UNITED NATIONS

EP

United Nations Environment Programme

Distr.
GENERAL

UNEP/OzL.Pro/ExCom/89/10/Rev.1
31 May 2022

ORIGINAL: ENGLISH

EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Eighty-ninth Meeting
Montreal, 7-11 March 2022
Postponed to 16, 18 and 20 May 2022 (part I) and
16-18 June 2022 (part II)[1]

ANALYSIS OF THE INCREMENTAL CAPITAL COSTS AND INCREMENTAL OPERATING COSTS AND THEIR DURATION, AND THE COST-EFFECTIVENESS OF ALL APPROVED INVESTMENT PROJECTS IN THE RELEVANT MANUFACTURING SECTORS AND SUB-SECTORS (DECISION 84/87(a))[2]

Background

1. In the context of the development of the cost guidelines for the phase-down of HFCs in Article 5 countries, the Executive Committee has decided, in relation to the incremental costs for the consumption manufacturing sector, to agree on the categories of cost determined by decision XXVIII/2 of the Parties and to include them in the draft template of the HFC phase-down cost guidelines. By means of decision 78/3(f), the Executive Committee made the following categories of costs eligible:

(a) Incremental capital costs (ICCs);

(b) Incremental operating costs (IOCs) for a duration to be determined by the Executive Committee;

(c) Technical assistance activities;

(d) Research and development, when required to adapt and optimize low-global warming potential (GWP) or zero-GWP alternatives to HFCs;

[1] Due to coronavirus disease (COVID-19), part I of the 89th meeting will be held online while part II will be held in-person.

[2] **The present document is issued as a revision to document UNEP/OzL.Pro/ExCom/89/10, to make several corrections and to regroup projects in stage I of the sector plan for the industrial and commercial refrigeration, air-conditioning and heat-pump water heater sector in China, previously collectively presented in Table 4, as follows: projects related to air-conditioning have been moved to Table 2, compressor projects have been moved to Table 6, and projects related to commercial refrigeration have remained in Table 4. For ease of reference, all modifications made in Tables 2, 4 and 6, and in paragraphs 20, 22 and 24, are shown in bold.**

(e) Costs of patents and designs, and incremental costs of royalties, when necessary and cost-effective; and

(f) Costs of the safe introduction of flammable and toxic alternatives.

2. Furthermore, at its 78th meeting, the Executive Committee decided to consider approving a limited number of HFC-related projects in the manufacturing sector only,[3] to gain experience in the ICCs and IOCs that might be associated with phasing down HFCs in Article 5 countries (decision 78/3(g)).[4] The Executive Committee further agreed to adopt additional criteria that these projects should meet, and to consider further stand-alone investment projects on a rolling basis after the first meeting in 2019 (decision 79/45).

3. Subsequently, at its 84th meeting, the Executive Committee *inter alia:*

(a) Decided to continue considering proposals for HFC-related stand-alone investment projects up to the 87th meeting, in accordance with the criteria set out in decisions 78/3(g), 79/45 and 81/53, and prioritizing projects in the stationary air-conditioning (AC), commercial refrigeration and mobile AC sectors (decision 84/53); and

(b) Requested the Secretariat to prepare, for the 86th meeting, a document providing analysis of and information, including aggregated information, in tabular form, on the ICCs and IOCs and their duration, and the cost-effectiveness of all approved investment projects in the relevant manufacturing sectors and sub-sectors, including the controlled substances that had been phased out and the alternative substances that had been phased in (decision 84/87(a)).

Scope of the document

4. In line with decision 84/87(a), the Secretariat submitted the present document to the 89th meeting. This document was originally requested for the 86th meeting, but its consideration has been deferred to the 89th meeting in accordance with the agreed procedures for conducting the 86th, 87th and 88th meetings in light of the COVID-19 pandemic. The present document is a re-issue of the documents submitted to the previous meetings,[5] with some necessary updates, including the addition of a new entry in Table 7 to reflect the polyurethane (PU) foam project that was approved for Bahrain at the 88th meeting.

5. In addition, the Secretariat is preparing an addendum to the present document to provide a preliminary analysis of the ICCs and IOCs incurred in four completed HFC-related stand-alone investment projects approved pursuant to decision 78/3(g). Due to a number of factors, including the impact of the COVID-19 pandemic, the dates of completion for the remaining projects approved pursuant to decision 78/3(g) were extended, and their final reports have not yet been received. The Secretariat will update the analysis contained in the addendum for a future meeting, once the remaining final reports are

[3] Such approvals would be on the understanding: that any Article 5 country submitting a project proposal should have ratified the Kigali Amendment or submitted a formal letter indicating the government's intention to ratify the Amendment; that no further funding would be available until the instrument of ratification had been received by the depositary at the United Nations Headquarters in New York; and that any amount of HFC reduced as a result of the project would be deducted from the starting point.

[4] To consider approving a limited number of HFC-related projects in the manufacturing sector only, without prejudice to different kinds of technology, no later than at the first meeting of 2019, to allow the Committee to gain experience in the ICCs and IOCs that might be associated with phasing down HFCs in Article 5 countries, on the understanding: that any Article 5 country that submitted a project should have ratified the Kigali Amendment or submitted a formal letter indicating the government's intention to ratify the Amendment; that no further funding would be available until the instrument of ratification had been received by the depositary at the Headquarters of the United Nations in New York; and that any amount of HFC reduced as a result of the project would be deducted from the starting point.

[5] UNEP/OzL.Pro/ExCom/86/91, UNEP/OzL.Pro/ExCom/87/49, and UNEP/OzL.Pro/ExCom/88/74

submitted by the implementing agencies.

6. The present document contains an analysis of the relevant policies and practices applied to incremental costs and cost-effectiveness thresholds under the Multilateral Fund; an analysis of the ICCs and IOCs and their duration, and of the cost-effectiveness of approved projects in the relevant manufacturing sectors and sub-sectors, including the controlled substances that had been phased out and the alternative substances that had been phased in; and a recommendation.

ANALYSIS OF THE POLICIES AND PRACTICES

Policy background

7. A detailed analysis of previous policy and practice applied to incremental costs and cost-effectiveness thresholds under the Multilateral Fund is contained in the document on Information relevant to the development of the cost guidelines for the phase-down of HFCs in Article 5 countries: draft criteria for funding.[6] This section presents a summary of the most relevant aspects of that discussion for the purpose of this document.

8. In early 1995, cost-effectiveness threshold values were established to prioritize approvals of investment projects, since the level of funding requested in submitted projects was above the level of funding available at that time in the Multilateral Fund. This permitted an equitable distribution of the available funding between the various sectors, covering all Article 5 countries and ensuring that no sectors were left without financial support.[7]

9. The Secretariat assesses incremental costs[8] based on, *inter alia*, the eligibility of the enterprise and the manufacturing line, the baseline equipment in the enterprise, the number of products manufactured, the amount of controlled substances and other raw materials used, the consideration of technological upgrades[9] and the alternative technology selected. Once all technical and cost issues have been satisfactorily addressed and an agreement on the incremental costs has been reached between the Secretariat and relevant bilateral/implementing agencies, the cost-effectiveness of the project is calculated by dividing the agreed level of funding by the total amount of controlled substances to be phased out. In cases where an enterprise is partially owned by non-Article 5 capital, the agreed level of funding is adjusted by proportionally deducting the foreign share ownership of the enterprise.[10] In cases where an enterprise exports part of its production to non-Article 5 countries, the agreed funding could also be adjusted depending on the percentage of export of the total production.[11] As the total amount of controlled substances used by the enterprise counts as phase-out (irrespective of the local share ownership), the resulting "adjusted" cost-effectiveness value of the project will be lower (in absolute numbers) than if the enterprise was completely locally owned.

10. At the 55th meeting (July 2008), the Secretariat prepared a document on revised analysis of relevant cost considerations surrounding the financing of HCFC phase-out (decisions 53/37(i) and 54/40),[12] which served as a reference to bilateral and implementing agencies when preparing HCFC phase-out projects in the foam, refrigeration and AC sectors.[13] In particular:

[6] Paragraphs 44 to 87 of document UNEP/OzL.Pro/ExCom/78/5
[7] UNEP/OzL.Pro/ExCom/58/47
[8] Incremental costs comprise the ICCs and the IOCs.
[9] Decisions 18/25 and 25/48
[10] In line with the decision on transnational corporations adopted at the 7th meeting (paragraph 88 of document UNEP/OzL.Pro/ExCom/7/30).
[11] In line with the decision on guidelines for enterprises that export part of their production to non-Article 5 countries adopted at the 15th meeting (paragraphs 146 and 147 of document UNEP/OzL.Pro/ExCom/15/45).
[12] UNEP/OzL.Pro/ExCom/55/47
[13] Agencies are requested to use the technical information contained in document as a guide (decision 60/44/(f)(i)).

(a) Annex III contains detailed information on equipment required and estimation of ICCs and IOCs for the conversion from HCFC to several alternatives (i.e., hydrocarbon (HC), HFC-245fa, methyl formate (MF), and water-based) in several PU foam applications (i.e., panels, pipe-in-pipe foam, thermoware, domestic refrigerators, spray foam, discontinuous block foam and integral skin), including several plant capacities; and

(b) Annex IV provides technical considerations when replacing HCFC-22 in the refrigeration and AC sector with several alternatives (i.e., R-410A, R-407C, R-404A, HFC-134a and R-290) and general estimations of ICCs and IOCs for the conversion of manufacturing plants to those alternatives in room and mini-split AC units, ducted commercial and packaged air conditioners, chillers, and several commercial refrigeration applications (i.e., stand-alone equipment, stand-alone commercial-sized freezers, beverage vending machines, and condensing units).

11. In reviewing the HCFC phase-out investment projects (as stand-alone projects or as a component of HPMPs) in the foam and commercial refrigeration manufacturing sectors, the Secretariat has taken into consideration document UNEP/OzL.Pro/ExCom/55/47; information from approved projects; updated information on alternatives produced by TEAP; and consultation with independent experts, as required.

12. In addition, the Secretariat used as a reference for the recommendation on funding, the cost-effectiveness threshold values used for CFC phase-out,[14] and the additional cost-effectiveness threshold set in decision 62/13.[15] Funding of up to a maximum of 25 per cent above the threshold is provided when low-GWP alternative technologies are introduced (decision 60/44(f)(iv)). For stage II of the HPMPs, up to 40 per cent above the cost-effectiveness threshold is provided when low-GWP alternative technologies are introduced by small and medium-sized enterprises (SMEs) in the foam sector with consumption of less than 20 metric tonnes (mt) (decision 74/50(c)(iii)). With regard to the aerosol, fire extinguisher and solvent sectors, the eligibility of incremental costs is considered on a case-by-case basis (decisions 60/44(f)(xvi) and 74/50(c)(xvii)).

13. As CFCs were not extensively used in the stationary AC manufacturing sector, a cost-effectiveness threshold for this sector was not established. However, in reviewing HCFC phase-out investment projects submitted under this sector, the Secretariat has been guided by the technical information contained in the document on the revised analysis of relevant cost considerations surrounding the financing of HCFC phase-out (in line with decision 60/44(f)(i)),[16] and the maximum allowable level of IOCs of US $6.30/kg (in line with decision 60/44(f)(viii)).

14. A summary of the existing cost-effectiveness thresholds currently being applied is presented in Table 1 below.

[14] Paragraph 32 of the final report of the 16th meeting, document UNEP/OzL.Pro/ExCom/16/20

[15] At the 60th meeting, the Government of Colombia submitted a stand-alone project for the conversion of four domestic refrigeration manufacturing enterprises using HCFCs for the production of PU rigid insulation foam. The project was approved with a cost-effectiveness of US $12.02/kg, which was below the thresholds of US $13.76/kg for domestic refrigeration and US $15.21/kg for commercial refrigeration (UNEP/OzL.Pro/ExCom/60/25). However, at the 62nd meeting, based on the experience gained from the review of similar projects, the Committee established the cost-effectiveness threshold for rigid insulation refrigeration foam at US $7.83/kg with a maximum of up to 25 per cent above this threshold for low-GWP alternatives.

[16] UNEP/OzL.Pro/ExCom/55/47

Table 1: Cost-effectiveness (CE) thresholds for CFC and HCFC phase-out

Sector	National ODS phase-out plans (UNEP/OzL.Pro/ExCom/16/20 para. 32)			HPMPs (decisions 60/44, 62/13 and 74/50)		
	Baseline substance	Main alternatives introduced	CE threshold (US $/kg)	Baseline substance	Main alternatives introduced	CE threshold (US $/kg)
Domestic refrigeration (refrigerant and PU foam panel components)	CFC-12	HFC-134a R-600a	13.76	n.a.	n.a.	n.a.
	CFC-11	HCFC-141b cyclopentane		HCFC-141b	Cyclopentane	7.83*,**
Commercial refrigeration (refrigerant and PU foam panel components)	CFC-12	HFC-134a	15.21	HCFC-22	HFC-32, R-290, HFC-134a, carbon dioxide (CO_2), ammonia (NH_3), cascade systems	15.21*
	CFC-11	HCFC-141b cyclopentane water		HCFC-141b	Cyclopentane, water, MF, methylal, HFC-245fa, reduced HFO	
Rigid PU foam (including PU foam panel in commercial refrigeration)	CFC-11	HCFC-141b cyclopentane water	7.83	HCFC-141b	Cyclopentane, water, MF, methylal, HFC-245fa, reduced hydrofluoroolefins (HFOs)	7.83*,**
Flexible PU foam	CFC-11	HCFC-141b cyclopentane water	6.23	HCFC-141b	Cyclopentane, water, MF, methylal, HFC-245fa, reduced HFOs	6.23*,**
Integral skin	CFC-11	HCFC-141b cyclopentane water	16.86	HCFC-141b	Cyclopentane, water, MF, methylal, HFC-245fa, reduced HFOs	16.86*,**
XPS foam	CFC-12	HFC-134a	8.22	HCFC-22/ HCFC-142b	HC, CO_2	8.22*,**
Aerosol	CFC-12/ CFC-11	HC	4.40	HCFC-22/ HCFC-141b	HC HFC-134a, HFC-152a, perchloretylene, HFO	Case-by-case
Fire extinguishing	Halon	ABC dry powder, CO_2	1.48	HCFC-123	No projects approved yet	Case-by-case
Solvent	CFC-113	Heat cleaning, aqueous cleaning, trichlorethylene, HC, others	19.73	HCFC-141b	Iso-paraffin	Case-by-case
Solvent	TCA		38.50	n.a	n.a	n.a
Metered dose inhaler (MDI)	CFC-12/ CFC-11	HFC-134a	n.a	n.a	n.a	n.a
Mobile AC	CFC-12	HFC-134a	n.a	n.a	n.a	n.a
Domestic AC manufacturing (room AC, domestic heat pumps)	n.a.	n.a	n.a	HCFC-22	R-410A HFC-32 R-290	Case-by-case

Sector	National ODS phase-out plans (UNEP/OzL.Pro/ExCom/16/20 para. 32)			HPMPs (decisions 60/44, 62/13 and 74/50)		
	Baseline substance	Main alternatives introduced	CE threshold (US $/kg)	Baseline substance	Main alternatives introduced	CE threshold (US $/kg)
Other refrigeration and AC manufacturing (heat pumps, transport, chillers, industrial)	CFC-11/ CFC-12 (chillers)	HFC-134a/ HFC-123 (chillers)	n.a	HCFC-22	R-410A HFC-32 R-290 CO_2, NH_3, cascade systems	Case-by-case

* Funding of up to a maximum of 25 per cent above the cost effectiveness threshold will be provided for projects when needed for the introduction of low-GWP alternatives (decision 60/44(f)(iv)).

** For SMEs in the foam sector with consumption of less than 20 mt, the maximum would be up to 40 per cent above the cost-effectiveness threshold (decision 74/50(c)(iii)).

Previous policy on the duration of IOCs

15. At their Fourth Meeting (November 1992), the Parties established the Multilateral Fund and approved the indicative list of categories of incremental costs, as set out in Annex VIII to the report of the meeting (decision IV/18). In doing so, the Parties noted that the evaluation of requests for financing the incremental costs of a given project should take into account a number of general principles, including the principle that the funding of incremental costs is intended as an incentive for early adoption of ozone-protecting technologies. The Parties also noted that incremental recurring costs (i.e., IOCs) apply only for a transition period to be defined. In this respect, the Executive Committee was given the mandate to decide on the appropriate time scales for payment of incremental costs in each sector.

16. Further to this mandate, the Executive Committee has considered a variety of factors in deciding the duration of IOCs. In particular, the Committee considered that incremental costs were intended as an incentive for early adoption of alternatives and, therefore, providing IOCs for a transitional period was considered to help safeguard those enterprises that phase out their consumption of controlled substances early from being at a competitive disadvantage. On this basis, for the phase-out of CFCs, the Executive Committee approved IOCs for projects whose duration has varied by sector and with time.

17. For the phase-out of HCFCs, decision 60/44 provides specific criteria on the duration of the period during which IOCs can be claimed in the refrigeration, AC and foam sectors (which represent most uses of HCFC in the manufacturing sector in Article 5 countries). With regard to the aerosol, fire extinguisher and solvent sectors, the eligibility of incremental costs will be considered on a case-by-case basis (decision 60/44(f)(xvi)). Subsequently, in considering a stand-alone project proposal in the aerosol sector[17] submitted to the 62nd meeting, the Committee noted that in decision 60/44 the duration of IOCs had been agreed for a one-year period for most of the other sectors, and decided that the IOCs for the aerosol sector should be determined on the basis of a one-year duration (decision 62/9).

ANALYSIS OF ICCs AND IOCs OF APPROVED PROJECTS

18. The present document provides aggregated information on the ICCs and IOCs and their duration, and the cost-effectiveness of approved investment projects under stages I and II of HPMPs.[18] In preparing this information, the Secretariat took into consideration the following:

[17] The project for the phase-out of 130.7 mt (11.1 ODP tonnes) of HCFC-22 and HCFC-141b used in aerosol products at Silimex (Mexico), submitted by UNIDO, originally requested operating costs calculated over a four-year period (paragraphs 23 to 26 of document UNEP/OzL.Pro/ExCom/62/10).

[18] Similar information was prepared for the Executive Committee's consideration in document UNEP/OzL.Pro/ExCom/71/57 for the discussion on the criteria for funding stage II of the HPMPs.

(a) The analysis includes the investment projects at eligible enterprises;[19] HCFCs that were phased out outside of the projects, i.e., without assistance from the Multilateral Fund, are not included;

(b) ICCs and IOCs do not reflect savings that were returned to the Multilateral Fund upon completion of the project;

(c) ICCs and IOCs do not reflect adjustments to the agreed incremental costs of the investment projects after approval; e.g., the costs for stage II of the HPMP for China do not reflect the reduced costs agreed at the 84th meeting, but the costs as approved at the 76th and 77th meetings and reflected in the Agreement approved at the 79th meeting;

(d) Investment projects that were approved but subsequently cancelled prior to implementation are not included;

(e) In cases where the distribution of the cost among ICCs and IOCs is not available, whenever possible it has been estimated based on the project proposal;

(f) Demonstration projects are presented separately as the incremental costs of such projects may differ from subsequent conversion projects given their demonstrative nature; and

(g) The actual number of enterprises that would be converted during stages I and II of the HPMP for China were not known at the time of submission of the HPMP; in the sectors where this number has already been determined, the value has been included.

19. The Secretariat notes that all HCFC phase-out investment project proposals, either submitted as stand-alone projects or covering several enterprises under an umbrella/sector approach, have been recommended for approval within the applicable cost-effectiveness thresholds. This is the case even though, in some instances, the cost-effectiveness values of individual enterprises, or a group of enterprises within an umbrella project, were above the threshold, in line with previous policies.

Projects approved in the AC manufacturing sector

20. Table 2 presents an analysis of investment projects in the AC manufacturing sector undertaken under stages I and II of the HPMPs of 13 Article 5 countries.[20] Implementation of these projects will result in the phase-out of **1,738** ODP tonnes (**31,596** mt) of HCFC-22, at a total cost of US $**226,020,919** and an overall cost-effectiveness of US $**7.15**/kg. These projects include:

(a) *Stage I:* Conversion of enterprises in nine Article 5 countries consuming **1,124** ODP tonnes (**20,431** mt) of HCFC-22, at a total cost of US $**125,269,087**, resulting in an overall cost-effectiveness of US $**6.13**/kg. Replacement technologies included R-410A, HFC-32**, HFC-134a,** and R-290; and

(b) *Stage II:* Conversion of enterprises in seven Article 5 countries consuming 614 ODP tonnes (11,165 mt) of HCFC-22, at a total cost of US $100,751,832, resulting in an overall cost-effectiveness of US $9.02/kg. Replacement technologies included HFC-32, HFO and R-290.

[19] In the case of China, the value of the investment component of each sector plan was agreed by the Executive Committee meeting for a specific level of HCFC phase-out at the time of approval of stage I (64th meeting) and stage II (76th and 77th meeting), and this funding was subsequently allocated to eligible enterprises during implementation.

[20] The conversion projects in Bahrain (decision 84/65(a)(ii)), Brazil (decision 86/89(a)(iii) and (iv)), Philippines (decision **87/19(b) ~~to be taken at the 87th meeting~~**), and Tunisia (decision 83/28(a)) were cancelled prior to implementation and are not included in the table.

Table 2. Analysis of HCFC phase-out investment projects in the AC manufacturing sector

Country*	Sector	HCFC-22 (ODP tonnes)	Replacement technology	Cost (US $)			CE (US $ /kg)
				Approved	ICCs	IOCs	
Stage I							
Algeria (1)	Room AC	8.30	HFC-32	1,379,460	433,200	946,260	9.19
Argentina (9)	Room AC	53.50	R-410A	8,435,542	3,161,385	5,274,157	8.68
China (TBD)	Room AC	153.15	R-410A	4,548,219	n.a.	n.a.	1.63
	Room AC	393.58	R-290	56,276,018	35,410,952	20,865,066	7.86
	Commercial AC	**368.56**	**R-410A, HFC-32, HFC-134a**	**32,121,055**	**23,097,944**	**9,023,111**	**4.79**
Indonesia (21)	Commercial / Room AC	36.00	HFC-32	4,728,453	2,633,748	2,094,705	7.24
Islamic Republic of Iran (1)	Room AC	35.40	R-410A	3,950,246	594,064	3,356,182	6.14
Jordan (2)	AC	1.43	R-410A	628,000	464,200	163,800	24.15
Jordan (1)	AC / Commercial refrigeration**	6.90	R-410A	2,167,033	882,772	1,284,261	15.89
Lebanon (1)	Room AC	4.90	R-410A	920,600	353,600	567,000	10.33
Syrian Arab Republic (1)	Several AC	4.98	R-410A	994,520	525,800	468,720	10.98
Thailand (12)	Room AC	57.00	HFC-32	9,119,941	4,612,410	4,507,531	8.80
Sub-total stage I		**1,123.70**		**125,269,087**	**72,170,075**	**48,550,793**	**6.13**
Stage II							
Bangladesh (4)	Room AC	16.96	R-290	4,844,842	2,901,695	1,943,147	15.71
Bangladesh (1)	Commercial AC	0.13	HFC-32	74,824	60,000	14,824	31.84
China (TBD)***	Room AC **and heap-pump water heater**	446.71	R-290****	68,042,072	34,591,350	33,450,722	8.38
Egypt (5)	Room AC	65.44	HFC-32	10,751,623	4,253,197	6,498,426	9.04
India (6)	Room AC	62.72	HFC-32	12,511,459	5,327,575	7,183,884	10.97
Lebanon (3)	Commercial AC	1.96	HFC-32	424,765	204,880	219,885	11.92
Lebanon (2)	Commercial AC	3.17	HFC-32/ HFO	440,260	288,430	151,830	10.78
Pakistan (1)	Room AC	7.39	R-290	1,561,720	715,000	846,720	11.62
Viet Nam (4)	Room / Commercial AC	9.63	HFC-32	2,100,267	1,126,050	974,217	12.00
Sub-total stage II		**614.10**		**100,751,832**	**49,468,177**	**51,283,655**	**9.02**
Total		**1,737.80**		**226,020,919**	**121,638,252**	**99,834,448**	**7.15**

* The numbers in parentheses represent the number of enterprises to be converted.
** Assisted enterprise also converted 1.2 ODP tonnes of HCFC-141b used in commercial refrigeration panels to cyclopentane.
*** The Executive Committee subsequently adjusted the costs of this project (decisions 84/69, and decisions 86/34 to 86/40).
**** Does not include the planned conversion of two heat-pump water heater manufacturing lines to CO_2 that was cancelled prior to implementation.

21. In addition, the Executive Committee approved five projects to demonstrate low-GWP technologies in several AC applications as shown in Table 3, noting that their incremental costs may differ from those in the investment projects, given their demonstrative nature.

Table 3. Low-GWP technology demonstration projects in the AC manufacturing sector

Country	Sector	HCFC-22 (ODP tonnes)	Replacement technology	Cost (US $)			CE (US $/kg)
				Approved	ICCs	IOCs	
China	Room AC (Midea)	13.20	R-290	4,026,507	2,816,907	1,209,600	16.78
China	Commercial AC (Tsinghua Tong Fang Artificial Env. Co. Ltd)*	3.40	HFC-32	1,229,336	552,928	676,408	19.86

Country	Sector	HCFC-22 (ODP tonnes)	Replacement technology	Cost (US $)			CE (US $/kg)
				Approved	ICCs	IOCs	
Colombia	Commercial AC (Thermotar)**	0.73	R-290	500,000			37.68
Saudi Arabia	Packaged AC (Petra KSA)***	3.59	R-290 and HFC-32	554,400			8.49
Saudi Arabia	Room AC (Alessa)	0	Low-GWP alternatives	1,300,000			n/a

* Small-sized commercial air-source water chillers/heat pumps.

** Condensing units and ducted package-type systems.

*** A portion of the project at the Saudi Factory for Electrical Appliances Co. Ltd. was cancelled prior to implementation (decision 82/22) and is not included in Table 3.

Projects approved in the industrial and commercial refrigeration (ICR) manufacturing sector

22. Table 4 presents an analysis of investment projects in the ICR manufacturing sector undertaken under stages I and II of the HPMPs of eight Article 5 countries. Implementation of those projects will result in the phase-out of **520** ODP tonnes (**9,460** mt) of HCFC-22 and **46** ODP tonnes (**422** mt) of HCFC-141b at a total cost of US $**105,209,158**. The overall cost-effectiveness of the conversion of this sector is US $**11.12**/kg. These projects include:

(a) *Stage I:* Conversion of enterprises in five Article 5 countries consuming **87** ODP tonnes (**1,575** mt) of HCFC-22, and 46 ODP tonnes (422 mt) of HCFC-141b at a total cost of US $**17,315,593**, resulting in an overall cost-effectiveness of US $**10.99**/kg. Replacement technologies included R-410**A**, R-404A, HFC-134a, ~~**HFO,**~~ HFC-32, CO_2, NH_3 and R-290; and

(b) *Stage II:* Conversion of enterprises in four Article 5 countries consuming **434** ODP tonnes (**7,885** mt) of HCFC-22 ~~**and 2.70 ODP tonnes (24.54 mt) of HCFC-141b**~~, at a total cost of US $87,893,565, resulting in an overall cost-effectiveness of US $**11.15**/kg. Replacement technologies included HFC-32, R-600a, R-290, CO_2, HFOs pure and in blends and NH_3, while no conversions to R-410A, R-404A or HFC-134a were funded under stage II of the HPMPs.

Table 4. Analysis of HCFC phase-out investment projects in the ICR manufacturing sector

Country*	Sector	Consumption (ODP tonnes)		Replacement technology	Cost (US $)			CE (US $/kg)
		HCFC-22	HCFC-141b		Approved	ICCs	IOCs	
Stage I								
Armenia (1)	Commercial refrigeration	1.40	0.87	R-290	534,353	534,353	0	16.19
Bosnia and Herzegovina (6)	Commercial refrigeration	0.80	0.20	R-410A, R-404A	247,923	166,108	81,815	15.24
China (**5**) **	Commercial refrigeration	**73.05**	0.00	**NH_3/CO_2, NH_3, HFC-134a, CO_2**	**12,150,538**	**8,620,044**	**3,530,495**	**9.15**
Indonesia (33)	Commercial refrigeration	9.10	45.40	HFC-32/CO_2/ NH_3/HC	4,022,649	3,464,450	438,199	8.11
Serbia (4) ***	Commercial **AC &** refrigeration	2.30	0.00	NH_3/R-410A	360,130	360,130	0	8.73
Sub-total stage I		**86.65**	**46.47**		**17,315,593**	**13,145,085**	**4,050,509**	**10.99**
Stage II								
Brazil (25)	Commercial refrigeration	15.74	0.00	R-290, R-600a, CO_2, HFOs pure/ blends	2,695,332	2,472,500	222,832	9.42
China (TBD) ****	**Commercial refrigeration**, **AC**	**357.5**	**0.00**	R-290, **R-513A,** NH_3/CO_2, HFC-32, CO_2	77,744,313	52,636,713	25,107,600	11.96

Country*	Sector	Consumption (ODP tonnes)		Replacement technology	Cost (US $)			CE (US $/ kg)
		HCFC-22	HCFC-141b		Approved	ICCs	IOCs	
	& heat-pump water heaters							
Iran (Islamic Republic of) (43)	Commercial refrigeration	43.75	0.00	R-290, CO_2	3,817,920			4.80
Viet Nam	Commercial refrigeration	16.67	0.00	low-GWP	3,636,000	2,484,600	1,151,400	12.00
Sub-total stage II		**433.66**	**0.00**		87,893,565	57,593,813	26,481,832	**11.15**
Total		**520.31**	**46.47**		**105,209,158**	**70,738,898**	**30,532,341**	**11.12**

* The numbers in parentheses represent the number of enterprises to be converted.
** **Eight** equipment manufacturing lines in **five** enterprises.
*** **In three of these four SMEs manufacturing commercial refrigeration equipment, a minor component of manufacturing also included AC equipment**.
**** The Executive Committee subsequently adjusted the costs of this project (decisions 84/69, and 86/34 to 86/40). **The approval also includes commercial AC units and heat pump water heaters; however, the portion to be used for AC could only be extracted and moved to Table 2 (AC) after stage II of the ICR sector plan is completed. An additional 120.29 ODP tonnes of HCFC-22 and 2.7 ODP tonnes of HCFC-123 will be phased out through regulatory measures.**

23. The Executive Committee also approved three projects to demonstrate low-GWP technologies in the ICR manufacturing sector, as shown in Table 5, noting that their incremental costs may differ from those in the investment projects, given their demonstrative nature.

Table 5. Low-GWP technology demonstration projects in the ICR manufacturing sector

Country	Sector	HCFC-22 (ODP tonnes)	Replacement technology	Cost (US $)			CE (US $ /kg)
				Approved	ICCs	IOCs	
Stage I							
China	ICR (Yantai Moon)	13.75	NH_3, CO_2	3,964,458	2,847,590	1,116,868	15.86
Costa Rica	ICR (end-user)	0.035	NH_3, CO_2	524,000			n/a
Maldives	Fisheries (end-users)	0.00	Low-GWP	141,000			n/a

Projects approved for the conversion of compressor manufacturing capacity

24. Table 6 presents an analysis of **six** projects to convert compressor manufacturing lines to **HFO/HFC-134a, HFC-32, CO_2,** R-290 and NH_3/CO_2 in China at a cost of US $**18,514,717**.

Table 6. Compressor conversion projects approved in the AC and ICR sectors in China

Sector	HCFC-22 (ODP tonnes)	Replacement technology	Cost (US $)
Room AC (demonstration at Meizhi - one line)	n/a	R-290	1,875,000
Room AC (stage I - three lines)	n/a	R-290	4,112,902
Room AC (stage II - three lines) *	n/a	R-290	4,500,000
Commercial AC (stage I, two lines)	**n/a**	**HFO/HFC-134a, HFC-32**	**3,800,000**
Commercial refrigeration (stage I, two lines)	**n/a**	**CO_2, HFC-32**	**3,200,000**
ICR (demonstration at Fuijan Snowman - one line)	**19.59	NH_3/CO_2	1,026,815
Total			**18,514,717**

* During implementation, four manufacturing lines were converted
** Indirect phase-out by manufacturers using 3,000 new converted compressors per year.

Projects approved in the foam sector

25. The two main foam sub-sectors where HCFCs are used in Article 5 countries are the rigid PU foam sector, including integral skin applications, where HCFC-141b is used as a blowing agent (and HCFC-22 to a lesser extent as a co-blowing agent), and the extruded polystyrene (XPS) foam sector, where usually a mixture of HCFC-22 and HCFC-142b is used as a blowing agent.

PU foam

26. The HPMPs of 48 Article 5 countries included projects for the conversion of PU foam enterprises manufacturing various types of foam products.[21] The associated consumption of HCFCs by these enterprises is 7,752 ODP tonnes (70,468 mt) of HCFC-141b and 27 ODP tonnes (485 mt) of HCFC-22. The total funding approved for the conversion of these enterprises amounts to US $352,223,140, resulting in an overall cost-effectiveness of US $5.00/kg, as shown in Table 7. These projects include:

(a) *Stage I:* Conversion of enterprises in 41 Article 5 countries consuming 3,272 ODP tonnes (29,746 mt) of HCFC-141b and 27 ODP tonnes (485 mt) of HCFC-22, at a total cost of US $167,425,188, resulting in an overall cost-effectiveness of US $5.63/kg. Replacement technologies include mainly cyclopentane, followed by MF, methylal, CO_2, and in two cases HFC-245fa; and

(b) *Stage II:* Conversion of enterprises in 21 Article 5 countries consuming 4,479.53 ODP tonnes (40,723 mt) of HCFC-141b, at a total cost of US $184,797,952, resulting in an overall cost-effectiveness of US $4.54/kg. Replacement technologies include cyclopentane, n-pentane, HFOs, MF, methylal, and CO_2.

Table 7. Analysis of HCFC phase-out investment projects in the rigid PU foam manufacturing sector

Country*	HCFC-141b (ODP tonnes)	Replacement technology	Cost (US $)			CE (US $/kg)
			Approved	ICCs	IOCs	
Stage I						
Algeria (1)	2.40	Cyclopentane	215,380	216,045	(665)	9.87
Argentina (1)	18.46	Cyclopentane	838,612	837,210	1,402	5.00
Bangladesh (1)	20.20	Cyclopentane	1,146,074	1,025,750	120,324	6.24
Bosnia and Herzegovina (1)	4.78	Cyclopentane	425,361	363,149	62,212	9.79
Brazil (4)	32.50	Cyclopentane	2,136,135	2,307,610	(171,475)	7.23
Brazil (8)	47.3	MF	2,155,419	1,881,881	273,536	5.01
Cameroon (9)	15.70	MF	310,900	310,900	0	2.18
China (54)	1,403.92	Cyclopentane	63,363,428			4.96
Colombia (4)	46.21	Cyclopentane	5,621,483	5,058,456	563,027	9.39
Costa Rica (1)	14.00	Cyclopentane	593,523	593,523	0	4.66
Croatia (1)	1.76	Water/CO_2	210,000	210,000	0	13.13
Cuba (5)	13.35	Cyclopentane	1,187,527	1,187,527	0	9.78
Democratic Peoples's Republic of Korea (2)	14.38	MF	418,550	418,550	0	3.20
Dominican Republic (1)	3.70	Cyclopentane	332,775	316,775	16,000	9.89
Dominican Republic (13)	15.77	MF	663,450	480,700	182,750	4.63
Ecuador (1)	14.96	Cyclopentane	1,331,440	1,198,440	133,000	9.79
Ecuador (7+SMEs)	4.85	Pre-blended HC, water, HFO	431,719			9.79
Egypt (8)	77.54	Cyclopentane/MF	3,359,155	3,617,900	(258,745)	4.77
El Salvador (3)	4.94	Cyclopentane/MF	439,277	424,427	14,850	9.78
Eswatini(1)	7.70	Cyclopentane	667,948	667,948	0	4.77
Guatemala (1)	1.40	Cyclopentane	109,637	109,637	0	8.61
India (16)	310.53	Cyclopentane	13,981,990	12,631,330	1,350,660	4.95
Indonesia (26)	33.51	HFC-245fa	2,714,187	2,706,587	7,600	8.91
Indonesia (4)	10.40	Cyclopentane	777,395	775,287	(2,108)	8.22
Islamic Republic of Iran (23)	62.56	Cyclopentane	4,782,642	5,325,750	(543,109)	8.41

[21] For example, insulation foam for domestic refrigerators, panels, insulation for water heaters, block, and integral skin.

Country*	HCFC-141b (ODP tonnes)	Replacement technology	Cost (US $)			CE (US $/kg)
			Approved	ICCs	IOCs	
Jamaica (1)	3.60	MF	95,450	57,200	38,250	2.92
Kuwait (2 + SMEs)	36.55	Cyclopentane	738,382			2.22
Lebanon (1)	15.10	Cyclopentane	1,342,209			9.78
Libya (3)	23.84	Cyclopentane	1,690,627	1,574,496	(3,869)	7.80
Malaysia (13)	94.60	Cyclopentane	7,327,470	6,816,745	510,725	8.52
Mexico (1)	38.94	Cyclopentane	2,428,987	2,293,104	135,883	3.68
Mexico (3)	22.99	Cyclopentane	2,046,110	1,711,710	334,400	9.79
Morocco (1)	11.00	Cyclopentane	951,740	990,000	(38,260)	9.52
Oman (1)	1.10	Water/CO_2	79,120			7.91
Pakistan (5)	71.60	Cyclopentane	4,840,849	4,844,400	(3,552)	7.44
Philippines (60)	43.00	Cyclopentane/CO_2	2,088,000			5.34
Saudi Arabia (18)	125.10	Pentane	6,882,370	7,642,050	(759,680)	6.05
South Africa (2)	38.90	Cyclopentane	2,498,848	2,498,848	0	7.07
Sri Lanka (1)	0.45	Cyclopentane	18,860	18,860	0	4.61
Sudan (4)	11.87	Cyclopentane	1,056,341	1,056,911	(570)	9.76
Syrian Republic	7.90	Cyclopentane	470,841	456,500	14,341	6.56
Thailand (28)	73.96	Cyclopentane	6,111,060			9.09
Thailand (103)	91.40	HFC-245fa	5,383,202			6.48
Trinidad and Tobago (5)	2.50	MF	173,800	151,900	21,900	7.65
Turkey (sector)	228.63	Cyclopentane	3,631,897	3,050,700	581,197	1.75
Viet Nam (12)	140.10	Cyclopentane	8,876,200	6,837,200	2,039,000	6.97
Zimbabwe (5)	6.10	Cyclopentane	478,818	547,650	(68,832)	8.63
Sub-total stage I	**3,272.05**		**167,425,188**	**83,213,656**	**4,550,192**	**5.63**
Stage II						
Argentina (2)	6.66	Cyclopentane	547,304	547,304	0	9.04
Bahrain (4)	1.37	HFO, CO_2	116,999	116,999	0	9.39
Brazil (13)	56.57	Cyclopentane, MF, water, HFO	**3,478,644	1,772,652	1,705,992	6.76
Chile (5)	12.43	HFO	918,507	594,090	324,417	8.13
China (TBD)***	3,639.35	Cyclopentane, water, HFO	128,950,000			3.90
Colombia (2)	7.23	Cyclopentane	607,675	605,696	1,979	9.24
Colombia (1)	0.73	Water	39,107	16,500	22,607	5.93
Egypt (9)	46.48	Cyclopentane	3,488,388	3,488,388	0	8.26
India (160)	289.31	Cyclopentane, MF, methylal, water	19,936,234	16,278,307	3,657,927	7.58
Indonesia (12)	24.51	Cyclopentane	2,251,650	2,251,650	-	10.11
Islamic Republic of Iran (12)	29.57	Pentane	2,153,773	2,438,700	(284,927)	8.01
Islamic Republic of Iran (2)	4.29	Water	168,350	143,000	25,350	4.32
Jordan (1)	2.62	Cyclopentane	180,946	255,600	(74,654)	7.60
Jordan (53)	35.85	HFO	1,844,788	341,300	1,503,488	5.66
Lebanon (4)	27.74	Cyclopentane	1,669,195	1,839,695	(170,500)	6.62
Lebanon (2)	5.58	HFO	332,680	278,000	54,680	6.56
Malaysia (57)	29.78	HFO	1,795,114	290,388	1,504,726	6.63
Malaysia (10)	41.21	HC and pre-blended HC	2,056,448	1,698,111	358,337	5.49
Nigeria (1)	10.56	Cyclopentane/ MF	664,000	664,000	0	6.92
Nigeria (4)	3.36	Water/MF/CO_2	156,838	60,000	96,838	5.14
Pakistan (11)	58.69	CO_2/water	2,703,552	2,058,671	671,881	5.12
Panama (5)	1.19	HFO	118,000	26,500	91,500	10.95

Country*	HCFC-141b (ODP tonnes)	Replacement technology	Cost (US $)			CE (US $/kg)
			Approved	ICCs	IOCs	
Sudan (6)	27.13	Cyclopentane	2,383,572	2,510,977	(127,405)	9.66
Thailand (71)	31.53	HFO	1,732,597	198,000	1,534,597	6.04
Tunisia (2)	5.02	Cyclopentane & n-pentane	458,306	458,306	0	10.04
Uruguay (19)	5.53	HFO	522,889	106,180	416,709	10.40
Viet Nam (26)	59.09	Cyclopentane	4,325,920	4,325,920	0	8.05
Viet Nam (17)	16.15	HFO	1,196,476	401,240	795,236	8.15
Sub-total stage II	**4,479.52**		**184,797,952**	**43,766,174**	**12,108,778**	**4.54**
Total	**7,751.58**		**352,223,140**	**126,979,830**	**16,658,970**	**5.00**

* The numbers in parentheses represent the number of enterprises to be converted.
** Estimated value from a total of US $15 million approved for the entire foam sector plan.
*** The Executive Committee subsequently adjusted the costs of this project (decision 84/69, and decisions 86/34 to 86/40).

27. In addition, the HPMPs for Argentina, Brazil, Chile, Colombia, Egypt, Indonesia, the Islamic Republic of Iran, Mexico, Nigeria, Saudi Arabia, and South Africa included projects for adapting locally-owned systems houses for manufacturing non-HCFC-141b pre-blended polyol systems and, through them, converting large numbers of downstream foam enterprises, as shown in Table 8. Through the systems house approach, a total of 1,027 ODP tonnes (9,340 mt) of HCFC-141b are being phased out at a cost of US $59,293,863, resulting in a cost-effectiveness of US $6.35/kg as follows:

(a) *Stage I:* A total of 721 ODP tonnes (6,557 mt) of HCFC-141b is being phased out in six countries, at a total cost of US $33,491,832 and cost-effectiveness of US $5.11/kg. Replacement technologies include MF, methylal, cyclopentane and CO_2; and

(b) *Stage II*: A total of 306 ODP tonnes (2,784 mt) of HCFC-141b is being phased out in eight countries at a total cost of US $25,802,031 and cost-effectiveness of US $9.27/kg. Replacement technologies include MF, methylal, cyclopentane, CO_2 and HFOs.

Table 8. Analysis of HCFC-141b phase-out through investment projects with systems houses

Country*	HCFC-141b (ODP tonnes)	Replacement technology	Cost (US $)			CE (US $/ kg)
			Approved	ICCs	IOCs	
Stage I						
Brazil (11, 380)	89.00	Cyclopentane/MF	10,184,564	8,844,212	1,340,351	**12,59
Egypt (4, 80)	75.74	MF	3,800,600	2,974,400	826,200	5.52
Mexico (12, 346)	299.79	MF	11,225,030	7,750,563	3,474,467	4.12
Nigeria (2, 148)	79.50	MF/CO_2	3,709,830	2,507,058	1,202,772	5.13
Saudi Arabia (5, 91)	133.21	Pentane	2,324,700	2,324,700	0	1.18
South Africa (2, 40)	44.00	MF	2,247,108	1,747,358	499,750	2.60
Sub-total stage I	**721.24**		**33,491,832**	**26,148,291**	**7,343,540**	**5.11**
Stage II						
Argentina (2, 139)	51.37	HFO	4,663,827	661,220	4,002,607	9.99
Brazil (14, >400)	115.65	MF, HFO, methylal	***11,521,356	7,111,850	4,411,593	10.96
Chile (2, 36)	10.49	HFO	1,019,627	150,384	869,243	10.70
Colombia (4, 791)	17.77	HFO	1,770,346	1,672,645	Uncertain	10.96
Egypt (1, 28)	5.48	MF	515,605	515,605	0	10.36
Indonesia (2, 200)	18.22	Pre-blended HC, HFO, water	1,762,655	934,385	828,270	10.64
Islamic Republic of Iran (1, 80)	54.08	Water	3,108,134	2,788,594	319,540	6.32

Country*	HCFC-141b (ODP tonnes)	Replacement technology	Cost (US $)			CE (US $/ kg)
			Approved	ICCs	IOCs	
Nigeria (1, 37)	33.15	MF	1,440,480	988,500	451,980	4.78
Sub-total stage II	**306.21**		**25,802,031**	**14,823,183**	**10,881,146**	**9.27**
Total	**1,027.45**		**59,293,863**	**40,971,474**	**18,224,686**	**6.35**

* Values in parentheses: (number of systems houses, estimated number of downstream users).
** In combination with the cost-effectiveness of individual projects, overall cost-effectiveness is US $9.43/kg.
*** Estimated value from a total of US $15 million approved for the PU foam sector plan.

28. Additional funding for technical assistance was approved for systems houses in stage I of the HPMPs for India (US $3,436,500), the Islamic Republic of Iran (US $225,500); Malaysia (US $970,000) and Thailand (US $224,003) without an amount of HCFC to be phased out respectively, except for Thailand with a nominal associated amount of 4.4 mt of HCFC-141b to be phased out.

29. Through the systems house approach, it was expected that the demand for HCFC-141b, particularly by a large number of SMEs, would be substantially reduced, and that the overall cost of the conversion would also be reduced, as many enterprises were expected to choose to convert to one of the non-HCFC-based formulations even before stage II commenced. The impact of these systems houses projects was taken into consideration when stages II were considered for funding.

30. In addition, the Executive Committee approved 13 projects to demonstrate low-GWP technologies in the PU foam manufacturing sector, as shown in Table 9, noting that their incremental costs may differ from those in the investment projects, given their demonstrative nature.

Table 9. Low-GWP technology demonstration projects in the PU foam manufacturing sector

Country	Sector	HCFC-141b (ODP tonnes)	Replacement technology	Approved (US $)	CE (US $/kg)
Brazil	Multiple	-	MF	401,500	n/a
Brazil	Multiple	-	Methylal	464,200	n/a
China	Multiple	6.80	Cyclopentane	1,214,936	19.65
China	Solar water heaters	5.10	Cyclopentane	786,668	16.97
Colombia	Spray foam	-	Supercritical CO_2	441,100	n/a
Colombia	Discontinuous panels	-	HFO	248,380	n/a
Egypt	Multiple	-	Pre-blended HC	473,000	n/a
Egypt	Multiple	4.40	HC	295,000	7.38
Mexico	Integral skin	-	Methylal	291,500	n/a
Morocco	Several SMEs	-	Pentane	280,500	n/a
Saudi Arabia	Spray foam	-	HFO	96,250	n/a
South Africa	Refrigeration insulation	-	Pentane (vacuum assisted injection)	222,200	n/a
Thailand	Spray foam	3.90	HFO-1233zd(E), HFO-1336mzz(Z) with CO_2	352,550	9.94

XPS foam

31. Stages I and II of the HPMPs of nine Article 5 countries had included projects for the phase-out of 2,184 ODP tonnes (37,455 mt) of HCFCs, consisting of 1,376 ODP tonnes (25,015 mt) of HCFC-22 and 808.54 ODP tonnes (12,439 mt) of HCFC-142b. The total funding approved amounts to US $168,495,851, resulting in an overall cost effectiveness of US $4.50/kg, as shown in Table 10. These projects include:

(a) *Stage I:* Conversion of enterprises in seven Article 5 countries consuming 884 ODP tonnes (14,814 mt) of HCFCs, at a total cost of US $62,632,399, resulting in an overall cost-effectiveness of US $4.23/kg. Replacement technologies include CO_2, dimethyl ether (DME), HFO, isobutane and HFC-152a; and

(b) *Stage II:* Conversion of enterprises in three[22] Article 5 countries consuming 1,301 ODP tonnes (22,641 mt) of HCFCs at a total cost of US $105,863,452, resulting in an overall cost-effectiveness of US $4.68/kg. Replacement technologies include CO_2, DME and HFO.

Table 10. Analysis of HCFC phase-out investment projects in the XPS foam manufacturing sector

Country*	HCFC-22	HCFC-142b	Total HCFCs		Replacement technology*	Approved (US $)	CE (US $/kg)
	ODP tonnes		ODP tonnes	mt			
Stage I							
China (25)	316.47	249.34	565.81	9,589.99	CO_2/DME	45,234,352	4.72
Kuwait	46.60	82.70	129.30	2,119.80	CO_2/DME/ HFO	7,943,295	3.75
Mexico (1)	-	6.63	6.63	101.97	HFO/DME	610,258	5.98
Mongolia (2)	0.50		0.50	9.80	HFC-152a	130,000	13.24
Qatar (3)	4.62	7.53	12.16	199.94	CO_2/DME/ HFC-152a	1,510,000	7.55
Saudi Arabia (2)	22.00	33.00	55.00	907.70	Isobutane	1,938,901	2.14
Turkey (4)	45.68	68.52	114.20	1,884.70	HFC-152a/ DME	5,265,593	2.79
Sub-total stage I	**435.87**	**447.72**	**883.59**	**14,813.90**		**62,632,399**	**4.23**
Stage II							
Argentina (2)	1.68	1.74	3.42	57.30	CO_2/DME	348,767	6.09
China (124)**	907.50	357.50	1,265.00	22,000.00	CO_2/DME	102,936,315	4.68
Egypt (4)	30.75	1.58	32.32	583.30	HFO/DME	2,578,370	4.42
Sub-total stage II	**939.93**	**360.82**	**1,300.74**	**22,640.60**		**105,863,452**	**4.68**
Total	**1,375.80**	**808.54**	**2,184.34**	**37,454.50**		**168,495,851**	**4.50**

* The numbers in parentheses represent the number of enterprises to be converted.

** The Executive Committee subsequently adjusted the costs of this project (decision 84/69, and decisions 86/34 to 86/40).

32. The cost-effectiveness of all the projects is below US $6.50/kg, except for Mongolia, where the very low level of HCFC-22 consumption resulted in a cost-effectiveness of US $13.24/kg. IOCs were only requested by four countries: Mexico (US $1.40/kg); Qatar (US $0.50/kg); Saudi Arabia (US $0.13/kg) and Turkey (US $0.37/kg), all within the US $1.40/kg threshold established under decision 60/44(f)(v).

33. It is expected that the projects approved in stages I and II of the HPMPs for these nine countries will result in the complete conversion of the XPS foam sector. It would appear that funding for the conversion of the majority of eligible XPS foam enterprises in Article 5 countries has already been approved.

34. In addition, the Executive Committee approved two projects to demonstrate low-GWP technologies in the XPS foam manufacturing sector, as shown in Table 11, noting that their incremental costs may differ from those in the investment projects, given their demonstrative nature.

Table 11. Low-GWP technology demonstration projects in the XPS foam manufacturing sector

Country	HCFC-22 (ODP tonnes)	HCFC-142b (ODP tonnes)	Total HCFCs		Replacement technology	Approved (US $)	CE (US $/kg)
			ODP tonnes	mt			
China	6.20	6.20	12.40	208.10	CO_2/MF	1,973,300	9.48
Turkey	-	-	-	-	HFO-1234ze/DME	165,000	n.a.

[22] The conversion project in Viet Nam (decision taken at the 87th meeting) was cancelled prior to implementation and not included in the table.

Projects approved in other sectors

35. During stages I and II of the HPMPs, Article 5 countries have included a limited number of investment projects in the aerosol and solvent sectors, as consumption of HCFCs in these sectors is small. Few countries have also requested technical assistance for fire extinguishing but no conversion projects. In line with decisions 60/44(f)(xvi) and 74/50(c)(xvii)), the eligibility of incremental costs for these sectors has been considered on a case-by-case basis. Table 12 below lists the investment projects approved in the solvent sector, and one project approved to demonstrate a low-GWP alternative technology to HCFC-141b in solvent applications, the incremental costs of which may differ from those in the investment projects, given its demonstrative nature.

Table 12. Analysis of HCFC phase-out investment projects in the solvent sector

Country	Consumption (ODP tonnes)			Replacement technology	Cost (US $)			CE (US $/kg)
	HCFC-22	HCFC-141b	Total		Approved	ICCs	IOCs	
Stage I								
China	0	69.00	69.00	KC-6,* HC, HFE	**5,000,000			7.97
Tunisia	0	0.94	0.94	HFC-365mfc	182,500	157,500	12,000	21.47
Sub-total stage I	**0**	**69.94**	**69.94**		**5,182,500**	**157,500**	**12,000**	**8.15**
Stage II								
China	0	159.80	159.80	KC-6	13,565,034	13,808,832	(243,798)	9.34
China	0	77.18	77.18	HC	8,760,807	9,842,707	(1,081,900)	12.49
China	0	81.72	81.72	HC/HFE solvents	9,115,159	8,718,696	396,463	12.27
China	0	81.72	81.72	HC/HFE formulations	11,171,640	0	11,171,640	15.04
Mexico	20.09	19.51	39.60	Perchloretylene/ HFC-152a	1,731,403	470,420	1,260,983	3.19
Mexico	1.03	22.73	23.76	HFO-1233zd(E)	1,551,229	0	1,551,229	6.88
Sub-total stage II	**21.12**	**442.65**	**463.77**	**-**	**45,895,273**	**32,840,655**	**13,054,618**	**10.41**
Grand total	**21.12**	**512.59**	**533.71**	**-**	**51,077,773**	**32,998,155**	**13,066,618**	**10.13**
Project to demonstrate a low-GWP alternative to HCFC in the solvent sector								
China	0	3.06	3.06	KC-6	557,667			20.05

* Any organic or inorganic chemical compounds of silicon, oxygen, and usually carbon and hydrogen, based on the structural unit R2SiO, where R is an alkyl group, usually methyl.

**This is the value of the entire sector plan. The portion allocated to conversion projects is not available but estimated to be close to 90 per cent of the value.

36. The only HCFC phase-out investment project in the aerosol manufacturing sector was to phase out 3.3 ODP tonnes (60.0 mt) of HCFC-22 and 7.8 ODP tonnes (70.9 mt) of HCFC-141b used for the manufacturing of technical aerosol products in Mexico.[23] The total cost of the project amounted to US $520,916, resulting in a cost-effectiveness of US $3.80/kg (i.e., below the cost-effectiveness threshold for CFC of US $4.40/kg). The enterprise selected four different propellants: HC, HFC-152a, HFC-134a, and a mixture of HFC-365mfc/ HFC-227ea.[24] In line with decision 62/9, IOCs were requested for a one-year period and represented approximately 40 per cent of the total costs.

RECOMMENDATION

37. The Executive Committee may wish:

(a) To note the document on the Analysis of the incremental capital costs and incremental operating costs and their duration, and the cost-effectiveness of all approved investment projects in the relevant manufacturing sectors and sub-sectors, contained in documents

[23] UNEP/OzL.Pro/ExCom/63/42

[24] The GWP values of HFC-134a and HFC-365mfc/HFC-227ea are 1,430 and 964, respectively. When the project was reviewed, the Secretariat calculated the climate impact of the conversion resulting in savings of 133,531 ODP tonnes of CO_2 equivalent.

UNEP/OzL.Pro/ExCom/89/10 and UNEP/OzL.Pro/ExCom/89/10/Add.1; and

(b) To take into account the information contained in the documents referred to in sub-paragraph (a) above, during the discussion of the development of the cost guidelines for the phase-down of HFCs in Article 5 countries.