DME), which is an extremely flammable gas. Based on the validation data collected so far, HFO-1234ze technology is believed to have good prospects for replacing the use of HCFCs and/or HFCs in XPS applications while providing acceptable thermal insulation and structural properties. However, to make such a product commercially acceptable, some optimization of density and surface will be required. The trials also showed that there is the potential to reduce flammability of the HFO-1234ze/DME blend and to improve thermal insulation performance by reducing the amount of DME. This would however require further trials.

**HC-290 used as a refrigerant in air-conditioning systems**

22. UNIDO has reported in progress reports on different aspects of the demonstration project on one manufacturer’s conversion from HCFC-22 to HC-290 (propane) in manufacturing air-conditioning equipment, but has not submitted a final report; the final report is expected for the 73rd meeting. However, UNIDO reported that the introduction of hydrocarbons, in particular R-290, in room air-conditioning systems will strongly influence the development of the markets. The feasibility of the technology has already been demonstrated through both the demonstration project as well as additional projects under implementation. Further, detailed information was provided regarding safety concepts of the manufacturing, incremental capital and incremental operating costs. The penetration in markets is at present difficult to assess, since codes and standards to allow the placing on the market of HFC-290-based equipment have been incomplete yet; certain national codes regarding the air-conditioning system were established recently (beginning of May 2013), but standards on refrigeration systems in general are still

[11] UNEP/OzL.Pro/ExCom/63/15.
[12] UNEP/OzL.Pro/ExCom/67/6.

outstanding, creating legal uncertainty. The reporting on the demonstration projects will be finalised before market information can be provided; however, the agency will continue the project until sufficient sales of air conditioners with HC-290 technology have been achieved to justify the payment of the IOC to the companies.

**HFC-32 used as a refrigerant in air-conditioning systems**

23. UNDP has provided a final report on the demonstration project converting medium sized air conditioners and heat pumps from HCFC-22 to HFC-32. UNDP reported already previously that the introduction of HFC-32 in medium capacity air-to-air heat pumps and air-conditioners will strongly influence the development of the related markets. The feasibility of the technology has already been demonstrated through both the demonstration project as well as additional projects under implementation. Detailed information was provided regarding safety concepts of the manufacturing, incremental capital and incremental operating costs; the report is annexed to document 72/11/Add1 to this meeting. Similar to the above mentioned issues related to the situation of HC-290, also for the flammable refrigerant HFC-32 the penetration in markets is at present difficult to assess, since codes and standards to allow the placing on the market of HFC-32-based equipment have been incomplete yet.

**Low-GWP refrigerants for air-conditioning in high-ambient temperature countries**

24. The objective of the project (implemented by UNEP and UNIDO) is to facilitate the technology transfer and exchange of experiences regarding low-GWP alternatives for the air-conditioning sector in high-ambient temperature countries. It will gather inputs from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) to identify and evaluate promising alternative refrigerants for major product categories through the Alternative Refrigerants Evaluation Programme AREP). The project will assess commercially available refrigerants and air-conditioning equipment in terms of suitability to operate under high-ambient conditions; assess relevant energy efficiency standards and codes; undertake an economic comparison of alternative technologies taking into consideration perspectives of manufacturing sectors, consulting sectors and operating/clients sectors; and will identify commercial opportunities and associated fiscal implications for facilitating the transfer of low-GWP technologies including commercial and trade barriers, patents and relevant intellectual property rights.

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# Annex III

## POTENTIAL FRAMEWORK CONDITIONS FOR DEMONSTRATION PROJECTS

1. The main body of this document contains substantial technical information meant to facilitate a discussion about different technology options and the need to demonstrate them. At the same time, the discussion might also benefit of considerations on methodologies on the preparation and implementation of demonstration projects, since this might support the Executive Committee in operationalizing any possible invitation of demonstration projects.

*Replication of demonstration projects*

2. A large number of demonstration projects for the replacement of HCFC have been funded in the past, and, in addition, a number of HPMPs as well as chiller demonstration projects have also worked on demonstration of alternative technologies to the use of HCFCs. The Secretariat notes that while a large share of the demonstration projects undertaken were meant to demonstrate the principle viability of the new technology or even develop it, the Executive Committee could in specific cases still consider to undertake demonstration projects on the same technology in other regions in order to facilitate the adoption of technologies and, to some lower extent, undertake regionally specific developments and broader validations. In this context, the Secretariat would particularly like to point towards the joint project of UNEP and UNIDO "Promoting low GWP refrigerants for air-conditioning sectors in high-ambient temperature countries", where prototypes of different technologies for air conditioners in hot climates are being tested. Subsequent to the conclusion of tests and selection of possible technologies, demonstration conversion projects might be meaningful, even for those technologies which have already been demonstrated in other parts of the world with more moderate climates.

3. With the above mentioned exception, this document will not focus further on the possibility of replication of existing demonstration projects for further dissemination and acceptance of technology, since there is no firm technical basis on which to assess the benefits of such an approach generically. Instead, any assessment would have to reflect the current need in a particular region, the sustainability of this need vis-à-vis the project implementation time, and the priority assigned to such a replication vis-à-vis other activities. This remark is without prejudice on the assessment of usefulness for any such activity.

*Time specific nature of assessments of the need for demonstration projects*

4. A conversion project under the Multilateral Fund is meant to eliminate the use of an ODS in the manufacture of a product and sustainably convert the enterprise manufacturing the product to a new technology. This objective is valid for conversion projects, plans and also for demonstration projects. This implies for such demonstration projects that typically, the different parts forming this technology such as the alternative itself, other chemicals needed in the process such as polyols or refrigeration oils as well as other components such as compressors are available or are likely to be available in the near future, and that the technology will probably sustain in the market[1].

[1] It should in this context be noted that any assessment whether an emerging technology will be available during the implementation of a demonstration project and whether it will sustain in the market is time specific. The Secretariat can only provide a snapshot of the current situation in this document.

*Timing of demonstration projects*

5. Initial requests for funding of the preparation for stage II of HPMPs as well as for one stage II HPMP implementation have been submitted to this meeting. Preparation of stage II HPMPs will commence soon in several countries. In order to allow results of demonstration projects to inform decision making on the selection of and conversion to new alternative technologies, the related information has to be developed rapidly. At the same time, it appears that some potential candidate technologies have not quite reached sufficient commercial availability to be a meaningful candidate for a demonstration project yet. Consequently, any potential activities of the Executive Committee towards additional demonstration projects should include measures to accelerate project approval, and to ensure fast implementation. Possible measures would be to allow implementing agencies to submit with the next business plan entries for demonstration projects in selected sub-sectors; and to allow implementing agencies to provide a request for project preparation funding in parallel with a request for entry of an activity into the business plan. In order to facilitate focussed and rapid implementation, the Executive Committee might also limit the time available for project preparation to an interval of one meeting (two-meeting per year schedule) or two meetings (three meetings per year schedule), after which the agencies would not be allowed to undertake further obligations, remaining funds would have to be returned and a brief report on funded activities provided. Further, the time for project implementation should be limited to two years except where agreed otherwise at the time of project approval, after which the agencies would not be allowed to undertake further obligations, remaining funds would have to be returned and a detailed report on the implementation, costs, lessons learned and other relevant findings to be provided to the next meeting.

*General criteria for demonstration projects*

6. In order to be considered as a demonstration project in the manufacturing sector, any project proposal should offer improving significantly the current know-how in terms of an alternative technology or its application. The technology used should be replicable within approximately five years from the time of approval, with the potential to be used in several activities. Given that a short time for implementation is essential for the projects, an eligible company should have been identified. This company should commit to the conversion of their manufacturing process to the new technology and to cease using HCFC. Finally, criteria should include a strong assurance of timely reporting of results and findings.

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