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EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Seventy-sixth Meeting
Montreal, 9-13 May 2016

PROJECT PROPOSALS: CHINA

This document consists of the comments and recommendations of the Secretariat on the following project proposals:

Phase-out

- HCFC phase-out management plan (stage II, first tranche)

Polyurethane foam sector plan	World Bank
Extruded polystyrene foam sector plan	UNIDO, Germany
Industrial and commercial refrigeration and air-conditioning sector	UNDP
Room air-conditioning manufacturing and heat pump water heaters sector plan	UNIDO
Solvent sector plan	UNDP
Refrigeration servicing sector plan and enabling programme	UNEP, Germany, Japan

Refrigeration

- Demonstration project for ammonia (NH₃) semi-hermetic frequency convertible screw refrigeration compression units in the industrial and commercial refrigeration industry at Fujian Snowman Co., Ltd. UNDP

PROJECT DESCRIPTION

Overarching strategy of stage II of the HPMP for China

Introduction

1. On behalf of the Government of China, UNDP, as the lead implementing agency, has submitted to the 76th meeting stage II of the HCFC phase-out management plan (HPMP) consisting of the overarching strategy, the six sector plans listed below, and a national co-ordination plan:

- (a) Polyurethane foam (PU foam sector plan) (World Bank);
- (b) Extruded polystyrene foam (XPS foam sector plan) (UNIDO/Germany);
- (c) Industrial and commercial refrigeration and air-conditioning (ICR sector plan) (UNDP);
- (d) Room air-conditioning manufacturing and heat pump water heaters (HPWH) (RAC sector plan) (UNIDO);
- (e) Solvent sector plan (UNDP); and
- (f) Refrigeration servicing sector plan and enabling programme (UNEP/Germany/Japan).

2. The total cost of stage II of the HPMP has been estimated at US \$708,269,541, plus agency support costs for UNDP, UNEP, UNIDO, the World Bank, and the Governments of Germany and Japan, as originally submitted. Stage II as originally submitted proposes a phase out of 4,749 ODP tonnes of HCFCs by 2020, and an additional 4,684 ODP tonnes by 2026 to assist the Government of China in meeting the 35 per cent and the 67.5 per cent reduction targets by 2020 and 2025, respectively.

Scope of the document

3. To assist the Executive Committee in reviewing the overall stage II of the HPMP for China, the present document is organized as follows:

- (a) Overview of progress of stage I of the HPMP (as of February 2016)¹;
- (b) Overview of stage II of the HPMP:
 - (i) HCFC consumption and production in China;
 - (ii) Phase-out targets and strategy, proposed activities (including regulatory actions and activities by sector), local implementing entities, and estimated cost; and
- (c) Secretariat's comments and recommendation (on the overarching strategy of stage II of the HPMP).

4. Each of the sector plans included in stage II of the HPMP for China are described in stand-alone documents, containing *inter alia* a summary progress report on the implementation of activities associated with the sector plan in stage I; description of the current situation of the sector; the proposed action plan and phase-out activities with associated costs; and comments and recommendations by the Secretariat.

¹ A comprehensive progress report was included in the last tranche request for stage I of the HPMP for China submitted to the 75th meeting (UNEP/OzL.Pro/ExCom/75/41).

Overview of progress of stage I of the HPMP

Background

5. Stage I of the HPMP for China covering the period from 2011 to 2015 was approved in principle at the amount of US \$265,000,000 (excluding agency support costs) at the 64th meeting². It consisted of the PU foam, XPS foam, ICR, RAC and refrigeration servicing sector plans, the national enabling programme and the national co-ordination plan (decision 64/49). The solvent sector plan was subsequently approved at the 65th meeting (decision 65/36)³, increasing the overall phase-out and funding level to 3,386 ODP tonnes of HCFCs and US \$270,000,000, respectively.

6. The Agreement between the Government of China and the Executive Committee was updated at the 67th meeting⁴, reflecting the established HCFC baseline for compliance under Article 7 of the Montreal Protocol; the change in responsibility of co-operating agencies; and the established agency support costs (decision 67/20).

7. An overview of the HCFC phase-out targets and funds approved by sector is shown in Table 1.

Table 1. HCFC phase-out targets and funds approved for stage I of the HPMP for China

National/ sector	2013 (ODP tonnes)		2015 (ODP tonnes)		Total phase- out (ODP tonnes)	Total funds (US \$)
	Max. allowable consumption	Phase-out amount	Max. allowable consumption	Phase-out amount		
National	18,865.4		16,978.9			
Sector						
PU	5,392.2	672.8	4,449.6	942.6	1615.4	73,000,000
XPS	2,540	338	2,286	254	592.0	50,000,000
ICR	2,402.8	224.5	2,162.5	240.3	464.8	61,000,000
RAC	4,108.5	176	3,697.7	410.8	586.8	75,000,000
Solvent	494.2	26.9*	455.2	39.0	65.9	5,000,000
Servicing		61.1		0.0	61.1	5,640,000
National coordination						360,000
Total		1,499.3		1,886.7	3,386.0	270,000,000

*Excludes 3.1 ODP tonnes associated with a demonstration project for which a separate funding was approved (decision 64/48).

ODS policy and regulation framework

8. The Ministry of Environmental Protection (MEP) issued a Circular on Strict Management of HCFC Production, Sales and Consumption in 2013, requiring quota permits from all enterprises producing HCFCs and consuming over 100 metric tonnes (mt) of HCFCs, and registration at local Environmental Protection Bureaus (EPBs) for enterprises consuming less than 100 mt.

9. A revised version of the Circular on the Management of the Import and Export of ODS was issued in 2014 to strengthen ODS trade controls and supplement relevant articles on penalties for illegal ODS uses. The Air Pollution Prevention Law was also revised in 2015 to place higher priority on ODS phase-out.

Overview of progress in implementation of sector plans

10. Table 2 presents an overview of progress in the implementation of the sector plans included in stage I.

² UNEP/OzL.Pro/ExCom/64/53.

³ UNEP/OzL.Pro/ExCom/65/60.

⁴ UNEP/OzL.Pro/ExCom/67/39.

Table 2. Overview of progress in the implementation of the sector plans included in stage I

Sector	Status of progress stage I	HCFC phase-out target (mt)	HCFC phased out so far (mt)
PU	Out of the 54 PU foam enterprises addressed, 21 had completed their conversions to cyclopentane (nine enterprises) and water-blown technologies (12 enterprises). The remaining 33 enterprises are expected to be converted to cyclopentane or water-blown technologies by the end of 2016. Six systems houses received assistance to introduce pre-blended hydrocarbons-based polyols. A ban on using HCFC-141b in the refrigerators and freezer, reefer container and small household appliance sub-sectors is expected to be effective by July 2016.	14,685	2,422
XPS	Out of the 25 XPS foam enterprises addressed, four had completed their conversions to CO ₂ technology, and the remaining 21 enterprises are expected to be converted to CO ₂ or butane (one enterprise) by the end of 2016 (14 enterprises) and 2017 (seven enterprises).	10,031	1,520
ICR	Out of the 32 production lines in 17 enterprises addressed, eight lines had been converted; the remaining 24 production lines are at different stages of conversion. Technologies selected include HFC-32 (54 per cent of the lines), HFC-410A (28 per cent of the lines ⁵), and ammonia/CO ₂ systems, HFC-134, ammonia and CO ₂ /HFC-134 systems (18 per cent of the lines).	8,484	1,045
RAC	Out of the 25 RAC manufacturing lines and 3 compressor manufacturing lines, 11 were converted, and the remaining are at different stages of conversion. Seventeen production lines will be converted to HC-290 technology and the remaining eight to R-410A technology. One additional line will be converted to HC-290; on an exceptional basis, that line may manufacture residential heat pump water heaters rather than RAC equipment as originally proposed.	10,670	6,115
Solvent	The nine enterprises addressed had completed their conversions. Six enterprises manufacturing medical devices selected KC-6 (siloxane) as solvent; two metal cleaning enterprises selected HC/trans-1-chloro-3,3,3-trifluoropropene; and one electronics cleaning enterprise selected isopropanol/alcohol.	599	610
Servicing and enabling programme	Several standards and technical codes on refrigeration had been developed or amended; two national and 17 regional training centres had been established; several studies on certification and vocational centers needs are under implementation. Approximately 4,000 trainers and refrigeration service technicians had been trained and 500 enterprises certified; the qualification certification scheme for refrigeration servicing companies had been updated. A demonstration project to strengthen EPBs capacity had been implemented; and outreach and awareness activities on good refrigeration servicing practices had been conducted. Enabling activities implemented include training workshops for local EPBs and other authorities; distribution to EPBs of a manual on ODS policies and regulations and booklets on China's compliance activities; annual co-ordination meetings for government stakeholders; and outreach activities.	1,111	

11. In addition to the conversion of enterprises to non-HCFC alternative technologies, each sector plan is implementing technical assistance activities to support the conversion of enterprises and to facilitate the introduction of alternative technologies.

⁵ Due to the lack of a suitable lower-GWP technology for unitary and multi-connected air-conditioning systems.

Status of disbursement

12. As of February 2016, of the total funds of US \$270,000,000 approved for the implementation of stage I of the HPMP, US \$112,731,395 had been disbursed. An additional US \$69,139,760 will be disbursed between February and December 2016. Table 3 presents the funds approved and status of disbursement for stage I.

Table 3. Funds approved and status of disbursement for stage I of the HPMP (as of February 2016*)

Sector plan	Agency	Funding approved (US \$)	Last tranche approved (US \$)	Disbursement (US \$)	Disbursement (%)
PU	World Bank	73,000,000	10,950,000	29,467,499	40
XPS	UNIDO/Germany	50,000,000	7,233,000	27,245,422	54
ICR	UNDP	61,000,000	9,150,000	23,431,022	38
RAC	UNIDO	75,000,000	11,250,000	25,923,381	35
Solvent	UNDP	5,000,000	500,000	4,032,344	81
Servicing**	UNEP/Japan	5,640,000	866,000	2,422,387	43
PMU	UNDP	360,000	0	209,340	58
Total		270,000,000	39,949,000	112,731,395	42

* Disbursement from the Foreign Economic Cooperation Office (FECCO) to beneficiary enterprises.

**Including enabling activities.

Overview of stage II of the HPMPHCFC consumption and production and sector distribution

13. The Government of China has reported consumption of HCFC under Article 7 of the Montreal Protocol as shown in Table 4. The total estimated consumption levels of HCFC-22, HCFC-141b and HCFC-142b in 2015 were 4 per cent, 18 per cent and 61 per cent respectively below the starting point established in the Agreement between the Government and the Executive Committee.

Table 4. HCFC consumption in China (2012-2014 Article 7 data, 2015 estimated)

HCFC	2012	2013	2014	2015*	Starting point
Metric tonnes					
HCFC-22	237,397	179,350	190,318	201,318	209,006
HCFC-123	778	998	1,006	**	507
HCFC-124	(6)	32	96	**	140
HCFC-141b	63,864	47,631	51,848	43,982	53,502
HCFC-142b	15,274	9,790	9,918	8,792	22,624
HCFC-225***	36	29	33	**	17
Total (mt)	317,343	237,830	253,219	254,092	285,796
ODP tonnes					
HCFC-22	13,057	9,864	10,468	11,073	11,495
HCFC-123	16	20	20	**	10
HCFC-124	(0)	1	2	**	3
HCFC-141b	7,025	5,239	5,703	4,838	5,885
HCFC-142b	993	636	645	572	1,471
HCFC-225***	1	1	1	**	1
Total (ODP t)	21,091	15,761	16,839	16,482	18,865

* Estimated.

** No estimation reported.

***Includes HCFC-225ca and HCFC-225cb.

14. Stage I of the HCFC production phase-out management plan (HPPMP) for China was approved at the 69th meeting at the amount of US \$95,000,000 in principle (excluding agency support costs) for the 2013-2016 period (decision 69/28)⁶. The Agreement between the Government of China and the Executive Committee for the HPPMP was approved at the 71st meeting (decision 71/49)⁷. The quota for the HCFC production sector was established to regulate both domestic and export markets.

15. The total estimated production of 23,929 in 2015 was 9 per cent below the production levels allowed under the Agreement between the Government of China and the Executive Committee, as shown in Table 5. The domestic production quota of 16,480 ODP tonnes for 2015 was lower than the maximum allowable consumption of 16,978.9 ODP tonnes for that year, and was issued after giving due consideration of the HCFC consumption limits for each sector.

Table 5. HCFC production in China (2012-2014 Article 7 data, 2015 estimated)

HCFC	2012	2013	2014	2015*	Starting point
Metric tonnes					
HCFC-22	364,547	288,489	299,946	274,279	310,000
HCFC-123	1,687	2,078	1,931	2,819	2,800
HCFC-124	221	209	315	401	409
HCFC-141b	117,131	87,124	86,911	66,313	98,709
HCFC-142b	22,159	16,954	16,566	22,845	33,954
Total (mt)	505,745	394,854	405,669	366,657	445,872
ODP tonnes					
HCFC-22	20,050	15,867	16,497	15,085	17,050
HCFC-123	34	42	39	56	56
HCFC-124	5	5	7	9	9
HCFC-141b	12,884	9,584	9,560	7,294	10,858
HCFC-142b	1,440	1,102	1,077	1,485	2,207
Total (ODP t)	34,414	26,599	27,180	23,929	30,180

* Estimated, based on the production quotas for 2015.

16. Table 6 presents the sector distribution of HCFC consumption as reported in the country programme data report for 2014. The levels of HCFC consumption for each of the sectors with a consumption target in stage I were below the allowable levels of consumption under the Agreement for 2013 and 2014.

Table 6. Distribution of HCFCs by sector and substance (2014 CP data)

HCFCs	RAC	ICR	Servicing	PU foam	XPS foam	Solvent	Aerosol*	Total
Distribution of HCFCs (mt)								
HCFC-22	62,000	39,500	56,705		29,900		2,217	190,322
HCFC-141b				46,864		4,400	584	51,848
HCFC-142b		100	518		9,300			9,918
HCFC-123		649	357					1,006
HCFC-124			96					96
HCFC-225ca						33		33
Total (mt)	62,000	40,249	57,676	46,864	39,200	4,433	2,802	253,224
Percentage	20%	13%	19%	31%	13%	3%	1%	100%
Compliance with sector targets (ODP tonnes)								
Starting point	4,109	2,403	n/a	5,392	2,540	494	n/a	18,865
2013	3,790	2,225	3,104	5,097	2,377	466	138	17,196
2014	3,410	2,192	3,162	5,155	2,249	485	186	16,839

* Not addressed in stage I of the HPMP.

⁶ UNEP/OzL.Pro/ExCom/69/40.

⁷ UNEP/OzL.Pro/ExCom/71/64.

17. An overview of the sectors where HCFCs are used in China (based on 2014 data) is presented below:

- (a) The PU foam sector consists of about 2,000 enterprises, the majority of which are small and medium enterprises (SMEs), locally owned and with annual consumption below 20 mt of HCFC-141b as a foam blowing agent. Four subsectors, namely panel, spray, insulation for pipes and insulation for solar water heaters, account for approximately 69 per cent of the total consumption;
- (b) The XPS foam sector consists of approximately 300 XPS foam enterprises, many of them consuming less than 150 mt, with limited technical and financial capabilities. Due to more stringent national fire safety policies in place since 2011, the market for XPS foam products, particularly for building insulation, has declined resulting in the closure of some enterprises;
- (c) The ICR sector consists of more than 1,000 enterprises manufacturing a variety of products with different capacities, of which more than 50 per cent are SMEs with consumption less than 50 mt. Approximately 90 per cent of HCFCs consumed in this sector is by the locally-owned enterprises;
- (d) The RAC sector consists of about 30 large-sized enterprises with an annual production of approximately 118 million units (about 49 per cent are HCFC-22-based units and 51 per cent are R-410A-based inverter units). The sector has experienced substantial growth since 2009 due to increased demand in the local market (i.e., equivalent to 64 per cent of the total production of RAC units). There has also been a rapid growth of residential HPWH with an associated consumption of 1,100 mt of HCFC-22, mainly manufactured by the same enterprises that manufacture air-conditioning systems. Compressors are manufactured by a small number of enterprises, with three of them accounting for more 65 per cent of the total production;
- (e) The solvent sector consists of approximately 400 enterprises, many of which are SMEs with consumption below 10 mt, largely using HCFC-141b and small amounts of HCFC-225ca or HCFC-225cb for disposal medical devices, metal and electronics cleaning and solvent formulation; and
- (f) The refrigeration servicing sector consists of several thousand of refrigeration service workshops of different size and technical knowledge and skills scattered throughout the country. The charge of HCFC in refrigeration and air-conditioning equipment has been estimated at 1,000,000 mt of HCFCs and, since 2011 is increasing annually by approximately 100,000 mt of HCFCs charged in new equipment.

Phase-out targets and strategy

18. The Government of China will phase out HCFC production and consumption in accordance to the Montreal Protocol control target, namely, to reduce 35 per cent of production and consumption of baseline level in 2020; to reduce 67.5 per cent of production and consumption of baseline level in 2025; and to complete the accelerated phase-out of production and consumption in 2030 while allowing for servicing an annual average of 2.5 per cent during the period 2030-2040.

19. The overarching strategy of stage II of the HPMP for China was developed to follow the Montreal Protocol phase-out schedule and was based on the principles of the National 13th Five-Year Plan of China, the Ecological Civilization Strategy, and the adoption of sustainable and environmentally friendly and sound technologies. Stage II proposes a reduction of 4,749 ODP tonnes of HCFC by 2020

and an additional reduction still to be determined by 2025 to achieve the 35 per cent and 67.5 per cent reductions from the HCFC consumption baseline, respectively. Table 7 presents stage II consumption limits and reduction targets.

Table 7. Stage II consumption limits and reduction targets (ODP tonnes)

Sector	Starting point	2015 Max. allowable consumption	2020 consumption limit	2020 reduction	2025 consumption limit	2025 reduction	2026 reduction	Total reduction required
PU	5,392	4,450	2,966	1,484	330	2,636	330	4,450*
XPS	2,540	2,286	1,397	889	165	1,232	165	2,286
ICR	2,403	2,163	1,682	481	TBD	TBD	TBD	481
RAC	4,109	3,698	2,671	1,027	TBD	TBD	TBD	1,027
Solvent	494	455	321	134	55	266	55	455
Servicing	3,898	3,734**	3000**	734	TBD	TBD	TBD	734
Aerosol***	30	193**	225**	0	TBD	TBD	TBD	0
Total	18,865	16,979	12,262	4,749	TBD	TBD		9,433

* Based on the maximum allowable consumption for 2015; however, the actual consumption is slightly lower, i.e 4,444 ODP tonnes.

** The aerosol, refrigeration servicing and other sectors (i.e., tobacco and laboratory uses) have no control targets in 2015 and 2020. The figure is the estimated consumption in 2015 and 2020 based on consumption targets.

*** Includes tobacco and laboratory uses.

20. The strategy for stage II of the HPMP proposes to achieve:

- (a) Total phase-out of the consumption of HCFCs used in the PU foam sector (HCFC-141b), the XPS foam sector (HCFC-22/HCFC-142b) and the solvent sector (HCFC-141b and HCFC-225ca) by 2026, amounting to 84,423 mt (7,196 ODP tonnes) of HCFCs (i.e., 44,623 mt of HCFC-141b, 45 mt of HCFC-225ca, 9,939 mt of HCFC-142b, and 29,816 mt of HCFC-22);
- (b) The phase-out of 8,822 mt (481 ODP tonnes) of HCFC-22 and HCFC-123 (i.e., 30 per cent reduction) in the ICR sector by 2020;
- (c) The phase-out of 18,675 mt (1,027 ODP tonnes) of HCFC-22 (i.e., 35 per cent reduction) used in the RAC sector by 2020; and
- (d) The phase-out of 13,345 mt (734 ODP tonnes) of HCFC-22 (i.e., 23 per cent reduction) in the refrigeration servicing and through enabling programme by 2020.

21. The 2025 consumption limits and associated reductions for the RAC, ICR and refrigeration servicing sectors will be defined in 2020, considering *inter alia*, the availability and technical feasibility of low-GWP alternative technologies, and the demand for servicing refrigeration and air-conditioning equipment.

Proposed activities in stage II of the HPMP

Regulatory actions and monitoring

22. The ODS regulatory system established during the phase-out of CFCs and during the implementation of stage I of the HPMP will constitute the overarching legal framework for stage II. Additional control measures that will be considered up to 2020 include *inter alia*: development and revision of standards; revision of the test framework for technician certification in the refrigeration and air-conditioning sector; establishment of a requirement to recycle and recover HCFCs before retirement of equipment; issuing a ban on the use of HCFC-141b in the PU foam sector; development of a catalogue on key alternative technologies replacing HCFCs, guidelines on HCFC alternatives, list of low-carbon

technology and guidelines on monitoring of illegal activities; feasibility study on environmental tax for HCFCs; and environmental labelling and green procurement.

Sector plans

23. The actual phase-out of HCFCs in stage II will be accomplished through funded conversion of enterprises to low-GWP alternative technologies in the same sectors plans established in stage I, as well as activities foreseen under the enabling programme and the national co-ordination component. In addition, conversions for which no funding is requested may not be to low-GWP technologies. An overview of the activities proposed for stage II is described in Table 8.

Table 8. Overview of HCFC phase-out activities under stage II of the HPMP

Sector	Summary of phase-out activities
PU	<p>Phase-out of HCFC-141b used in the sector based on the following schedule: 45 per cent reduction by 2020 (phase-out of 1,484 ODP tonnes); and additional 49 per cent reduction by 2025 (phase out of 2,636 ODP tonnes); and complete phase-out by 2026 (phase out of 330 ODP tonnes in the spray foam subsector).⁸</p> <p>Phase-out activities include the conversion of eligible PU foam enterprises to HCs, water-based or HFOs blowing agent technologies; technical assistance to eight systems houses for the development of HC-based pre-blended polyols; technical assistance to support the conversion of a large number of SMEs; and a project implementation and monitoring unit. A ban on the use of HCFC-141b in manufacturing insulation foam for solar water heaters and pipes will be in effect from 1 January 2020, and in the whole PU foam sector from 1 January 2026.</p>
XPS	<p>Phase-out of HCFC-22 and HCFC-142b used in the sector based on the following schedule: 45 per cent reduction by 2020 (phase out of 889 ODP tonnes); and additional 48.5 per cent reduction by 2025 (phase out of 1,232 ODP tonnes); and complete phase out by 2026 (165 ODP tonnes).</p> <p>Phase-out activities include the conversion of 124 eligible XPS foam enterprises to optimized CO₂-based technology (with HFC-152a as a secondary blowing agent in some of the applications to maintain performance); technical assistance to facilitate the introduction of the technology and support the conversions; and a project implementation and monitoring unit.</p>
ICR	<p>Phase-out of 481 ODP tonnes of HCFC-22 (30 per cent reduction) used in the sector by 2020; the target for 2025 will be determined based on the progress achieved during implementation of stage II.</p> <p>Phase-out activities include the conversion of 110 manufacturing lines and three compressor lines to NH₃, CO₂, HC-290, HFO, or HFC-32 (and other HFCs, as transition alternative where required, noting that the average GWP value of the technologies to be phased in would be below 400) refrigerant technologies; technical assistance to facilitate the introduction of the technology and support the conversions; and a project implementation and monitoring unit.</p>
RAC	<p>Phase-out of 1,027 ODP tonnes of HCFC-22 (35 per cent reduction) used in the sector by 2020; the target for 2025 will be determined based on the progress achieved during implementation of stage II.</p> <p>Phase-out activities include the conversion of 20 RAC manufacturing lines to HC-290 or HFC-161 refrigerant technologies; five residential HPWH manufacturing lines to HC-290 and R-744 refrigerant technologies; and four compressor manufacturing lines. It will also include technical assistance to facilitate the introduction of the technology and support the conversions; and a project implementation and monitoring unit. Over half of the phase-out (i.e., 578 ODP tonnes) will be achieved through conversions of manufacturing lines most likely to high-GWP alternatives without funding from the Multilateral Fund.</p>

⁸ Based on the maximum allowable consumption for 2015; however, the actual consumption is slightly lower, i.e. 4,444 ODP tonnes.

Sector	Summary of phase-out activities
Solvent	Phase-out of HCFC-141b and HCFC-225 used in the sector based on the following schedule: 35 per cent reduction by 2020 (phase-out of 134 ODP tonnes); and additional 54 per cent reduction by 2025 (phase out of 266 ODP tonnes); and complete phase-out by 2026 (phase out of 55 ODP tonnes). Phase-out activities include the conversion of eligible enterprises to low-GWP cleaning alternatives (i.e. KC-6, HFEs and HC-based solvents); technical assistance to facilitate the introduction of the technology and support the conversions; and a project implementation and monitoring unit.
Servicing and enabling programme	Phase-out of 734 ⁹ ODP tonnes of HCFC-22 (20 per cent reduction), as submitted, used in the sector. Phase-out activities include <i>inter alia</i> establishing additional training centres, training refrigeration technicians, increasing technicians' capacity to safely handle flammable refrigerants, demonstrating good practices in the supermarket subsector, promoting recovery and recycling of refrigerants, establishing policies and incentives to increase reuse of HCFC, enhancing the capacity of local EPBs to manage and monitor the servicing sector, and conducting outreach activities. The enabling programme will include <i>inter alia</i> capacity-building for local authorities; outreach activities; and HCFC import and export control.
National coordination	Activities include five national stakeholder co-ordination meetings to monitor the progress of implementation of the seven sector plans; periodic review and reporting co-ordination between the project management teams of the sector plans; co-ordination, management and monitoring of HCFC phase-out activities including the quota and licensing system; development and implementation of national policy and regulations; data collection; supervision of enterprises carrying out the conversion out; and monitoring of expenditures.

24. The HCFC production sector plan (to be submitted to a future meeting of the Executive Committee) will prioritize the phase-out of HCFCs produced with high-ODP values. The producers will be encouraged to develop low-GWP alternatives which are selected by the consumption sectors (e.g., HFOs and HFO blends in some applications of the PU foam and ICR sectors).

Local implementing entities

25. The implementation of stage II of the HPMP will be carried out by the following local entities:
- (a) FECO/MEP will be in charge of the overall co-ordination of activities under the HPMP, with the assistance of UNDP (as the lead implementing agency), and will act as the National Ozone Unit (NOU) responsible for the development of national ODS legislation;
 - (b) Implementation Support Agency (ISA) will provide technical advice and support to FECO/MEP in the implementation of the PU foam and XPS foam sector plans;
 - (c) Local Environmental Protection Bureaus (EPBs) will support the implementation of phase-out activities by *inter alia* enforcing local policies that support ODS regulations; collecting, analysing and reporting on ODS production and consumption; raising awareness and conducting training on ODS phase-out; facilitating implementation of ODS phase-out projects and encouraging adoption of low-GWP alternatives; improving capacity to sustainably manage ODS; and assisting enterprises to meet environmental and safety requirements; and
 - (d) Technical experts who will provide technical, financial and other support for the implementation of the HPMP.

⁹ As submitted. UNEP later clarified that the tonnage included in the overarching strategy was indicative, and did not denote a commitment from the Government of China to phase out that amount. The Government of China is committed to phase-out 232 ODP tonnes of HCFC-22.

26. The financial arrangements will be similar to the ones established in stage I, where the implementing agencies will sign an agreement with the Government of China for each sector plan to channel funds from the Multilateral Fund. The agreement will contain terms and conditions under which the funds will be disbursed to China. The beneficiaries (enterprises or service providers) will sign contracts with FECO to receive funds.

Total cost of stage II of the HPMP

27. The total cost of stage II of the HPMP for China to be funded through the Multilateral Fund has been estimated at US \$708,269,541, as originally submitted (excluding support costs). Of this amount, US \$71,209,040 is being requested for the first tranche of stage II, as originally submitted (Table 9):

Table 9. Total cost stage II of the HPMP for China (US \$)

Sector	Agency	Total funds	Agency support	First tranche	Agency support
PU	World Bank	205,842,106	14,408,947	10,253,172	717,722
XPS	UNIDO	163,800,000	11,466,000	11,000,000	770,000
	Germany	1,200,000	142,000	0	0
	Sub-total	165,000,000	11,608,000	11,000,000	770,000
ICR	UNDP	118,165,000	8,271,550	17,725,000	1,240,750
RAC	UNIDO	140,972,435	9,868,070	24,617,000	1,723,190
Solvent	UNDP	57,500,000	4,025,000	3,433,868	240,371
Servicing and enabling programme	UNEP	18,890,000	2,087,900	3,300,000	364,747
	Germany	1,000,000	120,000	300,000	36,000
	Japan	400,000	52,000	80,000	10,400
	Sub-total	20,290,000	2,259,900	3,680,000	411,147
National coordination	UNDP	500,000	35,000	500,000	35,000
Total cost		708,269,541	50,476,467	71,209,040	5,138,180

28. A summary of the distribution of the total incremental costs (i.e., capital and operating, technical assistance and Project Implementation and Monitoring Unit (PMU)) as submitted for each sector under stage II of the HPMP is presented in Table 10.

Table 10. Summary of the total cost of stage II of the HPMP as submitted in the sector plans

Sector	Reduction (eligible)		Reduction (total)		ICC+IOC	TAS	PMU	Total cost	CE (US \$/kg)	
	MT	ODP	MT	ODP					Eligible	Total
PU foam	33,085	3,639	40,400	4,444	190,655,807	5,694,862	9,491,437	205,842,106	6.22	5.10
XPS foam	22,000	1,265	39,755	2,286	148,466,740	5,813,260	10,720,000	165,000,000	7.5	4.15
ICR	7,614	419	8,822	481	103,305,000	7,260,000	7,600,000	118,165,000	15.52	13.39
RAC	8,170	449	18,675	1,027	125,239,435	7,998,000	7,735,000	140,972,435	17.25	7.55
Solvent	3,640	400	4,173	455	52,312,641	2,187,359	3,000,000	57,500,000	15.80	13.78
Servicing					n/a	14,770,000	1,200,000	15,970,000		
Enabling programme	4,227	*232	4,227	232	n/a	4,000,000	320,000	4,320,000	4.8	4.8
Coordination	0	0	0	0	n/a	n/a	500,000	500,000	n/a	n/a
Grand total	78,736	6,404	116,052	8,925	619,979,623	47,723,481	40,566,437	708,269,541	9.00	6.10

SECRETARIAT'S COMMENTS AND RECOMMENDATION

COMMENTS

29. The Secretariat reviewed stage II of the HPMP for China in light of stage I, the policies and guidelines of the Multilateral Fund, including the criteria for funding HCFC phase-out in the consumption sector for stage II of HPMPs (decision 74/50), and the 2016-2018 business plan (BP) of the Multilateral Fund.

30. The Secretariat notes with appreciation that the Government of China, with the assistance of bilateral agencies (i.e., Germany and Japan) and all implementing agencies, has submitted an ambitious, comprehensive and well-prepared stage II of the HPMP that includes the total phase-out of HCFC consumption in three sectors (PU foam, XPS foam and solvents), and gives priority to the introduction of low-GWP technologies to the extent possible.

31. The Secretariat further notes with appreciation the cooperation, collaborative approach and support from the staff of the bilateral and implementing agencies throughout the complex and prolonged project review process, where detailed information and further clarifications were provided on all issues raised by the Secretariat.

32. The Secretariat's comments included in this section of the project document for China are related to the overarching strategy of stage II and broad issues relevant to all sectors including, *inter alia*, overlap of implementation among stages I and II; key considerations on HCFC consumption (remaining HCFC consumption eligible for funding, funded and unfunded levels of HCFC consumption associated with stage II, verification of HCFC consumption during stage II of the HPMP); observations on alternative technologies selected and impact on the climate; observations on the costs of stage II of the HPMP; 2016-2018 business plan of the Multilateral Fund; and duration of stage II of the HPMP.

33. Detailed description, and Secretariat's comments and recommendation on each sector plan are presented in the specific section for that sector plan.

Overlap of implementation among stages I and II

34. In view of the funding still available from stage I of the HPMP (with the last funding tranche approved at the 75th meeting), the number of activities still ongoing, and the completion date of the stage extended until 2019, a clarification was sought on whether stage II could commence at a later date (e.g., 2017). In responding, UNDP explained that most conversion projects will be completed by the end of 2016, with remaining funding balance associated with the last payment to some enterprises (including operating costs). Furthermore, when substantive conversions under stage I are being completed in 2016, activities under stage II will be limited to verification of enterprises to be converted, consultations on the selection of technology and contract signing. To reach the reduction targets in 2018 and 2020, and given a much larger number of enterprises to be converted mostly to low-GWP alternative technologies in stage II with an average implementation timeframe of at least two years, the Government of China considers that it is important to start implementation of stage II as soon as possible.

Key considerations on HCFC consumption

Compliance with stage I consumption targets

35. The Government of China has not submitted its Country Programme Implementation Report. However, it provided estimated HCFC consumption by sector, as reflected in Table 4.

Remaining consumption eligible for funding

36. Based on the Agreement for stage I of the HPMP between the Government of China and the Executive Committee, the remaining HCFC consumption eligible for funding is 15,420.25 ODP tonnes as shown in Table 11. The remaining consumption eligible for funding for future stages of the HPMP would be dependent on the level of HCFC phase out agreed for stage II.

Table 11. Overview of the remaining HCFC consumption in China

	HCFC-22	HCFC-123	HCFC-124	HCFC-141b	HCFC-142b	HCFC-225	Total
ODP tonnes							
Starting point	11,495	10	3	5,885	1,471	1	18,865
Reduction in stage I	1,444	-	-	1,681	261	-	3,386
Phase-out approved prior to stage I	36	-	-	17	7	-	59
Remaining consumption after stage I	10,016	10	3	4,187	1,203	1	15,420
Reduction proposed in stage II (actual)	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Remaining consumption for future stages	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Metric tonnes							
Starting point	209,006	507	140	53,502	22,624	17	285,794
Reduction in stage I	26,250	-	-	15,284	4,012	-	45,547
Phase-out approved prior to stage I	654	-	-	152	102	-	909
Remaining consumption after stage I	182,102	507	140	38,065	18,509	17	239,339
Reduction proposed in stage II (actual)	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Remaining consumption for future stages	TBD	TBD	TBD	TBD	TBD	TBD	TBD

37. Noting that stage II of the HPMP proposes to cease the use of HCFC-141b in the PU foam and the solvent sectors by 2026, a clarification was sought on the phase-out of HCFC-141b currently used in the aerosol sector, which had not yet been addressed, and which is expected to increase to 225 ODP tonnes by 2020. UNDP indicated that there is only one medical aerosol enterprise in China, with a 2015 quota of 2,300 mt of HCFC-22 and 600 mt of HCFC-141b. Its conversion to HFC-134a technology has been delayed due to an administration reform within the Food and Drug Administration and will only start in 2020. However, it is expected that the enterprise will complete its conversion before 2025. On this basis, the Secretariat considers that the phase out in the aerosol sector should also be accounted for in stage II in the event that stage II is determined to extend to 2025. The HCFC phase out in the aerosol sector should be included at the time the 2025 targets for the RAC, ICR and servicing sectors are determined (2019).

38. Implementation of stage II of the HPMP will address a consumption of 4,749 ODP tonnes of HCFC to achieve the Montreal Protocol compliance target in 2020 (i.e., an additional reduction of 25 per cent from the starting point for aggregate reduction in HCFC consumption in China, based on the consumption limits established in its Agreement with the Executive Committee). Noting that the reductions on HCFC consumption associated with stage I were equivalent to 18.3 per cent of the starting point; that the level of HCFC consumption in 2014 was more than 10 per cent below the starting point; and that additional HCFC consumption associated with the ongoing conversions will be phased out mostly during 2016, the Secretariat considered that reduction in HCFC consumption associated with the activities included in stages I and II (up to 2020 as only three sectors plans had included activities up to 2026) would be above 35 per cent of the starting point by 2020.

39. UNDP indicated that the Government of China considers that stage I of the HPMP was approved to achieve the freeze and the 10 per cent reduction targets in 2013 and 2015, respectively. The approval of HCFC consumption phase out equivalent to 18.3 per cent of the starting point was to allow compliance with the freeze given the expected growth of HCFC in 2012, which did occur as reflected under Article 7 of the Montreal Protocol. Although there are enterprises with ongoing conversions for which HCFC phase-out has not yet been accounted, many of them have already stopped using HCFCs as reflected in the 2014 consumption and, therefore, cannot be deducted from the consumption reported for 2014.

HCFC consumption associated with stage II

40. Implementation of stage II will result in the phase-out of 116,052 mt (8,925 ODP tonnes) of HCFCs (mainly, HCFC-141b, HCFC-142b and HCFC-22) by 2020 and 2026. In reviewing the total amount of HCFCs to be phased out, the Secretariat notes with appreciation that 37,316 mt (2,521 ODP tonnes) of HCFCs, representing over 13 per cent of the starting point for aggregate reduction on HCFC consumption will be phase-out without assistance from the Multilateral Fund, as shown in Table 12.

Table 12. HCFCs to be phased out during stage II of the HPMP

Sector	Tonnage			Percentage	
	Funded	Funding not requested	Total	Funded	Funding not requested
Metric tonnes					
PU foam	33,085	7,315	40,400	81.9%	18.1%
XPS foam	22,000	17,755	39,755	55.3%	44.7%
ICR	7,614	1,208	8,822	86.3%	13.7%
RAC	* 8,170	10,505	18,675	43.7%	56.3%
Solvent	3,640	533	4,173	87.2%	12.8%
Servicing and enabling programme	4,227	-	4,227	100.0%	0.0%
Total (mt)	78,736	37,316	116,052	67.8%	32.2%
ODP tonnes					
PU foam	3,639	805	4,444	81.9%	18.1%
XPS foam	1,265	1,021	2,286	55.3%	44.7%
ICR	419	62	481	87.1%	12.9%
RAC	449	578	1,027	43.7%	56.3%
Solvent	400	55	455	87.9%	12.1%
Servicing and enabling programme	232	-	232	100.0%	0.0%
Total (ODP tonnes)	6,404	2,521	8,925	71.8%	28.2%

* The Secretariat recommends an additional phase-out of 832.5 mt associated with the funding recommended for servicing tools.

41. The phase out for which funding was not requested corresponds in the case of PU foam and the solvent sector to non-eligible consumption due to cut-off date or non-Article 5 ownership that will be phase out in parallel to the stage II project. In case of XPS in addition to cut-off date and non-Article 5 ownership it includes consumption that has already been reduced given more stringent national fire safety policies. In the RAC sector 10,505 mt will cover any non-eligible items related to the conversions with the vast majority of those conversions will be to R-410A. The non-eligible consumption in ICR sector is due to the non-Article 5 ownership.

Verification HCFC consumption during stage II of the HPMP

42. During stage I, the annual verification of HCFC consumption in China was undertaken under the HCFC production phase-out management plan (HPPMP) implemented by the World Bank. In addition, under the HPMP every year the implementing agencies submitted a verification report of a random sample of at least 5 per cent of the manufacturing lines which had completed their conversion in the year to be verified, on the understanding that the total aggregated HCFC consumption of the random sample of the manufacturing lines represents at least 10 per cent of the sector consumption phased out in that year.

43. The Secretariat noted that while information on overall HCFC consumption in China was included in the production verification report, the verification was conducted at the HCFC production facilities and did not include sector consumption nor data from imports/exports. Accordingly, the Secretariat discussed with UNDP (as the lead implementing agency of the HPMP) and the World Bank

(as the lead implementing agency of the HPPMP) on options to undertake verifications of HCFC consumption during implementation of stage II. On the difference in methodology used for HCFC production and consumption verifications, UNDP explained that it takes several months annually to conduct verification of 28 production enterprises which would be difficult to replicate in the consumption sector where thousands of enterprises are involved. The Secretariat notes that as the HPPMP progresses, the number of production facilities to be verified will be reduced, and efforts could be directed to verify HCFC consumption, including exports, which has relevance to overall compliance in China. However, having an accurate verification of the consumption per sector is still difficult. UNDP informed that given the complexities involved in changing the verification process, the preference from the Government of China is not to change the verification process.

Implementation modality

44. Noting that the implementation modality and financial arrangements will be similar to the ones established in stage I, the Secretariat did not further discuss this subject on the understanding that existing rules and decisions applied to stage I will equally be applied to stage II.

Observations on alternative technologies selected and impact on the climate

45. In reviewing the sector plans of stage II of the HPMP, the Secretariat notes with appreciation the priority given by the Government to the introduction of low-GWP technologies to the extent possible, as show in Table 13.

Table 13. Alternative to be phased in during implementation of stage II of the HPMP

Sector	Alternative technologies
PU	HCs, water-based, HFOs
XPS	Optimized CO ₂ -based (with HFC-152a as a secondary blowing agent in some of the applications to maintain performance)
ICR	NH ₃ , CO ₂ , HFO, or HFC-32 (and other HFCs as transition alternative where required; the average GWP value of the technologies to be phased in would be below 400)
RAC	HC-290, HFC-161 for RAC equipment; HC-290, R-744 for HPWH. High-GWP alternatives likely for conversions for which funding is not requested.
Solvent	KC-6, HFE, hydrocarbon solvents, HFO
Servicing	Good service practice including recovery and recycling of refrigerants

PU, XPS and solvent

46. The introduction of low-GWP alternatives in the PU foam, XPS foam and solvent sectors would avoid the emission into the atmosphere of 68,771 thousand tonnes of CO₂-equivalent per year. Table 14 presents the climate impact in the PU, XPS and solvent sectors.

Table 14. Impact on the climate associated with stage II of the HPMP for China (PU, XPS, solvent)

Sector	CO ₂ -equivalent tonnes		
	HCFC (baseline)	Alternative technologies	Emissions reduction
PU	23,986,625	399,786	-23,586,839
XPS	42,570,000	7,089	-42,562,911
Solvent	3,026,875	405,820	-2,621,055
Total	69,583,500	812,695	-68,770,805

RAC and ICR

47. The conversion of the RAC and ICR manufacturing enterprises to low-GWP alternatives would avoid the emission to the atmosphere of some 39,421 thousand tonnes of CO₂ equivalent per year. Table 15 presents the climate impact in the air conditioning sector using the Multilateral Fund Climate Impact Indicator.

Table 15. Impact on the climate associated with stage II of HPMP for China (ICR, RAC)

Sector	CO ₂ -equivalent tonnes		
	HCFC (baseline)	Alternative technologies	Emissions reduction
ICR	111,904,421	91,692,368	-20,212,053
RAC	335,506,546	316,296,836	-19,209,710
Total	447,410,967	407,989,204	-39,421,763

Servicing

48. In addition, the proposed activities in the refrigeration servicing sector (i.e., leak prevention and reduction on emission of refrigerants through training of refrigeration technicians and recovery and recycling operations), will reduce the amount of HCFC-22 used for refrigeration servicing. Each kilogramme of HCFC-22 not emitted due to better refrigeration practices results in a savings of approximately 1.8 CO₂-equivalent tonnes.

Observations on costs of stage II of the HPMP

49. Stage II of the HPMP for China covers five manufacturing sectors, the refrigeration servicing sector and enabling programme as well as national coordination activities. Given the complexity of stage II, where over 116,000 mt of HCFCs used by several hundreds of enterprises scattered throughout the country will be phased out, and where various low-GWP alternatives technologies will be introduced, the calculation of the incremental capital and operating costs for each manufacturing sector plan was based on the baseline equipment typically installed on production lines by these enterprises.

Issues on technical assistance, PMU and national coordination

50. While cost-related issues are described in detail in each sector plan, the Secretariat noted that the overall level of funds requested for technical assistance, PMU and national coordination, not directly associated with any HCFC reduction, amounted to US \$68 million as shown in Table 16, representing 9.8 per cent of the total cost of stage II of the HPMP excluding servicing sector (4.2 per cent for technical assistance and 5.7 per cent for PMU). While it was acknowledged that there are still obstacles to achieving a larger penetration of low-GWP technologies, especially in the RAC and ICR sectors, based on the substantive progress achieved so far, the level of funds requested for these activities was not fully justified.

Table 16. Costs for technical assistance PMU and national co-ordination (US \$1,000)

Description	XPS	PU foam	RAC	ICR	Solvent	Total*
Investment component	148,467	190,655	125,239	103,305	52,313	619,979
Technical assistance	5,813	5,695	7,998	7,260	2,187	28,953
PMU	10,720	9,491	7,735	7,600	3,000	38,546
National co-ordination						500
Total funds requested	165,000	205,842	140,972	118,165	57,500	687,978
Technical assistance/Total funding	3.5%	2.8%	5.7%	6.1%	3.8%	4.2%
PMU/Total funding	6.5%	4.6%	5.5%	6.4%	5.2%	5.6%
Technical assistance and PMU/Total funding	10.0%	7.4%	11.2%	12.6%	9.0%	9.8%

*Excludes servicing sector and enabling programme, where a total of US \$20,290,000 is being requested with the associated phase-out of 4,227 mt (232 ODP tonnes) at US \$4.8/kg, including PMU.

51. In discussing the matter with UNDP (as the lead implementing agency of the entire stage II of the HPMP), the Secretariat highlighted that approximately US \$39 million had been approved for the same components under stage I when several HCFC-related regulations had not yet been promulgated, local infrastructure for implementation of HCFC phase-out activities had not yet been established, information on the HCFC consumption sectors was limited, and uncertainties on alternative technologies existed. Since then, the Government of China and the industrial sectors have accumulated experience in policy regulations, technology conversion, project management and implementation. Regulations to ensure compliance are already in place, technical assistance has been provided to develop and introduce new technologies and remove barriers to their adoption. In addition, China has successfully implemented eight projects to demonstrate low-GWP technologies (out of 14 approved worldwide) at a cost of US \$13.7 million. It was also noted that the funds requested for technical assistance and PMU in the RAC and ICR sector plans, which will be implemented through to 2020 were at the same level as those requested for the XPS and PU foam sector plans, to be implemented through to 2025. It is also noted that the enabling programme within the refrigeration servicing sector plan includes capacity building of local Government officials to implement regulations to facilitate the phase out of HCFCs.

52. UNDP indicated that stage II proposes an additional 47 per cent reduction from the starting point (compared to 18.3 per cent in stage I), with a longer implementation period and larger number of enterprises including SMEs to be converted compared to stage I. With regard to the RAC and ICR sectors, more efforts will be needed to promote low-GWP alternatives. With the activities proposed in stage II, the workload and corresponding costs of the PMU will also grow substantially.

53. The Secretariat noted potential overlaps between responsibilities described for the PMU, the national co-ordination component, and the implementation support agencies (ISA) funded under the technical assistance components. UNDP explained that the PMU/FECO is the national monitoring institution of the HPMP representing the Government, while the ISA is usually an industrial association or university with a mandate to provide technical advice and support to FECO on project management and implementation. UNDP also justified that funds for the national co-ordination component are crucial given the need to have a regular co-ordination mechanism at the national level to ensure the implementation of all the activities and the achievement of the consumption compliance targets. While technical assistance and the PMU in each sector plan will focus on the activities specified for the sector, national co-ordination will focus on the overall policies, industries and general public, and will cover multi-sectoral co-ordination and project management issues.

54. With regard to the PMU, the Secretariat discussed with UNDP the possibility of subsuming the cost of the PMU for stage II with those under stage I, at least for the years when both stages are implemented in parallel, noting that sufficient funds for the PMU under the ongoing six sector plans have already been approved and the completion date of stage I has been extended to 2019. UNDP indicated that it would be difficult to subsume the PMU costs, given that stage I and stage II are relatively independent projects and staff and project management costs will grow with the increasing workload. The Secretariat notes that conversions under stage I will be completed between 2016 and 2017 in most sectors by the time new conversions can start given the time required to identify enterprises and sign agreements.

55. It was also noted by the Secretariat that the percentage of funds allocated to PMUs vary from 4.6 per cent to 6.5 per cent of the total funding requested per sector.

56. An agreement could not be reached on a reasonable share of the PMU with the overall project costs. The Secretariat and the implementing agencies agreed to continue discussions on the technical assistance components as part of the sector plans (specific comments on these costs are reflected separately in the sector plans), and continue discussions with UNDP on the national coordination component and the PMU for all sectors as part of the overarching strategy.

Observation on the overall cost of stage II of the HPMP

57. The Secretariat notes with appreciation the collaboration and cooperation by bilateral and implementing agencies in discussing all the technical and cost issues raised during project review, which resulted in costs adjustments of US \$48,074,033, agreed by the Government of China. Although at the end of the project review process, agreements on funding levels for several of the sector plans between the Secretariat and the relevant agencies could not be reached, the difference between the two proposals was reduced to US \$149,691,913 (29 per cent), as shown in Table 17. This difference could be reduced as the Secretariat's proposal does not yet include funding for the PMUs and national co-ordination components.

Table 17. Overview of funding levels as revised by the Government and as recommended by the Secretariat

Sector	Total costs (US \$)				Percentage difference	CE	
	As submitted	Revised by the Government	Proposed by the Secretariat	Difference		Revised by the Government	Revised by the Government with PMU and coordination
(a)	(b)	(c)	(d)	(e) =(c)-(d)	(f) =1-(c)/(d)		
PU foam	196,350,669	178,864,714	149,636,544	29,228,170	-20%	5.41	5.69
XPS foam	154,280,000	150,295,250	115,900,674	34,394,576	-30%	6.83	7.32
ICR	110,565,000	103,351,875	87,694,313	15,657,562	-18%	13.57	14.57
RAC	133,237,435	119,656,374	88,291,206	31,365,168	-36%	14.65	15.59
Solvent	54,500,000	48,690,858	48,690,858	0	0%	13.38	14.20
Servicing and enabling programme	20,290,000	20,290,000	20,290,000	0	0%	4.80	4.80
Coordination	500,000	500,000	n/a**	500,000	n/a	-	-
PMU*	38,546,437	38,546,437		38,546,437		-	-
Grand total	708,269,541	660,195,508	510,503,595	149,691,913	-29%	7.89	8.38

*Excludes servicing sector and enabling programme, where PMU was included in the total cost requested of US \$20,290,000 with the associated phase-out of 4,227 mt (232 ODP tonnes) at US \$4.8/kg.

** The Secretariat has not recommended the proposed PMU and coordination cost; to be further discussed.

Co-financing

58. UNDP indicated that there is no direct financial support from the Government of China for ODS phase-out activities in stage II. However, of the 8,925 ODP tonnes of HCFCs to be phased out during stage II, 2,521 ODP tonnes will be phase-out with no assistance from the Multilateral Fund.

2016-2018 business plan of the Multilateral Fund

59. The level of funds allocated for stage II of the HPMP for China in the business plan of the Multilateral Fund for 2016 and 2017 (current replenishment) of US \$144 million and for the 2016–2018 period of US \$229.6 million, is approximately US \$43 million and US \$96 million respectively less than the actual level of funds being requested under stage II for the same periods, as shown in Table 18. In addition, although activities in three of the sectors included in stage II, namely PU foam, XPS foam and solvent, will be implemented over the next nine years (up to 2025), 25 per cent of the total funds under stage II are being requested in the first three years (2016-2018).

Table 18. Funds requested in stage II as compared to funding in the business plan ('000 US \$)*

Sector	2016-2018**			2019 and beyond			Total		
	Stage II	BP	Difference	Stage II	BP	Difference	Stage II	BP	Difference
PU foam	54,854	75,835	20,981	164,564	36,513	(128,051)	219,417	112,348	(107,069)
XPS	47,080	48,618	1,538	129,470	33,112	(96,358)	176,550	81,731	(94,819)
RAC	105,152	55,329	(49,823)	45,689	36,886	(8,803)	150,841	92,215	(58,626)
ICR	92,443	31,867	(60,576)	33,994	17,159	(16,835)	126,437	49,025	(77,412)
Solvent	12,860	11,381	(1,479)	48,667	6,128	(42,539)	61,527	17,509	(44,018)
Servicing	12,690	6,237	(6,453)	9,020	104,542	95,522	21,710	110,779	89,069
PMU	535	-	(535)	-	-	-	535	-	(535)
Total	325,614	229,267	(96,347)	431,404	234,340	(197,064)	757,017	463,607	(293,410)

*Including an assumed support cost of 7 per cent to make figures comparable to BP figures.

** Considering current resources available (2015-2017) and an over-programming of US \$47.5 million.

60. While the business plan figures are indicative for planning purposes, the Secretariat suggested that the level of funds requested for the first two tranches be within (or even lower than) the business plan amounts. These funding levels will be defined once discussions on the cost of all sector plans are concluded.

Duration of stage II of the HPMP

61. Stage II of the HPMP for China will cover the period 2016 to 2025 to completely phase-out the consumption of HCFCs (namely HCFC-141b and HCFC-142b) used in the PU foam, XPS foam and solvent sectors, with specific phase-out targets in 2020, 2025 and 2026. Stage II will also cover the period 2016 to 2020 to phase-out additional consumption of HCFC-22 used in the RAC, ICR and refrigeration servicing sectors, with specific phase-out targets in 2020. Accordingly, consumption limits and associated reductions of HCFCs up to 2025 in the RAC, ICR and refrigeration servicing sectors will be defined only in 2020, considering *inter alia*, the availability and technical feasibility of low-GWP alternative technologies, and the demand for servicing refrigeration and air-conditioning equipment. Stage II will also phase out small amounts of HCFC-123 in the ICR sector and HCFC-225ca in the solvent sector.

62. Given that some of the activities in stage II will be finalized in 2020 (RAC, ICR servicing) while others will be extended to 2025 (PU foam, XPS and solvent), the Secretariat suggested that stage II would conclude in 2020 and stage III, covering the 2020 to 2025 period, would be submitted in 2019, when targets and funds for all sectors are determined. While this would not represent changes to the already agreed overarching strategy, nor to the PU foam, XPS foam and solvent sector plans addressing the total consumption of HCFCs used by those sectors up to 2026, it would make it possible to have two sequential stages with clearly separated completion dates, funding and HCFC reduction targets. The Secretariat also noted that the total phase-out of HCFC in the PU foam, XPS foam and solvents could be approved in principle by the Executive Committee along with the approval of stage II. Accordingly, the Agreement between the Government of China and the Executive Committee for stage II would extend to 2020 with clear targets and funds allocations, and the funds approved in principle and HCFC reduction targets for the PU foam, XPS foam and solvent sectors between 2020 and 2025 could be reflected in "Appendix 8-A Sector Specific Arrangements" of the Agreement, with the indication that they will be integrated into the stage III Agreement once it is approved.

63. On this suggestion, UNDP indicated that the Government of China considers that the implementation of stage II and stage III in parallel between 2020 and 2025 is possible, as each stage will be addressing different activities and sectors. Furthermore, a large number of SMEs will be involved in the conversion of the PU foam, XPS foam and solvent sectors. Approving a partial phase-out in 2020 for these sectors instead of a total phase-out would make SMEs wait until the last stage to convert, which will generate implementation difficulties and put the compliance status at both national and sector levels at risk. Total phase-out plans will provide a strong signal for the industry to mobilize enterprises to conduct

conversions, and will also facilitate the management and implementation of sector plans while ensuring a level playing field among competitors.

Issues for discussion by the Executive Committee at the 76th meeting

64. Discussions between the Secretariat and the relevant bilateral and implementing agencies on all of the components comprising stage II of the HPMP have concluded with no policy issues identified, all technical issues have been satisfactorily addressed, and the difference in the level of funding of several sector plans as agreed by the Government of China and as recommended by the Secretariat has been narrowed.

65. In addition to approving the level of HCFC consumption to be phased-out and associated funding levels for the sectors plans, enabling activities and national coordination activities, the Executive Committee would need to consider the duration of stage II of the HPMP (either 2020 or 2026), and the process for the verification of HCFC consumption. Once the Executive Committee concludes its deliberation on stage II of the HPMP for China, a decision for its approval would need to be drafted. In this regard, the Executive Committee may wish to consider adapting the text of decision 64/49 approving in principle stage I of the HPMP, presented below:

- (a) To approve, in principle, stage II of the HCFC phase-out management plan (HPMP) for China for the period 2016 to 20xx to reduce HCFC consumption by XX per cent of the baseline, at the amount of US \$XX plus agency support costs for the Government of Germany, the Government of Japan, UNDP, UNEP, UNIDO and the World Bank;
- (b) To deduct XX ODP tonnes of HCFCs from the starting point for sustained aggregate reduction in HCFC consumption;
- (c) To approve the Agreement for stage II between the Government of China and the Executive Committee for the reduction in consumption of HCFCs, as contained in Annex XX to the present report; and
- (d) To approve the first tranche of stage I of the HPMP for China and the corresponding implementation plan for 2016-2017 at the amount of US \$XX, consisting of US \$XX, plus agency support costs of US \$XX for (each bilateral and implementing agency).

Draft Agreement

66. In view of the complexity of stage II of the HPMP for China comprising six sector plans, enabling activities and a national coordination plan, with completion dates of 2020 for three sectors and 2026 for three other sectors, and that the amount of HCFCs to be phase-out and associated funding levels would need to be approved by the Executive Committee, a draft Agreement between the Government of China and the Executive was not included in the submission of stage II.

67. During the discussion of stage II of the HPMP at the 76th meeting, the Executive may wish to request UNDP, in collaboration with relevant bilateral and implementing agencies, to prepare a draft Agreement for stage II, based on the format of Appendix 2-A (the targets, and funding) of the Agreement of stage I as shown in Table 19.

Table 19. Appendix 2-A: The Targets, and Funding for stage II of the HPMP for China

Row	Particulars	2016	2017	2018	2019	2020	Total
Consumption targets							
1.1	Montreal Protocol reduction schedule of Annex C, Group I substances (ODP tonnes)						

Row	Particulars	2016	2017	2018	2019	2020	Total
Consumption targets							
1.2	Maximum allowable total consumption of Annex C, Group I substances (ODP tonnes)						
1.3.1	Maximum allowable consumption of Annex C, Group I substances in the ICR sector (ODP tonnes)						
1.3.2	Maximum allowable consumption of Annex C, Group I substances in the XPS foam sector (ODP tonnes)						
1.3.3	Maximum allowable consumption of Annex C, Group I substances in the PU foam sector (ODP tonnes)						
1.3.4	Maximum allowable consumption of Annex C, Group I substances in the RAC sector (ODP tonnes)						
1.3.5	Maximum allowable consumption of Annex C, Group I substances in the solvent sector						
Funding industrial and commercial refrigeration and air conditioning (ICR) sector plan							
2.1.1	Sector Lead IA (UNDP) agreed funding (US \$)						
2.1.2	Support costs for UNDP (US \$)						
Funding extruded polystyrene (XPS) foam sector plan							
2.2.1	Sector Lead IA (UNIDO) agreed funding (US \$)						
2.2.2	Support costs for UNIDO (US \$)						
2.2.3	Sector cooperating agency (Germany) agreed funding (US \$)						
2.2.4	Support costs for Germany (US \$)						
Funding polyurethane rigid (PU) foam sector plan							
2.3.1	Sector Lead IA (World Bank) agreed funding (US \$)						
2.3.2	Support costs for World Bank (US \$)						
Funding room air conditioning (RAC) sector plan							
2.4.1	Sector Lead IA (UNIDO) agreed funding (US \$)						
2.4.2	Support costs for UNIDO (US \$)						
Funding service sector plan, including enabling programme							
2.5.1	Sector Lead IA (UNEP) agreed funding (US \$)						
2.5.2	Support costs for UNEP (US \$)						
2.5.3	Sector cooperating agency (Japan) agreed funding (US \$)						
2.5.4	Support costs for Japan (US \$)						
Funding national co-ordination							
2.6.1	Overall Lead IA (UNDP) agreed funding (US \$)						
2.6.2	Support costs for UNDP (US \$)						
Funding solvent sector plan							
2.7.1	Overall Lead IA (UNDP) agreed funding (US \$)						
2.7.2	Support costs for UNDP (US \$)						
Overall funding							
3.1	Total agreed funding (US \$)						
3.2	Total support cost (US \$)						
3.3	Total agreed costs (US \$)						

Row	Particulars	2016	2017	2018	2019	2020	Total
Consumption targets							
Phase-out and remaining eligible consumption							
4.1.1	Total phase-out of HCFC-22 agreed to be achieved under this Agreement (ODP tonnes)						
4.1.2	Phase-out of HCFC-22 to be achieved in previously approved projects (ODP tonnes)						
4.1.3	Remaining eligible consumption for HCFC-22 (ODP tonnes)						
4.2.1	Total phase-out of HCFC-123 agreed to be achieved under this Agreement (ODP tonnes)						
4.2.2	Phase-out of HCFC-123 to be achieved in previously approved projects (ODP tonnes)						
4.2.3	Remaining eligible consumption for HCFC-123 (ODP tonnes)						
4.3.1	Total phase-out of HCFC-124 agreed to be achieved under this Agreement (ODP tonnes)						
4.3.2	Phase-out of HCFC-124 to be achieved in previously approved projects (ODP tonnes)						
4.3.3	Remaining eligible consumption for HCFC-124 (ODP tonnes)						
4.4.1	Total phase-out of HCFC-141b agreed to be achieved under this Agreement (ODP tonnes)						
4.4.2	Phase-out of HCFC-141b to be achieved in previously approved projects (ODP tonnes)						
4.4.3	Remaining eligible consumption for HCFC-141b (ODP tonnes)						
4.5.1	Total phase-out of HCFC-142b agreed to be achieved under this Agreement (ODP tonnes)						
4.5.2	Phase-out of HCFC-142b to be achieved in previously approved projects (ODP tonnes)						
4.5.3	Remaining eligible consumption for HCFC-142b (ODP tonnes)						
4.6.1	Total phase-out of HCFC-225 agreed to be achieved under this Agreement (ODP tonnes)						
4.6.2	Phase-out of HCFC-225 to be achieved in previously approved projects (ODP tonnes)						
4.6.3	Remaining eligible consumption for HCFC-225 (ODP tonnes)						

RECOMMENDATION

68. The recommendation for approval of each sector plan by the Executive Committee is found in each sector plan. The Executive Committee may wish to acknowledge with appreciation the commendable efforts made by China towards the implementation of HCFC phase-out activities in the polyurethane foam (PU), the extruded polystyrene foam (XPS), the industrial and commercial refrigeration (ICR), the refrigeration and air conditioning (RAC), solvent and the servicing sectors to enable it to meet the 2020 phase-out targets stipulated in the Montreal Protocol.

PROJECT EVALUATION SHEET – MULTI-YEAR PROJECTS
China

(I) PROJECT TITLE	AGENCY
HCFC phase-out plan (stage II) XPS foam	Germany/UNIDO(Lead)

(II) LATEST ARTICLE 7 DATA (Annex C Group I)	Year: 2014	16,838.53 (ODP tonnes)
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(III) LATEST COUNTRY PROGRAMME SECTORAL DATA (ODP tonnes)								Year: 2014	
Chemical	Aerosol	Foam	Fire fighting	Refrigeration		Solvent	Process agent	Lab use	Total sector consumption
				Manufacturing	Servicing				
HCFC-123				12.9	7.1				20.0
HCFC-124					2.1				2.1
HCFC-141b	64.3	5,155				484			5,703.3
HCFC-142b		604.5		6.5	33.7				644.7
HCFC-22	121.9	1,644.5		5,582.5	3,118.8				10,467.7
HCFC-225ca						0.8			0.8

(IV) CONSUMPTION DATA (ODP tonnes)			
2009 - 2010 baseline:	19,269.0	Starting point for sustained aggregate reductions:	18,865.44
CONSUMPTION ELIGIBLE FOR FUNDING (ODP tonnes)			
Already approved:	3,445.19	Remaining:	15,420.25

(V) BUSINESS PLAN		2016	2017	2018	2019	2020	After 2020	Total
Germany	ODS phase-out (ODP tonnes)		2.4		3.1		3.9	9.4
	Funding (US \$)		300,000		400,000		500,000	1,200,000
UNIDO	ODS phase-out (ODP tonnes)	135.6	135.6	135.6	135.6	135.6		678.0
	Funding (US \$)	16,106,119	16,106,119	16,106,119	16,106,119	16,106,119		80,530,595

(VI) PROJECT DATA			2016	2018	2020	2023	2025	Total
Montreal Protocol consumption limits								
Maximum allowable consumption (ODP tonnes)								
Project costs requested in principle (US \$)	Germany	Project costs						
		Support costs						
Project costs requested in principle (US \$)	UNIDO	Project costs						
		Support costs						
Total project costs requested in principle (US \$)								
Total support costs requested in principle (US \$)								
Total funds requested in principle (US \$)								

(VII) Request for funding for the first tranche (2016)			
Agency		Funds requested (US \$)	Support costs (US \$)
Germany		TBD	TBD
UNIDO		TBD	TBD

Funding request:	Approval of funding for the first tranche (2016) as indicated above
Secretariat's recommendation:	For individual consideration

PROJECT DESCRIPTION

69. On behalf of the Government of China, UNIDO, as the lead implementing agency, has submitted to the 76th meeting stage II of the extruded polystyrene (XPS) foam sector plan (XPS foam sector plan) of the HCFC phase-out management plan (HPMP) for China, at a total cost of US \$176,608,000, consisting of US \$163,800,000, plus agency support costs of US \$11,466,000 for UNIDO, and US \$1,200,000, plus agency support costs of US \$142,000 for the Government of Germany, as originally submitted. The implementation of stage II of the XPS foam sector plan will completely phase out the HCFC consumption in the sector by 2026 and assist China in meeting the Montreal Protocol compliance targets of 35 per cent reduction by 2020 and 67.5 per cent by 2025.

70. The first tranche for stage II of the XPS foam sector plan of the HPMP being requested at this meeting amounts to US \$11,000,000, plus agency support costs of US \$770,000 for UNIDO only, as originally submitted.

Status of implementation of stage I of the XPS foam sector plan

71. Stage I of the XPS foam sector plan for China was approved at the 64th meeting at a total cost of US \$50,000,000, plus agency support costs for UNIDO and the Government of Germany, as part of stage I of the HPMP, to phase out 10,031 mt (592 ODP tonnes, of which 331 ODP tonnes of HCFC-22 and 260.8 ODP tonnes of HCFC-142b)¹⁰ and meet the 10 per cent reduction target for the sector in 2015.

72. Stage I of the XPS foam sector plan included the conversion of 25 XPS foam enterprises to CO₂ and butane (one enterprise), technical assistance (TA) activities, project monitoring and regulatory measures. Conversions of all enterprises will be completed in 2017, resulting in a total phase-out of 9,589.98 mt of HCFCs. An additional 441.02 mt will be phased out through regulatory measures.

Summary progress report on the implementation of stage I activities¹¹

ODS policy and regulation framework

73. The Ministry of Environmental Protection (MEP) issued a Circular on Strict Management of HCFC Production, Sale and Consumption in 2013 to ensure achievement of the freeze target in 2013 and the 10 per cent reduction in 2015. The circular established quota permits for enterprises (including XPS foam) consuming more than 100 mt of HCFCs per year.

Conversion activities

74. As of February 2016, of the 25 XPS foam enterprises addressed in stage I, four had completed their conversions to CO₂ with an associated consumption of 1,519.65 mt of HCFCs. The remaining 21 enterprises are at different stages of conversion, such as procurement, delivery of equipment, installation and trials.

¹⁰ The ratio of HCFC-22 to HCFC-142b in the XPS foam sector in China was on average 60 to 40 per cent in mt.

¹¹ A comprehensive progress report was included in the last tranche request for stage I of the HPMP for China submitted to the 75th meeting (paragraphs 9 to 14 of document UNEP/OzL.Pro/ExCom/75/41).

Technical assistance activities

75. The following TA activities were included in the XPS foam sector plan:

- (a) Revision of the standard on foam board for thermal insulation, to be enforced in 2017, and development of two new standards for panels used in cold storages and civil engineering¹², effective since 2016. The standards aim to facilitate the phase-out of HCFCs in the XPS foam sector and promote market acceptance of XPS foam products with alternative blowing agents;
- (b) Research on optimization of CO₂ technology, the key findings of which will be widely shared with the industry upon completion;
- (c) Revision of the manual on safe production of XPS foam using CO₂ technology with the aim of enhancing safety measures at enterprises, regulating their production process and promoting the adoption of CO₂ technology; the manual is expected to be available by the end of 2016; and
- (d) Support by the Institute of Plastic Processing and Application of Light Industry (IPPA) (designated as implementation support agency (ISA) to FECO) through technical consultations, training and information dissemination to XPS foam enterprises; technical advice to FECO and local Environmental Protection bureaus (EPBs); assistance to FECO/MEP audit agencies in carrying out on-site project and safety verifications.

PMU

76. A PMU with the responsibility to implement stage I of the XPS foam sector plan was established under the Foreign Economic Cooperation Office (FECO) of the MEP.

Status of disbursements

77. As of February 2016, of the total funds of US \$50,000,000 approved, US \$34,444,100 had been disbursed from the implementing agencies to FECO, and US \$27,245,422 had been disbursed by FECO to beneficiaries. Funding disbursed to enterprises accounts for 54 per cent of the total funding approved for stage I, and 79 per cent of the funding disbursed from the implementing agencies to FECO. An additional US \$15,251,400 will be disbursed to beneficiaries by December 2016. The remaining funding of US \$7,503,178 will be disbursed between 2017 and 2019.

Stage II of the XPS foam sector planHCFC consumption in the XPS sector

78. In 2015 the total estimated HCFC consumption in the XPS foam sector was the same as the consumption allowed under the Agreement between the Government of China and the Executive Committee, as shown in Table 1.

¹² XPS foam panels used for civil engineering applications (highways, railways, airports and canals) require higher compressive strength and better freeze-thaw resistance. The standard will play an important role in promoting access of new XPS foam to the market and broadening the application of XPS foam.

Table 1. HCFC consumption in the XPS foam sector in China (2012-2015)

HCFCs	2012	2013	2014	2015
HCFC-22	34,400	29,900	29,900	29,816*
HCFC-142b	9,800	11,264	9,300	9,939*
Total CP data report (mt)	44,200	41,164	39,200	39,755*
Total CP data report (ODP tonnes)	2,529	2,377	2,249	2,286*
Maximum allowable consumption (ODP tonnes)		2,540	2,540	2,286
Difference		163	291	0

*Estimated consumption. Data by each HCFC consumed is not yet reported.

79. The average ratio of HCFC-22 to HCFC-142b used in the XPS foam manufacturing sector has changed from the average 60 to 40 per cent estimated in stage I to 75 to 25 per cent since 2012 due to decrease in the price of HCFC-142b.

80. At the time of submission of stage I, the XPS foam sector was expected to grow. However, due to more stringent national fire safety policies in place since 2011, the market demand for XPS foam products, particularly for building insulation, declined resulting in the closure of some enterprises. There are approximately 300 XPS foam enterprises, mainly small and medium-sized (SMEs), with limited technical and financial capabilities.

Remaining consumption eligible for funding

81. Based on the Agreement between the Government of China and the Executive Committee for stage I of the HPMP, the remaining consumption of HCFC-22 and HCFC-142b eligible for funding is 10,015.59 and 1,203.06 ODP tonnes respectively. This consumption is distributed among the XPS foam, ICR, RAC, refrigeration servicing and aerosol sectors. Based on the XPS foam sector consumption targets in the Agreement and reductions from stage I including one stand-alone demonstration project, the total remaining consumption to be funded in stage II in the XPS foam sector should not exceed 1,935.7 ODP tonnes.

82. Stage II proposes the total phase-out of HCFC consumption in the XPS foam sector by 2026, estimated at 39,755 mt (2,286 ODP tonnes) in 2015, of which only 22,000 mt (1,265 ODP tonnes based on 75 to 25 per cent ratio of HCFC-22 to HCFC-142b) will be funded through the Multilateral Fund, and additional 10,814 mt (670.7 ODP tonnes) that are not eligible for funding or that correspond to enterprises that have closed, will be deducted from the remaining consumption eligible for funding.

Table 2. HCFCs reduction schedule in the XPS foam sector

Description	Stage I		Stage II				Total	
	2013	2015	2018	2020	2023	2025		2026
Consumption limit (mt)	43,051	39,755*	35,339	24,296	13,252	3,000	0	n.a.
Consumption limit (ODP tonnes)	2,540	2,286	2,032	1,397	762	165	0	n.a.
Reduction (mt)	5,726	3,296	4,417	11,043	11,043	10,252	3,000	
Reduction (ODP tonnes)	338	254	254	635	635	597	165	2,878
Reduction from starting point		10%	20%	45%	70%	94%	100%	n.a.
Funded reduction (ODP tonnes)	592		1,265				1,857**	

*Using 3:1 HCFC-22/HCFC-142b ratio from this year.

**In addition, 12.3 ODP tonnes were funded for a stand-alone demonstration project in the XPS sector in stage I

Phase-out strategy in the XPS foam sector for stage II

83. Similar to the stage I strategy, the phase-out of HCFC-22 and HCFC-142b in the XPS foam sector in stage II would be achieved through a combination of conversion of foam enterprises, regulatory actions, TA activities, and implementation and monitoring.

Regulatory actions and monitoring

84. The regulatory component will support the conversion of the XPS foam enterprises included in stage II. It will include a ban on the use of HCFCs in the XPS foam sector from 2025; the review and revision of technical standards on XPS foam products for ensuring performance with alternative technologies; guidelines on HCFC alternatives; revising MEP's catalogue of key HCFC alternatives; and introducing the environmental tax on HCFCs.

Conversion of XPS foam enterprises

85. Based on the survey conducted for the preparation of the XPS foam sector plan, it was estimated that 124 enterprises with a total consumption of 22,000 mt of HCFCs will be converted; 60 per cent of these enterprises had a consumption below 150 mt tonnes/year. Conversion of all enterprises will be completed by 2026. Table 3 presents an estimate of the distribution of enterprises by level of consumption:

Table 3. Estimated distribution of HCFC consumption in the XPS foam sector for 2014

Size of enterprise (in mt of HCFCs)	Consumption (mt)	Number of eligible enterprises
Below 150	6,402	73
150-300	7,759	34
300-500	5,226	12
500-600	2,613	5
Total	22,000	124

86. Based on experience from the implementation of stage I, optimized CO₂ (CO₂ as main blowing agent co-blown with one or two low-GWP foaming agents when required to maintain performance) has been chosen for stage II. The technology choice might be changed if other low-GWP alternatives become available.

87. To calculate the cost of enterprise conversion, stage II proposes to use a "standard" cost for the conversion of one production line to CO₂-based technology, as shown in Table 4.

Table 4. Proposed standard cost for the conversion of one production line

Description	Equipment, modifications and retrofit details	Cost (US \$)
Automatic weight-loss feeding system	Weight-loss metering, vacuum feeding devices and pipelines, material storage tanks and explosion-proof modifications to the motor and electrical system	120,000
Blowing agent storage and dosing system	Diaphragm pump, CO ₂ storage tanks; ethanol and other blowing agents cylinders, CO ₂ first order booster pumping system, explosion-proof modifications to the motor and electrical system	317,000
Extruders	Twin-screw extruder with the diameter of 75 mm, single-screw extruder with the diameter of 200 mm; explosion-proof modifications to the production line	400,000
Safety retrofit	Leakage monitoring system for inflammable gases, fire extinguishing and explosion proof system, antistatic protection system, emergency generator and necessary civil work	202,600
Training, trials, technology transfer		25,000
Total		1,064,600

88. The incremental capital costs (ICC) were calculated based on the "standard" cost described in above table, the number of eligible enterprises and the number of production lines per enterprise (i.e., as there are approximately 130 production lines, for the calculation of the ICC it was assumed one line for

enterprise consuming below 300 mt; 1.3 lines for those consuming 300-500 mt; and 1.5 lines for those consuming more than 500 mt).

89. Based on these assumptions, the ICC had been estimated at US \$138,504,460 as shown in Table 5.

Table 5. ICC for conversions of enterprises in stage II of the XPS foam sector plan

Size of enterprise (in mt)	Number of enterprises	Lines	Cost per activity (US \$)			Cost (US \$)	
			Equipment	Safety retrofit	Technology transfer	Per enterprise	Total
Below 150	73	1.0	837,000	202,600	25,000	1,064,600	77,715,800
150-300	34	1.0	837,000	202,600	25,000	1,064,600	36,196,400
300-500	12	1.3	1,088,100	263,380	32,500	1,383,980	16,607,760
500-600	5	1.5	1,255,500	303,900	37,500	1,596,900	7,984,500
Total	124						138,504,460

90. Incremental operating costs (IOC) were calculated at US \$2.11/kg of HCFC, taking into account the new polystyrene resin required for the application of CO₂ technology and the increased dosage of flame retardant. In line with decision 74/50¹³, IOC was adjusted US \$1.40/kg, resulting in a total of US \$30,800,000.

91. In line to the cost-effectiveness threshold of US \$10.27/kg for XPS foam, the overall cost for the conversion of the 124 enterprises covered under the XPS foam sector plan was estimated at US \$148,466,740 as shown in Table 6.

Table 6. Estimated costs for the conversion of XPS foam enterprises in China

HCFC (mt)		Cost (US \$)			CE (US\$/kg)		Total cost (US \$)
Size enterprise	Consumption	ICC	IOC	Total	Actual	Adjusted	
Below 150	6,402	77,715,800	8,962,800	86,678,600	13.54	10.27	65,780,550
150-300	7,759	36,196,400	10,862,600	47,059,000	6.07	6.07	47,097,130
300-500	5,226	16,607,760	7,316,400	23,924,160	4.58	4.58	23,935,080
500-600	2,613	7,984,500	3,658,200	11,642,700	4.46	4.46	11,653,980
Total	22,000	138,504,460	30,800,000	169,304,460	7.7	6.75	148,466,740

Technical assistance activities

92. In support of the conversion of XPS foam enterprises, the following TA activities have been proposed in stage II:

- (a) Training and workshops for beneficiaries on safety issues, policy measures and project implementation (US \$200,000);
- (b) Optimization and evaluation of alternative technologies (US \$400,000);
- (c) Formulation and revision of technical standards and guidelines on XPS foam products (US \$300,000);
- (d) Policy impact assessment prior to the establishment of the ban on the use of HCFCs in the XPS foam sector (US \$200,000);
- (e) Review and optimization of extruder configuration with alternative technology (US \$250,000);

¹³ UNEP/OzL.Pro/ExCom/74/56.

- (f) Capacity building of local EPBs and other agencies (US \$700,000);
- (g) Technical consulting for FECO (US \$600,000);
- (h) Study tours for beneficiaries, industrial associations and research institutes (US \$300,000); and
- (i) Public awareness and outreach (US \$150,000); and
- (j) Following the approach taken in stage I, an ISA will be designated to provide technical consultations, training and guidance to foam enterprises and technical advice to FECO and local EPBs, and facilitate on-site project and safety verifications to be conducted by FECO/MEP audit agencies (US \$2,713,260).

Implementation modality

93. The PMU established under FECO in stage I of the XPS foam sector plan will continue to be operational during stage II. It will coordinate the implementation of stage II activities by *inter alia* preparing regulations and policies; monitoring and reporting on the information-management system; verifying the eligibility of enterprises, signing contracts and reviewing their phase-out activities; managing financial aspects; developing indicators to verify and report on HCFC phase-out; preparing terms of references and signing contracts for TA activities; and supervising the implementation of all contracts. Local EPBs will provide project management support through visits to beneficiary enterprises to ensure HCFC consumption phase-out and policy implementation enforcement.

94. UNIDO, as the lead implementing agency, will ensure that financial verifications are conducted and progress in disbursement is made in accordance with the requirements set up in the sector plan, and will assist the Government in preparing annual implementation plans and progress reports. The Government of Germany will provide TA support and reports as required. Both agencies will conduct field visits and inspections to beneficiary enterprises; and provide assistance to the Government of China on policy development, planning and management of the sector plan and the implementation and assessment of the activities.

95. UNIDO and the Government of Germany will sign a Grant Agreement with the Government of China to channel funds from the Multilateral Fund to China. UNIDO and the Government of Germany will disburse funds to China in five instalments when specific implementation milestones have been achieved. To disburse funds to beneficiaries, FECO will sign contracts with XPS foam enterprises, or with consultancy service providers in the case of TA activities. Beneficiary foam enterprises will allow visits and inspections from FECO, local EPBs, UNIDO and the Government of Germany

Total cost of stage II of the XPS foam sector plan

96. The total cost of stage II of the XPS foam sector plan of the HPMP for China to be funded through the Multilateral Fund has been estimated at US \$165,000,000, as originally submitted (excluding support costs). The proposed phase-out activities will result in the phase-out of 1,265 ODP tonnes of HCFCs with an overall cost effectiveness of US \$7.50/kg (based on only eligible consumption). The cost breakdown is shown in Table 7 below:

Table 7. Summary of proposed activities and cost of stage II of the XPS foam sector plan for China

Component	Total reduction		Funded reduction		CE (US \$/kg)	Total cost (US \$)
	mt	ODP t	mt	ODP t		
Enterprises conversion	*32,814	1,936	22,000	1,265**	6.75	148,466,740
Technical assistance	0	0	0	0	n.a	5,813,260
PMU	0	0	0	0	n.a	10,720,000
Total	*32,814	1,936	22,000	1,265	7.50	165,000,000

* 32,814 mt of HCFC represents the remaining consumption eligible for funding. The non-funded reductions of 10,814 mt (difference between 32,814 mt and 22,000 mt) will be deducted from the remaining consumption eligible for funding.

** The ratio of HCFC-22 to HCFC-142b is 75 to 25 per cent (measured in mt).

SECRETARIAT'S COMMENTS AND RECOMMENDATION

COMMENTS

97. The Secretariat reviewed stage II of the XPS foam sector plan for China in light of stage I, the policies and guidelines of the Multilateral Fund, including the criteria for funding HCFC phase-out in the consumption sector for stage II of HPMPs (decision 74/50), and the 2016-2018 business plan of the Multilateral Fund.

98. The Secretariat noted with appreciation that, although the funding approved for the preparation of stage II of the XPS foam sector plan aimed at preparing a sector plan to reduce 35 per cent of HCFC consumption, the proposal submitted to the 76th meeting included the conversion of the entire XPS foam sector by 2026, replacing the total consumption of HCFC-22 and HCFC-142b used by XPS foam enterprises with low-GWP alternatives. In addition, the proposal was comprehensive and clear.

99. Considering the experience gained in the implementation of stage I, and noting that stage II will continue with a similar approach, most of the discussion between the Secretariat and UNIDO focused on the incremental cost of converting the sector.

Phase-out strategy and implementation modality

100. Noting the large number of enterprises included in stage II (five times the number of enterprises assisted during stage I), the Secretariat requested UNIDO to provide information on the criteria used to prioritize enterprises, and the mechanisms in place to reduce the time required for baseline verification and signature of contracts, and to avoid delays on implementation of conversion of enterprises. UNIDO indicated that through the data survey conducted for the preparation of the sector plan, it acquired a better understanding of the size of enterprises and their geographical distribution, which will allow for the signature of a large number of contracts within a limited time. While the first-come-first-serve principle will be followed, the enterprises with advanced technical competence and financial capacity will be prioritized. To ensure the timely achievement of the phase-out targets, TA activities will be carried out, increasing awareness on HCFC phase-out amongst beneficiaries.

101. Based on the explanation provided, and with the view that stage II of the XPS foam sector plan could be implemented similar to the stage I sector plan, it is suggested to give due consideration to reducing the time used in verifying the enterprises, signing contracts and starting the actual conversion of the enterprises.

Cost-related issues*Incremental capital cost*

102. The Secretariat noted that the approach to calculate the incremental cost of stage II of the XPS foam sector plan based on a “standard” production using the cost of equipment in enterprises funded under stage I raised uncertainties, as most of the enterprises in stage I consumed more than 150 mt of HCFCs, while the consumption of 73 of the 124 enterprises in stage II consume less than 150 mt. On this concern, UNIDO explained that based on the survey for the preparation of stage II, the costs for enterprises with consumption below 300 mt/year was based on an extruder with production capacity of 75/200 which is compatible with the production scale of such size enterprises without introducing technological or capacity upgrades.

103. The Secretariat also noted that the cost of equipment proposed in stage II were higher than those funded under stage I. For enterprises with consumption below 150 mt in particular, the cost of the conversion of one production line proposed in stage II was US \$1,187,378 as compared to US \$600,000 in stage I. On this issue, UNIDO indicated that while two enterprises with consumption below 150 mt received US \$600,000, the actual conversion cost was approximately US \$1,400,000 (including counterpart funding); in addition, one of the two enterprises was also an equipment manufacturer and had technical capacity to conduct conversions on existing equipment. In contrast, stage II enterprises have lower technical and financial capability and a cost of US \$600,000 would not be able to completely reflect their conversion needs.

104. The Secretariat and UNIDO discussed in detail the ICC of conversion of the standard production line. The Secretariat pointed out that the costs associated with enterprises with consumption below 300 mt/year should be US \$600,000 instead of US \$800,000 as originally proposed, taking into account that in some cases retrofit might be possible and the price of equipment can vary depending on the baseline equipment. The Secretariat also proposed safety costs of US \$120,000 for enterprises with consumption below 150 mt/year and US \$150,000 for enterprises with consumption below 300 mt/year. In responding UNIDO indicated that the suggested costs for the equipment were not sufficient given that small enterprises lack co-financing and technical capabilities; and introduction of flammable blowing agents will require additional investment by the enterprises in order to meet safety requirements. However, UNIDO agreed to reduce the cost of equipment from US \$837,000 to US \$800,000. The results of the discussions on the ICC are summarized in Table 8

Table 8. Proposed ICC by the Secretariat for the conversion of XPS foam enterprises

Description	Cost (US \$) based on size of enterprise							
	PROPOSED SECRETARIAT				REVISED UNIDO			
	<150 mt	150-300 mt	300-500 mt	>500 mt	<150 mt	150-300 mt	300-500 mt	>500 mt
Equipment	600,000	600,000	780,000	900,000	800,000	800,000	1,040,000	1,200,000
Safety	120,000	150,000	260,000	300,000	200,000	200,000	260,000	300,000
Training	5,000	5,000	6,500	7,500	5,000	5,000	6,500	7,500
Tech transfer	20,000	20,000	26,000	30,000	20,000	20,000	26,000	30,000
Subtotal	745,000	775,000	1,072,500	1,237,500	1,025,000	1,025,000	1,332,500	1,537,500
No. enterprises	73	34	12	5	73	34	12	5
Total	54,385,000	26,350,000	12,870,000	6,187,500	74,825,000	34,850,000	15,990,000	7,687,500
Grand total	99,792,500				133,352,500			

Incremental operational cost

105. The Secretariat and UNIDO also discussed in detail the IOC. The Secretariat proposed to blend a portion of recycled resin in the formulation (which is feasible even in the case of CO₂/ethanol technology) rather than using only new resin; a revised cost of HCFC-22 (at US \$1.90/kg), HCFC-142b (US 3.00/kg) (consistent with costs reflected in verified enterprises), flame retardant (at US \$4.34/kg based on the

verification of completed projects) and of additives (at US \$1.67/kg as the same cost of nucleating agent); and not considering the requests for increasing the density and the thickness of the foams together (in line with projects approved in other countries including China). On this basis, IOC would be considered at US \$0.55/kg (instead of US \$1.40/kg i.e., the cost-effectiveness threshold), resulting in total operating costs of US \$12,098,114 (instead of US \$30,800,000 being requested).

106. In responding UNIDO agreed using the costs of HCFC-142b and flame retardant as proposed by the Secretariat; however, it disagreed in the suggestion to use recycled resin as it would reduce the quality of the foam. On the factors of density and thermal conductivity, UNIDO explained that the adoption of CO₂ technology requires an increase in the consumption of raw materials; to obtain the same thermal insulation performance, the thickness of the board needs to be increased. During the production process different additives will be considered according to the specific requirements for foam performance, and did not agree to adjust the cost of the additive. With the adjustment agreed by UNIDO, the revised IOC would be US \$1.60/kg (instead of US \$2.11/kg as originally submitted), which is above the cost-effectiveness threshold of US \$1.40/kg. On this basis the IOC for the XPS foam sector plan would remain at US \$30,800,000 (i.e., US \$18,701,886 difference between the IOC suggested by the Secretariat and that being requested).

Costs of the TA and PMU

107. While the TA and PMU included in stage II do not have an associated reduction in HCFC consumption, the Secretariat noted that in the case of stage I, a total of 441 mt phase-out was associated with regulatory measures developed and implemented through those project components. UNIDO indicated that it is not necessary to associate reductions of HCFC consumption with the TA and the PMU. These project components will ensure smooth implementation of conversion activities in stage II where a higher amount of HCFCs will be phased out, the implementation period will be longer, and more enterprises will be converted.

108. Responding to a query on the unspent funds for the TA component from stage I (approximately US \$1,300,000 of US \$2,100,000 approved, as per the financial report submitted to the 75th meeting) and whether they could be used for some TA activities proposed under stage II, UNIDO clarified that the total commitments made to TA activities amount to US \$1,800,000, with an additional US \$275,000 allocated for activities included in the 2016 annual work programme approved at the 75th meeting.

109. The Secretariat and UNIDO discussed in detail the costs of TA noting the major advances during stage I in supporting the introduction and optimization of CO₂-based technology for XPS manufacturing, the completion of standards to support the use of the technology, the successful conversion of 24 enterprises to CO₂ technology, and the funds invested in studies, training workshops and awareness. The Secretariat required a justification for the overall cost for TA, which is more than twice the funds approved in stage I; the funds being requested for the ISA, which appear to be excessive for assisting 124 enterprises, and where the responsibilities overlap with some TA activities for which additional funding is being requested (and possibly with some PMU costs); and the funding being requested for capacity-building of local EPBs given the concentration of many enterprises in only a few regions. In responding, UNIDO indicated that due to the long duration of stage II, further development of low-GWP technologies might lead to adjustments in technology options requiring periodic review and assessment and more technical assistance for small enterprises. UNIDO also indicated that TA activities were designed to avoid overlaps with the PMU component; while the funding requested for the ISA had been based on experience from the implementation of stage I, noting that ISA will provide support mainly on a sub-project basis.

110. As a result of the discussions, agreement was reached on the costs of all TA activities except for the support to the ISA as shown in Table 9.

Table 9. Revised cost of TA component of the XPS foam sector plan

Description	Cost (US \$)			
	Original	Revised UNIDO	Proposed Secretariat	Difference
Public awareness and outreach	150,000	100,000	100,000	-
Training and workshops	200,000	100,000	100,000	-
Technical consulting service	600,000	400,000	400,000	-
Implementation support agency (ISA)	2,713,260	2,000,000	1,800,000	(200,000)
Policy impact assessment	200,000	100,000	100,000	-
Formulation and revision of technical standards	300,000	300,000	300,000	-
Capacity-building of local EPBs and other agencies	700,000	400,000	400,000	-
Optimization and evaluation of alternative technologies	400,000	320,000	320,000	-
Study tours on HCFC alternative technologies	300,000	180,000	180,000	-
Alternative extrusion configuration	250,000	250,000	250,000	-
Total cost	5,813,260	4,150,000	3,950,000	(200,000)

PMU

111. Taking into account the balance of PMU funding from stage I (of US \$2,700,000 approved, US \$1,600,000 had been disbursed as of July 2015), and the extension of stage I activities in the XPS foam sector until the end of 2017, the Secretariat suggested subsuming part of the PMU cost for stage II under stage I, thereby reducing the overall cost of the PMU for stage II. UNIDO clarified that as of December 2015 more than US \$1,800,000 had been disbursed; that stage II of the XPS foam sector plan is relatively independent from stage I; and the longer implementation period and increased number of projects would lead to an increase in the PMU's workload and, consequently, an increase in the PMU's staff and operation costs.

112. Noting that the Secretariat had raised the issue of project management costs related to all the sector plans China in the context of the overall stage II of the HPMP for China, it was agreed that the PMU cost requested for the XPS foam sector plan would be discussed in the context of the overarching strategy. Accordingly, the level of funds requested (6.5 per cent of the overall cost of the plan) has not been modified so far.

Total cost

113. A summary of the overall costs of stage II of the XPS foam sector plan in China, as submitted, as revised by UNIDO and as proposed by the Secretariat is presented in Table 10.

Table 10. Overall cost stage II of the XPS foam sector plan in China

Component	Cost (US \$)					
	As submitted		Revised UNIDO		Proposed Secretariat	
	Total	Requested	Total	Requested	Total	Requested
ICC	138,504,460	117,666,740	133,352,500	115,345,250	99,792,500	99,792,500
IOC	46,475,147	30,800,000	35,263,947	30,800,000	12,098,114	12,098,114
Total investment	184,979,607	148,466,740	168,616,447	146,145,250	111,890,614	111,890,614
Technical assistance		5,813,260		4,150,000		3,950,000
PMU*		10,720,000		10,720,000		10,720,000
Total		165,000,000		161,015,250		126,560,614

*Cost for PMU is as submitted. This cost is being discussed separately as part of the overarching strategy.

Impact on the climate

114. The conversion of the remaining XPS foam manufacturing enterprises in China would avoid the emission into the atmosphere of some 42,563 thousand tonnes of CO₂ equivalent per year, as shown in Table 11.

Table 11. Climate impact of XPS foam projects

Substance	GWP	Tonnes/year	CO ₂ -eq (tonnes/year)
Before conversion			
HCFC-22	1,810	16,500.00	29,865,000
HCFC-142b	2,310	5,500.00	12,705,000
Total		22,000.00	42,570,000
After conversion			
CO ₂	1	7,088.88	7,089
Net impact			(42,562,911)

RECOMMENDATION

115. The Executive Committee might wish to consider the sector plan for phase-out of the use of HCFC-22 and HCFC-142b in the extruded polystyrene foam sector in China in light of the Secretariat's comments contained in document UNEP/OzL.Pro/ExCom/76/25.

PROJECT EVALUATION SHEET – MULTI-YEAR PROJECTS
China

(I) PROJECT TITLE	AGENCY
HCFC phase out plan (stage II) PU foam	World Bank

(II) LATEST ARTICLE 7 DATA (Annex C Group I)	Year: 2014	16,838.53 (ODP tonnes)
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(III) LATEST COUNTRY PROGRAMME SECTORAL DATA (ODP tonnes)								Year: 2014	
Chemical	Aerosol	Foam	Fire fighting	Refrigeration		Solvent	Process agent	Lab use	Total sector consumption
				Manufacturing	Servicing				
HCFC-123				12.9	7.1				20.0
HCFC-124					2.1				2.1
HCFC-141b	64.3	5,155				484			5,703.3
HCFC-142b		604.5		6.5	33.7				644.7
HCFC-22	121.9	1,644.5		5,582.5	3,118.8				10,467.7
HCFC-225ca						0.8			0.8

(IV) CONSUMPTION DATA (ODP tonnes)			
2009 - 2010 baseline:	19,269.0	Starting point for sustained aggregate reductions:	18,865.44
CONSUMPTION ELIGIBLE FOR FUNDING (ODP tonnes)			
Already approved:	3,445.19	Remaining:	15,420.25

(V) BUSINESS PLAN		2016	2017	2018	2019	2020	After 2020	Total
World Bank	ODS phase-out (ODP tonnes)	412.5	412.5	412.5	412.5	0	0	1,650
	Funding (US \$)	25,278,410	25,278,410	25,278,410	25,278,410	11,235,850	0	112,348,490

(VI) PROJECT DATA			2016	2018	2020	2023	2025	Total
Montreal Protocol consumption limits								
Maximum allowable consumption (ODP tonnes)								
Project costs requested in principle (US \$)	World Bank	Project costs						
		Support costs						
Total project costs requested in principle (US \$)								
Total support costs requested in principle (US \$)								
Total funds requested in principle (US \$)								

(VII) Request for funding for the first tranche (2016)		
Agency	Funds requested (US \$)	Support costs (US \$)
World Bank	TBD	TBD

Funding request:	Approval of funding for the first tranche (2016) as indicated above
Secretariat's recommendation:	For individual consideration

PROJECT DESCRIPTION

116. On behalf of the Government of China, the World Bank, as the designated implementing agency, has submitted to the 76th meeting stage II of the polyurethane (PU) foam sector plan of the HCFC phase-out management plan (HPMP), at a total cost of US \$205,842,106, plus agency support costs of US \$14,408,947, as originally submitted. The implementation of stage II of the PU foam sector plan will completely phase out the consumption of HCFC-141b in the sector by 2026 and assist China in meeting the Montreal Protocol compliance targets of 35 per cent reduction by 2020 and 67.5 per cent by 2025.

117. The first tranche for stage II of the PU foam sector plan being requested at this meeting amounts to US \$10,253,172, plus agency support costs of US \$717,722, as originally submitted.

Status of implementation of stage I of the PU foam sector plan

118. Stage I of the PU foam sector plan for China was approved at the 64th meeting at a total cost of US \$73,000,000, plus agency supports costs for the World Bank, to phase out 14,685 mt (1,615.4 ODP tonnes) of HCFC-141b and meet the 17 per cent reduction target for the sector in 2015.

Summary progress report on the implementation of stage I activities¹⁴

ODS policy and regulation framework

119. The Ministry of Environmental Protection (MEP) issued a Circular on Strict Management of HCFC Production, Sale and Consumption in 2013 to ensure achievement of the freeze target in 2013 and the 10 per cent reduction in 2015. The circular established quota permits for enterprises (including PU foam) consuming more than 100 mt of HCFCs per year.

120. The ban on the use of HCFC-141b as foam blowing agent in three sub-sectors, namely refrigerators and freezers, reefer containers and small household appliances, is being prepared by the China Household Electrical Appliance Association (CHEAA) and is expected to be effective by July 2016.

Conversion activities

121. The PU foam sector plan included the conversion of 54 PU foam enterprises to water (17 enterprises) and hydrocarbon (HC) (37 enterprises) based technologies. Stage I will result in the complete phase-out of HCFC-141b used as a blowing agent for refrigerators and freezers, reefer containers and small household appliances, and partial phase out of HCFC-141b used in other sub-sectors, as shown in Table 1.

Table 1. Phase-out of HCFC-141b by sub-sector in stage I of the PU foam sector

Sub-sector	Phase-out of HCFC-141b	
	mt	ODP tonnes
Refrigerators and freezers	3,465	381.2
Reefer containers	6,815	749.7
Small household appliances	2,426	266.9
Other sub-sectors	1,979	217.7
Total	14,685	1,615.4

¹⁴ A comprehensive progress report was included in the last tranche request for stage I of the HPMP for China submitted to the 75th meeting (paragraphs 15 to 20 of document UNEP/OzL.Pro/ExCom/75/41).

122. As of February 2016, 21 enterprises completed their conversions (nine to cyclopentane and 12 to water-blown technologies), while the remaining 33 enterprises are at different stages of conversion and are expected to be completed by the end of 2016. Any other foam enterprise still using HCFC-141b in the refrigerators and freezers, reefer containers and small household appliances sub-sectors will be converted without funding from the Multilateral Fund.

123. The six systems houses that had received assistance have signed contracts with FECO/MEP and are currently conducting equipment procurement (e.g., pre-blending facilities or foam injection machines, cyclopentane storage tanks), and undertaking plant modification to meet the national safety standards.

Technical assistance (TA) activities

124. The following TA activities are being implemented in the PU foam sector plan:

- (a) Strengthening the capacity of local Environmental Protection Bureaus (EPBs) through training and discussions with the industry to ensure effective enforcement of the upcoming bans of HCFC-141b, monitoring the use of HCFC-141b, expand their administrative role and enable them to test alternatives;
- (b) Workshops for beneficiary foam enterprises on alternative blowing agents, including cyclopentane, water-blown, HFOs and HFO blends;
- (c) Research to assess the effectiveness of implementation of the foam conversions in the three sub-sectors and the availability of raw materials in the market;
- (d) Development of new and revision of existing guidelines and standards on the safe design and operation of PU foam plants using cyclopentane; and study on alternative technologies in spray foam;
- (e) Development of a management information system to track HCFC phase-out and provide project data and progress reports; and
- (f) Support by the China Plastic Processing Industry Association (CPPIA) (designated as implementation support agency (ISA) to FECO) through consultations, training and information dissemination to foam enterprises; technical advice and assistance in carrying out on-site project completion and safety verifications.

Project implementation and monitoring unit (PMU)

125. A PMU with the responsibility to implement stage I of the PU foam sector plan was established under FECO.

Status of disbursements

126. As of February 2016, of the total funds of US \$73,000,000 approved, US \$44,338,700 had been disbursed from the World Bank to FECO, and US \$29,467,499 had been disbursed by FECO to beneficiaries. Funding disbursed to beneficiaries' accounts for 40 per cent of the total funding approved for stage I, and 66 per cent of the funding disbursed from the World Bank to FECO. An additional US \$21,700,000 will be disbursed to beneficiaries by December 2016; the remaining funding of US \$21,832,501 will be disbursed between 2017 and 2019.

Stage II of the PU foam sector planConsumption of HCFC-141b

127. The estimated consumption of 4,383 ODP tonnes of HCFC-141b in the PU foam sector in 2015 was 1.5 per cent below the consumption of 4,449.6 ODP tonnes allowed under the Agreement between the Government of China and the Executive Committee, as shown in Table 2.

Table 2. HCFC-141b consumption in the PU foam sector in China (2012-2015)

HCFC-141b	2012	2013	2014	2015
Metric tonnes				
Maximum allowable consumption		49,020.0	49,020.0	40,450.9
CP data report	59,109.0	46,338.5	46,863.7	39,845.0*
Difference		2,681.5	2,156.3	606.9
ODP tonnes				
Maximum allowable consumption		5,392.2	5,392.2	4,449.6
CP data report	6,502.0	5,097.2	5,155.0	4,383.0*
Difference		295.0	237.2	66.6

* Estimated consumption.

Remaining consumption eligible for funding

128. After implementation of stage I, the remaining consumption of HCFC-141b eligible for funding is 4,187.18 ODP tonnes based on the Agreement between the Government and the Executive Committee. After deducting 137.83 ODP of HCFC-141b contained in exported pre-blended polyols in line with decision 68/42, the remaining consumption of HCFC-141b eligible for funding would be 4,049.35 ODP tonnes.

129. Stage II proposes to phase-out 4,449.6 ODP tonnes of HCFC-141b in the PU foam sector by 2026, of which 3,639.35 ODP tonnes will be funded through the Multilateral Fund, as shown in Table 3.

Table 3. Reduction schedule for HCFC-141b in the PU foam sector

Description	Stage I		Stage II					Total
	2013	2015	2018	2020	2023	2025	2026	
Consumption limit (mt)	49,020.0	40,450.9	34,314.0	26,961.0	9,804.0	3,000.0	0.0	
Consumption limit (ODP tonnes)	5,392.2	4,449.6	3,774.5	2,965.7	1,078.4	330.0	0.0	
Reduction (mt)	6,116.0	8,569.0	6,137.3	7,352.7	17,157.3	6,803.6	3,000.0	55,136.0
Reduction (ODP tonnes)	672.8	942.6	675.1	808.8	1,887.3	748.4	330.0	6,065.0
Reduction from starting point		17%	30%	45%	80%	94%	100%	
Funded reduction (ODP tonnes)	1,615.4		3,639.4					5,254.7

Phase-out strategy in the foam sector for stage II

130. Similar to the stage I strategy, the phase-out of HCFC-141b in the PU foam sector in stage II would be achieved through the conversion of foam enterprises, assistance to eight systems houses for the development of HC-based pre-blended polyols particularly for the use of SMEs; regulatory actions; TA activities in support of the phase-out; and implementation and monitoring.

Conversion of foam enterprises

131. Stage II proposes the conversion of approximately 2,100 enterprises, starting with enterprises producing insulation foam for solar water heaters and pipes and followed by gradual conversion of the remaining enterprises in the other sub-sectors. Depending on the sub-sector and the size of enterprise, HCs, CO₂ (water) and HFOs will be used as alternative blowing agents. Table 4 presents an estimate of the distribution of enterprises and their HCFC-141b consumption.

Table 4. Estimated distribution of HCFC-141b consumption in the PU foam sector for 2014

Sub-sector	No. of enterprises	Consumption (2014)	
		Mt	ODP tonnes
Stage II			
Foam panels	400	12,500	1,375.00
Spray foam	450	8,950	984.50
Pipe insulation	400	6,600	726.00
Solar water heaters	450	4,400	484.00
Shoe sole	150	3,000	330.00
Heat pump water heaters	100	1,000	110.00
Integral skin	10	150	16.50
Other use	140	3,800	418.00
Total	2,100	40,400	4,444.00
Stage I			
Reefer containers	*	3,900	429.00
Small household appliances	*	1,500	165.00
Refrigerators and freezers	*	1,100	121.00
Total		6,500	715.00
Grand total		46,900	5,159.00

*It includes eligible enterprises and an unknown number of non-eligible enterprises.

132. Conversion of all enterprises will be completed by 2025, with the exception of spray foam users, which will be completed by 2026. A ban on HCFC-141b consumption for foam manufacturing will be established as of 1 January 2026.

133. Individual agreements with FECO will be signed with a minimum of 150 medium to large enterprises (with consumption higher than 20 mt). Support will be provided to SMEs through acquisition and distribution of standard equipment and technical assistance from systems houses. Options to provide assistance to SMEs to phase-out their consumption of HCFCs are being considered, including market mechanisms that would promote competitive pricing of equipment while giving SMEs more discretion in equipment selection. Other options will be considered during the implementation timeframe.

134. The incremental capital costs (ICC) were calculated based on: the number of enterprises; the level of HCFC-141b consumption¹⁵ (i.e., large-size, with a consumption above 75 mt; medium-size, with a consumption between 20 mt and 75 mt tonnes; and small-size, with a consumption below 20 mt); and standard costs for replacing or retrofitting equipment in the baseline, installing new equipment (e.g., storage tanks and premixing stations for the use of HC blowing agent) and/or safety measures. The standard capital costs are summarized in Table 5.

¹⁵ The distribution of enterprises by level of consumption was based on the data provided by eligible enterprises (established before 21 September 2007) that responded to the survey conducted during the preparation of stage II of the PU foam sector plan. It is assumed that this distribution remains the same for the total consumption in each subsector, which is estimated based on the ratio of consumption of eligible and non-eligible enterprises that responded to the survey.

Table 5. Standard ICC for conversions of enterprises in stage II of the PU foam sector plan

Foam dispenser	Unit cost (US \$)	Standard conversion items	Unit cost per size of enterprise (US \$)		
			Large	Medium	Small
HC					
200 kg/min	165,500	Safety measures	216,000	145,000	88,000
100 kg/min	136,000	Storage tank	110,000	-	-
40 kg/min	88,100	Premixing unit	120,000	-	-
		Trial cost	40,000	20,000	10,000
Water					
200 kg/min	109,230	Production line conversion	40,000	20,000	10,000
100 kg/min	89,760	Heating house	10,000	5,000	2,500
40 kg/min	58,146	Trial cost	40,000	20,000	10,000
HFO					
Dispenser		Trial cost	40,000	20,000	10,000
Spray foam /water					
		Dispenser	16,129		
		Trial cost	20,000	20,000	20,000

135. Incremental operating costs (IOC) were calculated for each sub-sector based on the cost difference of raw chemicals (i.e., blowing agents and polyols) and changes to polyol formulation, which varies depending on the sub-sector.

136. Incremental capital costs (ICC) for the eight systems houses to introduce HC pre-blended polyols included procurement of either a foam dispenser for product testing or HC storage tanks and premixing stations; safety equipment and systems; packing facility for pre-blended polyols; trials, training and technical support, as shown in Table 6.

Table 6. The proposed cost of the conversion at eight system houses

Equipment	Cost (US \$)	
	Option 1	Option 2
Foaming equipment for product testing	170,000	
Cyclopentane pre-mixing units (2 units)		120,000
Underground HC storage tank		50,000
Safety equipment and systems	120,000	120,000
Packing facility for pre-blended polyols	40,000	40,000
Trials	10,000	10,000
Training and technical support	10,000	10,000
Total	350,000	350,000
Grand total (for 8 systems houses)	2,800,000	2,800,000

137. Based on the alternative technology selected by each foam enterprise, their level of consumption, the establishment date and foreign ownership, and the standard costs of the equipment required for the conversion of the production lines and the eight systems houses, the total cost has been estimated at US \$230,066,153, of which US \$190,655,807 are requested from the Multilateral Fund, as shown in Table 7. The funding level not being requested (US \$39,410,346) correspond to enterprises established after the cut-off date of 21 September 2007 and/or the portion of non-Article 5 ownership by assisted enterprises. The cost of the conversion of the eight systems houses (i.e., US \$2,800,000) has been included in total incremental costs by distributing the costs among the sub-sectors that will be using HC in pre-blended polyols.

Table 7. Total cost of enterprises included in the conversion of the PU foam sector plan

Sub-sector	Technology	Consumption (mt)		Total cost (US \$)	Cost requested (US \$)**			CE US \$/kg
		Total	Eligible*		Capital	Operating	Total	
Foam panels	HC	12,500	11,433	83,048,717	69,535,316	6,421,440	75,956,757	6.64
Solar water heaters	HC, water	4,400	3,711	36,798,298	27,243,716	3,790,119	31,033,835	8.36
Pipe insulation	HC, water	6,600	5,510	18,309,317	10,888,507	4,396,973	15,285,480	2.77
Heat pump water heaters	HC	1,000	797	9,790,000	7,591,313	215,300	7,806,613 ***	9.79
Spray foam	HFO, water	8,950	6,812	54,348,621	4,682,396	36,684,225	41,366,621	6.07
Integral skin	Water	150	150	402,230	209,394	192,836	402,230	2.68
Shoe sole	HC	3,000	2,061	16,739,278	11,830,770	-329,791	11,500,978	5.58
Other	Water	3,800	2,611	10,629,692	1,585,535	5,717,758	7,303,293	2.8
Grand total		40,400	33,085	230,066,153	133,566,947	57,088,860	190,655,807	5.76

* Eligible consumption per sector corresponds to enterprises established before 21 September 2007.

**Cost requested corresponds to the total incremental cost discounting the cost associated to enterprises established after 21 September 2007 and the cost associated with consumption in foreign-owned enterprises.

***The cost was adjusted based on the CE of US\$ 9.79/kg as per decision 74/50 (UNEP/OzL.Pro/ExCom/74/56).

TA activities

138. The following TA activities at a total amount of US \$5,694,862 have been included to support the conversion of foam enterprises in stage II:

- (a) Training and workshops for beneficiaries on safety issues, policy measures and project implementation (US \$200,000);
- (b) Development of alternative-based formulations (US \$356,742);
- (c) Research and development of technical and safety standards for foam products (US \$250,000);
- (d) Two policy impact assessments prior to the establishment of bans on the use of HCFC-141b in the PU foam sector (US \$200,000);
- (e) On-site technical support to SMEs (US \$450,000);
- (f) Market study to improve assistance to SMEs (US \$238,000);
- (g) Capacity building of local EPBs and other agencies (US \$1,200,000);
- (h) Technical consulting for FECO (US \$200,000);
- (i) Study tours for beneficiaries, industrial associations and research institutes (US \$100,000);
- (j) Public awareness and outreach (US \$200,000), and
- (k) Support to a national entity to be designated as ISA to provide technical consultations, training and guidance to foam enterprises and technical advice to FECO/MEP and local EPBs, and facilitate on-site project and safety verifications by audit agencies (US \$2,300,120).

139. The following regulatory measures will be promulgated to support the phase out of HCFC-141b in the PU foam sector: a ban on the use of HCFC-141b in manufacturing insulation foam for solar water heaters and pipes from 1 January 2020, and in the whole PU foam sector from 1 January 2026;

strengthening regulation on safety management; and review and revision of technical standards on rigid PU foam.

Implementation modality

140. The PMU established under FECO in stage I of the PU foam sector plan will continue to be operational during stage II. It will coordinate the implementation of stage II activities through preparing phase-out regulations and policies; strengthening monitoring and reporting and information-management systems; verifying the eligibility of enterprises, their execution plans, consumption and phase-out achieved and signing contracts with them; preparing terms of reference and signing contracts related to TA activities; managing financial aspects (disbursement and audit); preparing reports and plans; and overseeing all phase-out activities and monitoring the implementation status of all contracts. Local EPBs will provide project management support through random inspections at FECO's request and on-the-ground monitoring to ensure successful implementation of phase-out activities at the enterprise level.

141. The World Bank will share experience on alternative technologies, supervise sub-project implementation, conduct on-site sub-project visits, review terms of references for TA activities, discuss with FECO and relevant stakeholders and solve issues that may arise during project implementation. It will also perform verification of HCFC-141b consumption in a sample of enterprises in accordance with the Agreement between the Government of China and the Executive Committee.

142. The financial arrangements for the foam sector plan would be similar to those in stage I. The World Bank will sign a Grant Agreement with the Government of China to channel funds from the Multilateral Fund to China. The World Bank will disburse funds to FECO in three instalments when specific implementation milestones (e.g., compliance with the previous year's target or submission of the progress report to the World Bank) have been achieved. To disburse funds to beneficiaries, FECO will sign contracts with foam enterprises, or consultancy service providers for TA activities. Beneficiary foam enterprises will allow and facilitate visits and inspections from FECO, local EPBs and the World Bank.

Total cost of stage II of the PU foam sector plan

143. The overall total cost of the PU foam sector plan as a component of stage II of the HPMP for China to be funded through the Multilateral Fund has been estimated at US \$205,842,106, as originally submitted (excluding support costs). The proposed phase-out activities will result in the phase-out of 4,444 ODP tonnes of HCFC-141b with an overall cost effectiveness of US \$5.10/kg or US \$6.22/kg (based on only eligible consumption). Detailed activities and cost breakdown are shown in Table 8 below:

Table 8. Summary of proposed activities and cost of stage II of the PU foam sector plan for China

Sub-sector*	HCFC-141b phase-out		CE (US \$/kg)	Funds requested (US \$)
	mt	ODP tonnes		
Foam panels	11,433	1,257.6	6.64	75,956,757
Solar water heaters	3,711	408.2	8.36	31,033,835
Pipe insulation	5,510	606.1	2.77	15,285,480
Heat pump water heaters	797	87.7	9.79	7,806,613
Spray foam	6,812	749.3	6.07	41,366,621
Integral skin	150	16.5	2.68	402,230
Shoe sole	2,061	226.7	5.58	11,500,978
Other	2,611	287.2	2.80	7,303,293
Sub-total	33,085	3,639.4	5.76	190,655,807
TA activities				5,694,862
PMU				9,491,437
Total	33,085	3,639.4	6.22	205,842,106
Including unfunded consumption	40,400	4,444.0	5.10	

* The cost of the conversion of the eight systems houses (i.e. US \$2,800,000) has been distributed among the sub-sectors that will be using HC in pre-blended polyols.

144. The overall fund request and co-financing of the PU foam sector plan is presented in Table 9.

Table 9. Total funds request and co-financing PU foam sector plan for China

Component	Costs (US \$)		
	Total	Requested	Counterpart
Foam and system house conversions	230,066,153	190,655,807	39,410,345
Technical assistance, training and policy	5,694,862	5,694,862	*
Project management	9,491,437	9,491,437	*
Total	245,252,452	205,842,106	39,410,345

* In kind

SECRETARIAT'S COMMENTS AND RECOMMENDATION

COMMENTS

145. The Secretariat reviewed stage II of the PU foam sector plan for China in light of stage I, the policies and guidelines of the Multilateral Fund, including the criteria for funding HCFC phase-out in the consumption sector for stage II of HPMPs (decision 74/50), and the 2016-2018 business plan of the Multilateral Fund.

146. The Secretariat noted with appreciation that, although the funding approved for the preparation of stage II of the PU foam sector plan aimed at undertaking a survey only of enterprises manufacturing insulation foam for solar water heaters and pipes, the stage II sector proposal covers all PU foam sub-sectors that will be fully converted by 2026, replacing the total amount of HCFC-141b with low-GWP alternative blowing agents. In addition, the proposal was comprehensive and well thought-out.

Report on HCFC consumption

147. Comparing the results of the surveys of foam enterprises conducted in 2008 (for preparation of stage I) and 2014 (for preparation of stage II), a significant increase was noted in the use of HCFC-141b for panels, pipe insulation, heat pump water heaters, and shoe soles/others sub-sectors, noting that in the case of water heaters, the 2008 survey had not identified any HCFC consumption. This increase was explained by the growth in housing construction, food processing, appliance and other industries. It was also clarified that HCFC consumption in the heat pump water heaters in 2008 was reported under the "others" category. The World Bank also indicated that the majority of increased HCFC consumption was from the original production capacity and only a small proportion corresponds to new capacity. A total of 273 foam enterprises and 66 systems houses were surveyed in 2008 and 163 enterprises and 28 systems houses in 2014. Of those, 66 enterprises and 13 systems houses were covered by both surveys.

Distribution of HCFC-141b in pre-blended polyols

148. Responding to a question by the Secretariat, the World Bank indicated that there is no import of HCFC-141b in pre-blended polyols, and that the use of HCFC-141b in pre-blended polyol is controlled through the production and consumption quotas for HCFC-141b, and the local EPB recording mechanism. The pre-blended polyols are mostly consumed domestically. There are around 80 systems houses (most of them medium-sized and locally owned) that blend HCFC-based polyols in China largely for domestic consumption and limited export. The selection of the eight systems for the introduction of HC pre-blended polyols under stage II will be carried out during implementation, taking into consideration, *inter alia*, the systems houses' market share, research capacity, the number of downstream enterprises and their location.

Alternative technologies supply

149. In line with decision 74/20(a)(iii) the Secretariat requested the World Bank to provide information from the suppliers on the availability of the HFO technology in the local market. The World Bank informed that, while it is difficult at present to obtain detailed commercial information from the current HFO producers, it is expected that several international producers will start production of HFOs in China in 2017 with available capacities of 10,000 to 20,000 mt per year.

Phase-out strategy and implementation modality

150. While an implementation modality to address larger enterprises has been operational since stage I, several approaches are still being considered to provide assistance to SMEs and facilitate their conversion to low-GWP alternative blowing agents, including *inter alia* distribution of standard equipment, or use of systems houses as intermediaries. In discussing these approaches, the World Bank explained that studies to improve the understanding of the financial and technical needs of SMEs will determine the standard equipment required for further procurement and distribution. Considering that there are SMEs in the sub-sectors selected as a priority for stage II (water heaters and pipe insulation), a definition of the implementation modality for these enterprises would be determined soon to avoid delays in implementation. As this issue has not been fully resolved, the Secretariat suggests including the implementation modality for SMEs in the tranche implementation report to be submitted with the request for the second tranche.

Cost-related issues

151. The Secretariat expressed concern that the sample of enterprises included in the survey and used for the calculations of the incremental costs of the PU sector plan was not representative enough to extrapolate the results for the whole sector, in particular with regard to the distribution of enterprises by size, where a higher number of large enterprises was used in the cost model than exist in reality. The World Bank indicated that although questionnaires were sent to enterprises in different sub-sectors based on geographical location and estimated consumption (large, medium and small) most of the returned questionnaires were from large and medium enterprises. Therefore, a conservative scenario was used to calculation of the incremental capital costs; as a larger amount of SMEs will need to be addressed, this would increase the cost of the conversions.

Incremental capital cost

152. The Secretariat analysed the proposed standard costs (as shown in Table 5) in light of the extensive number of foam project so far approved, several reports related to cost of conversion of PU foam enterprises and consultations with independent technical experts. As a result of the review, the Secretariat presented to the World Bank a proposal of incremental cost where the costs of some equipment items (i.e., foam dispensers, HC storage tanks and premixers, safety costs and trials) were adjusted, and other items that considered not to be incremental (i.e., foam dispensers for water-based technology) were removed.

153. Further discussions with the World Bank on the equipment required for the conversion from HCFC-141b to alternative blowing agents and their associated costs, resulted in a common understanding to rationalize the cost of some of the equipment items. On this basis the World Bank presented a revised proposal of standard costs, with the cost of some equipment items lower than originally proposed. However, the costs of several equipment items were above those proposed by the Secretariat as shown in Table 10.

Table 10. Comparison of standard unitary costs for conversions of enterprises in stage II of the PU foam sector plan, proposals by the Secretariat and the World Bank (US \$)

Description	Characteristics	As submitted	Secretariat's proposal	World Bank's revised proposal
AGREED COSTS				
Standard conversion cost, water				
Production line conversion	Large enterprises	40,000	40,000	40,000
	Medium enterprises	20,000	20,000	20,000
	Small enterprises	10,000	10,000	10,000
Heating house	Large enterprises	10,000	10,000	10,000
	Medium enterprises	5,000	5,000	5,000
	Small enterprises	2,500	2,500	2,500
Trials for all technologies				
Trials	Large enterprises	40,000	30,000	30,000
	Medium enterprises	20,000	15,000	10,000
	Small enterprises	10,000	5,000	5,000
DIFFERENCE IN COSTS				
Standard conversion cost, HC				
Foaming equipment, HC	200 kg/min	165,500	109,727	132,840
	100 kg/min	136,000	90,168	101,775
	40 kg/min	88,100	58,410	76,797
Safety measures, cost	Large enterprises	216,000	210,000	216,000
	Medium enterprises	145,000	130,000	145,000
	Small enterprises	88,100	88,100	88,100
HC Storage tank		110,000	90,000	110,000
HC Premixing unit		120,000	90,000	120,000
Standard conversion cost, water				
Foaming equipment, water	200 kg/min	109,230	72,419	100,000
	100 kg/min	89,760	59,511	73,000
	40 kg/min	58,146	38,551	58,146
SPRAY FOAM/water				
Dispenser		16,129	0	16,129

154. As shown in Table 10, the Secretariat and the World Bank agreed on the costs for trials for all technologies, production line conversion¹⁶ and heating house¹⁷ as submitted. However, agreement was not reached with the costs of the following items:

- (a) *PU foam dispensers*: Based on the data from the surveyed enterprises, it was agreed that in 23.5 per cent of the cases baseline equipment was found to be suitable for retrofit while in the remaining 76.5 per cent cases, where baseline equipment is locally made and not suitable for safe retrofit, new equipment could be provided. For cost of the new dispensers the Secretariat proposed a 30 per cent reduction from that proposed by the World Bank considering that they would be locally manufactured with reduced costs for manufacturing and transportation;

¹⁶With the introduction of water-blown technology the process of foam injection has to be done horizontally to ensure the smooth flow of raw materials. Since the water tanks have a typical height of 2.2 to 2.4 meters and a diameter of 0.5 meter, a longer conveyor belt is needed in order to maintain the production capacity at the baseline level. In addition, the speed of the line has to be adjusted accordingly.

¹⁷ Production of insulated pipes in China takes place in a large number of non-heated workshops in areas where the temperature drops below zero Celsius during the winter period, which requires installation of a flexible and movable enclosure with a heater blower around the pipes when doing the foaming with water-blown technology.

- (b) *Safety measures:* Based on the funding approved for safety components in a large number of similar projects, the Secretariat proposed a minor rationalization of costs of safety related equipment for large- and medium- sized enterprises. However, the World Bank indicated that the Government of China was unable to compromise on this item;
- (c) *HC storage tanks and HC pre-mixing units:* The Secretariat proposed the cost of storage tanks at US \$90,000 based on the funding approved in a large number of similar projects (where it costs as low as US \$50,000 had been approved); similarly, the Secretariat proposed the cost pre-mixing stations at US \$90,000, noting that the costs for similar pre-mixers in projects submitted to the 76th meeting are US \$80,000. However, the World Bank maintained the costs of these items as submitted;
- (d) *PU foam dispensers for water based technology:* Based on technical advice and similar projects approved for water blown-technology the Secretariat considered that the existing high- or low-pressure foam dispenser can be used with the new formulations. While the World Bank agreed that the existing high-pressure dispenser can be used, minor adjustments are required for low-pressure dispensers, as reflected in the proposed standard costs;
- (e) *Spray foam dispensers for water-based technology:* The World Bank explained that most spray foam dispensers in the baseline operate with a polyol to MDI¹⁸ ratio of 1:1; as the amount of MDI in a water-based formulation is higher, a new dispenser would be required. In addition, dispensers with higher pressure might be needed since water-based formulations could be more viscous than HCFC-141b formulations. Upon consultation with one technical expert, the Secretariat considered that standard spray foam dispensers can operate with water-blown systems at a 1:1 ratio; furthermore, 100 per cent water systems can be formulated using off-the-shelf polyols and additives to have the required viscosity.

Incremental operational costs

155. The main issue regarding the calculation of the IOC related to the request for an increase in density for cyclopentane-based formulations (at 2 per cent) and for water-based formulations in spray foam (at 22 per cent):

- (a) In the case of cyclopentane, the World Bank explained the need for an increased density given the higher boiling point of cyclopentane that results in lower gas pressure in the cells, lower compressive strength and dimensional stability. Three independent experts consulted by the Secretariat indicated that there are no problems with compressive strength/dimensional stability of cyclopentane-blown foams. With regard to the difference in boiling point between cyclopentane and HCFC-141b, the most cost-effective and commonly applied solution, is to formulate the polyols to a higher crosslink¹⁹ density for more strength. A large number of projects converted to cyclopentane blowing technology have been approved under the Fund. Furthermore, a request for the conversion of foam enterprises to cyclopentane technology had been submitted to the 76th meeting, with no increase in foam density, resulting in operating savings;

¹⁸ Methylene diphenyl diisocyanate.

¹⁹ A cross-link is a bond that links one polymer chain to another to promote a difference in the polymers' physical properties.

- (b) The Secretariat noted that the 22 per cent increase in foam density for water-based formulations, is extremely high; in several similar projects a 10 per cent increase represented the maximum increase requested. Further to consultation with a technical expert, the Secretariat suggested 7 per cent increase. However, the World Bank indicated that the increase in density as proposed was required to maintain shape and dimensional stability, which will be affected by atmospheric conditions, in addition to CO₂ eventually escaping from the foam cell and being replaced by nitrogen and oxygen.

156. The analysis of the IOC due to the increase in foam density as requested in the PU foam sector plan and proposed by the Secretariat is presented shown in Table 11. The Secretariat further notes that a more cost-effective approach to address issues related to the increase in foam density (e.g., cell vapour pressure difference between cyclopentane and HCFC-141b) would be through additional TA to ensure adequate foam formulations.

Table 11. IOC for stage II of the PU foam sector plan proposed by the Secretariat

Sector (technology)	Eligible consumption (mt)	As submitted		Secretariat's proposal	
		Density increase	IOC (US \$)	Density increase	IOC (US \$)
Panel (HC)	11,433	2%	6,745,211	0%	1,714,884
Spray (water)	2,044	22%	10,217,768	7%	4,495,818
Pipe insulation (HC)	1,102	2%	297,540	0%	(187,340)
Solar water heater (HC)	2,226	2%	601,020	0%	(378,495)
Shoe sole (HC)	2,061	2%	(329,791)	0%	(3,380,362)
Heat pump water heater (HC)	797	2%	215,300	0%	(135,559)
Total	19,663		17,747,048		2,128,946

TA component and PMU

157. As approved in stage I, the TA and PMU components included in stage II do not have an associated reduction in HCFC consumption. However, the Secretariat noted that in the case of stage I, the phase-out of 211.6 ODP tonnes of HCFC-141b was associated with regulatory measures developed and implemented through the TA and PMU components. The World Bank indicated that, according to their understanding and practice, the funding for TA and PMU should be within the limit of 10 per cent of the total investment cost, and therefore HCFC consumption should not be deducted. The World Bank also added that TA activities and the PMU will play a key role in ensuring smooth implementation of conversion activities in stage II of the PU foam sector plan, where a higher amount of HCFCs will be phased out, the implementation period will be longer, and more enterprises will be addressed. The Secretariat acknowledges the benefits provided by the TA and PMU components and engaged in discussions with the World Bank on the activities included in the TA, and with UNDP on the activities included in the PMU, as part of the overarching strategy of stage II of the HPMP for China.

TA component

158. In reviewing the funding requested for TA activities, the Secretariat noted that, as of July 2015, approximately US \$4.7 million out of the US \$6.3 million approved for such activities under stage I had not been committed. The Secretariat asked whether those funds could be used for some of the TA activities proposed under stage II. The World Bank clarified that as of December 2015 the total commitments made to TA activities amounted to US \$4.5 million, while US \$952,650 have been allocated for activities included in the 2016 annual work programme approved at the 75th meeting.

159. Regarding the development of the alternative-based formulations, the Secretariat noted that this activity seems to overlap with the technical support and training provided to the systems houses. The World Bank indicated that the majority of the research at systems houses is on cyclopentane, which will be predominantly adapted by downstream clients, while the requested TA activity is for development of

other formulations besides cyclopentane. After further considerations on the potential overlap from both activities, the World Bank agreed to reduce the cost associated with this activity.

160. On the potential overlap between the technical consultant services for FECO and on-site technical support for SMEs, the World Bank indicated that the support for SMEs is for technical advice specific to the production process and products redesign, while services for FECO will provide policy advice and overall evaluation of emerging alternative technologies.

161. The Secretariat also questioned the inclusion of research and development of technical and safety standards, noting that under stage I new and revised guidelines and standards on the use of cyclopentane in large and small enterprises, including safety considerations, were being developed/revised and would be completed by the end of 2016. The World Bank clarified that stage II will address the conversion of enterprises in different sub-sectors than stage I, and that additional research and standard development is required to cover products in those new sub-sectors.

162. Based on the discussions on specific TA activities above mentioned, and noting that as a result of implementation of stage I, there is now a better understanding of alternative technologies, a proper local implementation modality, key regulations to ensure compliance, local capacity for implementation and monitoring, and a better understanding of the PU foam sector, the World Bank agreed to rationalize the costs associated with some of the TA activities. While an agreement between the Secretariat and the World Bank on the costs of all TA activities could not be reached, the difference in the costs had been reduced as indicated in Table 12.

Table 12. Costs of TA component of stage II of the PU foam sector plan in China

Description	Cost (US \$)			
	As submitted	Revised World Bank	Proposed Secretariat	Difference
Training and workshops for industrial stakeholders	200,000	150,000	100,000	(50,000)
Technical consultant services for FECO	200,000	200,000	200,000	-
Development of alternative formulations	356,742	250,000	150,000	(100,000)
On-call, on-site technical support for SMEs	450,000	250,000	200,000	(50,000)
Research and development of technical and safety standards	250,000	200,000	200,000	-
Policy impact assessments (2)	200,000	200,000	100,000	(100,000)
Market study to improve assistance to SMEs	238,000	150,000	100,000	(50,000)
Capacity building of local EPBs and other agencies	1,200,000	1,000,000	700,000	(300,000)
Public awareness and outreach	200,000	150,000	150,000	-
Implement support agency (ISA)	2,300,120	2,200,000	2,000,000	(200,000)
Study tours for beneficiaries, associations	100,000	100,000	100,000	-
Total cost	5,694,862	4,850,000	4,000,000	(850,000)

PMU

163. Taking into account the balance of funds for the PMU from stage I (US \$1.6 million as of July 2015) and the extension of stage I activities until the end of 2017, the Secretariat suggested subsuming part of the PMU cost for stage II under stage I, thereby reducing the overall cost of the PMU for stage II. The World Bank clarified that as of December 2015 more than US \$2.2 million under the PMU had already been disbursed; stage II of the PU foam sector plan is relatively independent from stage I; and the longer implementation period and increased number of projects would lead to an increase in the PMU's workload and, consequently, an increase in PMU staff and operation costs.

164. Noting that the Secretariat had raised the issue of project management costs related to all the sector plans China in the context of the overall stage II of the HPMP for China, it was agreed that the PMU cost requested for the PU foam sector plan would be discussed in the context of the overarching strategy. Accordingly, the level of funds requested (4.6 per cent of the overall cost of the plan) has not been modified so far.

Total cost

165. A summary of the overall costs of stage II of the PU foam sector plan in China, as submitted, as revised by the World Bank and as proposed by the Secretariat is presented in Table 13.

Table 13. Overall cost of stage II of the PU foam sector plan in China

Component	Costs (US \$)					
	As submitted		Revised World Bank		Proposed Secretariat	
	Total	Requested	Total	Requested	Total	Requested
Enterprises/systems houses	230,066,153	190,655,807	210,773,862	174,014,714	176,350,566	145,636,544
TA activities		5,694,862		4,850,000		4,000,000
PMU*		9,491,437		9,491,437		9,491,437
Total		205,842,106		188,356,151		159,127,981

*Cost reflected in this table for project management is as submitted. This cost is being discussed separately as part of the overarching strategy.

Impact on the climate

166. The conversion of the remaining PU foam manufacturing enterprises in China would avoid the emission into the atmosphere of some 23,586 thousand tonnes of CO₂ equivalent per year, as shown in Table 14.

Table 14. Climate impact of PU foam projects

Substance	GWP	Tonnes/year	CO ₂ -eq (tonnes/year)
Before conversion			
HCFC-141b	725	33,085	23,986,625
Total before conversion			
After conversion			
Cyclopentane, HFO, water	~20	19,989	399,786
Impact			(23,586,839)

RECOMMENDATION

167. The Executive Committee might wish to consider the sector plan for phase-out of HCFC-141b in the polyurethane foam sector in China in light of the Secretariat's comments contained in document UNEP/OzL.Pro/ExCom/76/25.

PROJECT EVALUATION SHEET – MULTI-YEAR PROJECTS

China

(I) PROJECT TITLE	AGENCY
HCFC phase out plan (stage II) industrial and commercial refrigeration and air conditioning	UNDP

(II) LATEST ARTICLE 7 DATA (Annex C Group I)	Year: 2014	16,838.53 (ODP tonnes)
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(III) LATEST COUNTRY PROGRAMME SECTORAL DATA (ODP tonnes)								Year: 2014	
Chemical	Aerosol	Foam	Fire fighting	Refrigeration		Solvent	Process agent	Lab use	Total sector consumption
				Manufacturing	Servicing				
HCFC-123				12.9	7.1				20.0
HCFC-124					2.1				2.1
HCFC-141b	64.3	5,155				484			5,703.3
HCFC-142b		604.5		6.5	33.7				644.7
HCFC-22	121.9	1,644.5		5,582.5	3,118.8				10,467.7
HCFC-225ca						0.8			0.8

(IV) CONSUMPTION DATA (ODP tonnes)			
2009 - 2010 baseline:	19,269.0	Starting point for sustained aggregate reductions:	18,865.44
CONSUMPTION ELIGIBLE FOR FUNDING (ODP tonnes)			
Already approved:	3,445.19	Remaining:	15,420.25

(V) BUSINESS PLAN		2016	2017	2018	2019	2020	After 2020	Total
UNDP	ODS phase-out (ODP tonnes)	90.0	0	105.0	0	105.0	0	300.0
	Funding (US \$)	14,708,636	0	17,158,909	0	17,158,909	0	49,026,454

(VI) PROJECT DATA			2016	2018	2020	2023	2025	Total
Montreal Protocol consumption limits								
Maximum allowable consumption (ODP tonnes)								
Project costs requested in principle (US \$)	UNDP	Project costs						
		Support costs						
Total project costs requested in principle (US \$)								
Total support costs requested in principle (US \$)								
Total funds requested in principle (US \$)								

(VII) Request for funding for the first tranche (2016)		
Agency	Funds requested (US \$)	Support costs (US \$)
UNDP	TBD	TBD

Funding request:	Approval of funding for the first tranche (2016) as indicated above
Secretariat's recommendation:	For individual consideration

PROJECT DESCRIPTION

168. On behalf of the Government of China, UNDP, as the designated implementing agency, has submitted to the 76th meeting stage II of the industrial and commercial refrigeration and air-conditioning (ICR) sector plan of the HCFC phase-out management plan (HPMP) at the amount of US \$118,165,000, plus agency support costs of US \$8,271,550 for UNDP, as originally submitted. The implementation of stage II of the HPMP will phase out 480.5 ODP tonnes of HCFCs and assist China in meeting the Montreal Protocol compliance target of 30 per cent reduction by 2020.

169. The first tranche for stage II of the ICR sector plan of the HPMP being requested at this meeting amounts to US \$17,725,000, plus agency support costs of US \$1,240,750 for UNDP, as originally submitted.

Status of implementation of stage I of the ICR sector plan

170. Stage I of the ICR sector plan for China was approved at the 64th meeting at a total cost of US \$61,000,000, plus agency support costs, for phasing out 8,450.00 metric tonnes (mt) (464.75 ODP tonnes), accounting for 19.3 per cent reduction of the sector.

Progress in implementation of stage I activities in the ICR sector

171. Implementation of stage I of the ICR sector plan is progressing well. Reductions were achieved through the conversion of manufacturing lines, and quota controls in foreign-owned enterprises. As of February 2016, 30 production lines had been converted or were in the process of conversion. The total phase-out of 8,029.24 mt (441.61 ODP tonnes) of HCFC-22 achieved through conversion plus the phase-out of 455.00 mt (25.03 ODP tonnes) through quotas has exceeded the stage I target of 8,450.75 mt (464.75 ODP tonnes). Out of the total phase-out through conversion, 49 per cent was converted to HFC-32, 26 per cent to HFC-410A, 17 per cent to NH₃/CO₂ cascade systems; and the remaining 8 per cent was to HFC-134a, NH₃, CO₂ and HFC-134a/HFO. Foreign-owned enterprises were mostly converted to R-410A and HFC-134a. Technical assistance (TA) activities, including the promotion of low-global warming potential (GWP) technologies, enforcement of policies and regulation, revision of technical standards, and awareness-raising activities were also conducted to support the conversion, the transition to HCFC alternatives and their market adoption.

Status of disbursements

172. As of February 2016, of the total funds of US \$61,000,000 approved so far, US \$51,850,000 had been disbursed from UNDP to FECO, and US \$23,431,022 had been disbursed from FECO to beneficiaries. Funding disbursed to beneficiaries accounts for 38 per cent of the total funding approved for stage I, and 45 per cent of the funding disbursed from UNDP to FECO. An additional US \$14,500,000 will be disbursed to beneficiaries by December 2016. The remaining funding of US \$23,068,978 will be disbursed between 2017 and 2019.

Stage II of the ICR sector plan

173. The Government of China is committing in stage II to reducing HCFC consumption by 30 per cent of the baseline in the ICR sector by 2020 with a total reduction of 8,822.00 mt (480.49 ODP tonnes) of HCFCs, consisting of 8,687.00 mt of HCFC-22 and 135 mt of HCFC-123, based on the 10 per cent reduction commitment under stage I.

HCFC survey and sector consumption

174. In preparation of stage II of the HPMP, a survey was conducted to collect information on the sector. A total of 422 enterprises were identified and 113 enterprises responded to the survey questionnaire. Of the 113 surveyed enterprises, 104 manufacture refrigeration equipment and nine manufacture air-conditioning (AC) equipment and components. The refrigerants used in the ICR sector include HCFCs (37.8 per cent); HFCs (47.4 per cent) and natural refrigerants (14.8 per cent). Based on the survey, the total HCFC consumption in China was estimated at 40,249 mt (2,191.98 ODP tonnes). Of this amount, HCFC-22 accounted for 98.1 per cent of the total consumption, as shown in Table 1.

Table 1. HCFC consumption in the ICR sector

Substance	2010	2011	2012	2013	2014	Baseline
Metric tonnes						
HCFC-22	45,315.00	47,515.00	46,842.00	40,120.00	39,500.00	43,521.08
HCFC-123	585.00	598.00	511.00	585.00	649.00	320.00
HCFC-142b	100.00	100.00	110.00	100.00	100.00	30.00
Total (mt)	46,000.00	48,213.00	47,463.00	40,805.00	40,249.00	43,871.08
ODP tonnes						
HCFC-22	2,492.33	2,613.33	2,576.31	2,206.60	2,172.50	2,393.66
HCFC-123	11.70	11.96	10.22	11.70	12.98	6.40
HCFC-142b	6.50	6.50	7.15	6.50	6.50	1.95
Total ODP tonnes	2,510.53	2,631.79	2,593.68	2,224.80	2,191.98	2,402.01

175. HCFC consumption in the ICR sector increased from 2008 to 2011 due to economic development and the demand for more refrigeration and air-conditioning equipment. The implementation of the activities in stage I, particularly the conversion of manufacturing capacities using HCFC-22 and the application of licensing and quota controls, has inhibited the growth trend. In 2014, HCFC consumption of 2,191.98 ODP tonnes accounted for 91 per cent of the ICR sector baseline.

176. The ICR sector has a wide range of products with various applications. The consumption in three major sub-sectors, ICR water chillers (42 per cent), unitary air-conditioners (35 per cent), and freezers and condensing units (11 per cent), accounts for 88 per cent of all consumption. Out of the approximately 1,000 enterprises in the sector, 56 per cent are very small (consumption of less than 10 mt per year) and small (10-50 mt) enterprises; 16 per cent are medium-sized (50-100 mt) enterprises and 28 per cent are large (more than 100 mt) enterprises. The distribution of HCFC consumption in the ICR sector is shown in Table 2.

Table 2. Estimated HCFC consumption distribution in the ICR sector (2014 data)

Refrigerant	Product category	HCFC consumption (mt)	No. of enterprises	No. of production lines	Production (units)
HCFC-22	Freezer and refrigeration, and condensing units	4,500	100-200	100-200	n/a
	Small-sized water chiller (heat pump)	1,000	110-200	110-200	150,000
	Industrial and commercial water chiller (heat pump)	16,800	220-300	220-300	320,000
	Heat pump water heater	2,100	100-200	100-200	500,000
	Unitary air-conditioners	14,200	100-200	100-200	3,000,000
	VRV/VRF (heat pumps)*	200	≈10	≈10	10,000
	Train air-conditioner	150	≈5	≈5	21,000
	Others (high temperature heat pump dryers and dehumidifiers)	550	10-20	10-20	
HCFC-123	Centrifugal water chiller	649	1	1	
HCFC-142b	Unitary air-conditioners	100	≈5	≈5	13,000
	Total	40,249	661-1,141	661-1,141	>4,014,000

*Variable refrigerant volume/variable refrigerant flow multi-connected air-conditioners

Phase-out strategy for stage II of the ICR sector plan

177. In the stage II ICR sector plan, the phase-out of HCFCs will be carried out through both investment activities for the conversion of manufacturing lines, and non-investment activities including the enforcement of policies and regulations, awareness-raising activities and TA activities. Priority will be given to the subsectors where market incentives, technical capacity and alternative technology exist. Priority will also be given to sub-sectors with high HCFC consumption and a high growth rate. In stage I, conversion mainly took place at large enterprises. In stage II, more small- and medium-sized enterprises (SMEs) will be covered, as well as enterprises manufacturing compressors as the basis for conversion of manufacturing capacity for ICR equipment.

178. In the stage II ICR sector plan, a total of 8,822.00 mt (480.49 ODP tonnes) of HCFCs will be phased out to achieve a reduction of 30 per cent of the sector baseline by 2020. Of this amount, 6,500 mt (357.50 ODP tonnes) will be phased out through the conversion of manufacturing lines for refrigeration equipment and the conversion of compressors; and 2,322 mt (122.99 ODP tonnes) will be phased out through enforcement of policy and regulations, quota controls on consumption in foreign-owned enterprises, and TA activities.

Policy and regulatory framework

179. The Government of China will develop a policy and regulatory framework to control the growth of consumption in the ICR sector, to provide incentives to adopt environmentally friendly alternative technologies and to ensure a smooth transition toward such technologies, and will include, *inter alia*, the following:

- (a) Licensing and quota system for HCFC production, import and export;
- (b) Notice on the control of new production facilities that use HCFCs;
- (c) First recommended list of key HCFC alternatives (to be released);
- (d) Circular on strengthening HCFC production, sale and application management (HCFC quota system);
- (e) Strengthening the import management of HCFC equipment and issuing a ban on the import of HCFC-22-based refrigeration equipment and compressors where appropriate;
- (f) Establishing incentives for environmentally friendly alternative refrigerants through tax policy; and promoting the use of products converted to environmentally friendly refrigerants by putting them on the government's green procurement list;
- (g) Issuing bans on the use of HCFCs in some sub-sectors (for example VRV/VRF and multi-connected ACs);
- (h) Technical requirements for environmental labelling of products/ODS alternatives;
- (i) Strengthening the management of production licenses for refrigeration and AC equipment; and
- (j) Promulgating regulations and policies geared specifically toward foreign-owned enterprises so that these enterprises can complete HCFC phase-out and conversion targets as scheduled.

Alternative technologies

180. During stage I implementation, there were limited technology choices, leading to the conversion of 81 per cent of consumption to HFCs. In 2012, an Alternative Technology Committee was established by the Government of China to research and explore alternative technologies that are environmentally sound and technically suitable for the country's circumstances.

181. The selection of alternative technologies in stage II, took into consideration the properties of refrigerants, energy efficiency, environmental friendliness (zero ODP and low GWP), safety and health related issues, and economic feasibility. Research and development will be conducted to test and assess potential alternative technologies to support ICR sector phase-out.

Conversion of manufacturing lines

182. In stage I, conversion took place in four subsectors: water chillers (2,117 mt), unitary air conditioners (3,864 mt), freezers and condensing units (1,664 mt), and VRV/VRF (heat pumps) (814.8 mt). Stage II plans to address the consumption in the following four sub-sectors: freezers, refrigeration and condensing units; ICR water chillers; heat pump water heaters; and unitary air conditioners. Based on the experience gained in stage I and the technologies commercially available on the market, 3,150 mt will be converted to HFC-32 technology, and 3,350 mt will be converted to six low-GWP alternatives including hydrocarbon (HC), HFOs, CO₂, NH₃, NH₃/CO₂ cascade and NH₃/CO₂ with CO₂ as secondary fluid.

183. Activities will be implemented in two phases. From 2016 to 2018, conversion projects will be implemented in subsectors with relatively mature technologies, such as HFC-32, NH₃ and NH₃/CO₂ cascade; and to HC and HFOs limited to large enterprises. From 2019 to 2020, conversions of SMEs to low-GWP technologies will be implemented. The detailed conversion plan is shown in Table 3.

Table 3. Plan for conversion of manufacturing lines

Sub-sector	Alternative refrigerant	HCFC-22 (mt)		Lines to be converted
		2016-2018	2019-2020	
Freezers and refrigeration, and condensing units	HFC-32	100		1
	CO ₂ , NH ₃ , HFOs, HC	700	1,200	31
Water chiller (heat pump)	HFC-32	600	400	17
	CO ₂ , NH ₃ , HFOs, HC	200	800	18
Heat pump water heater	HFC-32	50		2
	CO ₂ , NH ₃ , HFOs, HC	150	300	11
Unitary air-conditioning	HFC-32	900	1,100	30
Compressor	HFC-32	0	0	1
	CO ₂ , NH ₃	0	0	2
Total		2,700	3,800	113
		6,500		

Cost for conversion of manufacturing enterprises

184. The incremental capital costs (ICC) of conversion include process and product design, prototypes, manufacturing line conversion, retrofit of performance testing centre, commission and trial production, training of personnel, and upgrade of safety facilities. The incremental operating costs (IOC) are mainly to compensate for the increased cost of the raw materials, components and accessories after adopting alternative technologies.

185. The cost is calculated based on the following assumptions: there will be no technology and capacity upgrades during conversion; the price of the manufactured product after conversion will not increase as compared to the HCFC-22-based product.

186. Given that the consumption addressed in stage II is distributed in four subsectors with a variety of products to be converted to different technologies, standard models are proposed for cost calculation for conversion in large enterprises (average consumption of 80 mt) and SMEs (average consumption of 40 mt) for each technology. A detailed breakdown of the conversion costs of manufacturing lines are provided for each standard cost model; the cost effectiveness (CE) is derived from the standard model lines as shown in Table 4.

Table 4. Incremental unit costs for technology by subsector (US \$/kg)

Sub-sector		HFC-32		NH ₃ /CO ₂ (Cascade)		NH ₃ /CO ₂ (CO ₂ as heat transfer fluid)		NH ₃		CO ₂		HC		HFOs	
		ICC	IOC	ICC	IOC	ICC	IOC	ICC	IOC	ICC	IOC	ICC	IOC	ICC	IOC
Freezer & condensing unit	Large scale	7.1	8.5	12.6	6.2	10.5	4.8	8.3	4.2	13.2	100.4	15.7	9.6		
	SMEs	10.4	8.5	18.6	6.2	15.2	4.8	11.9	4.2	19.0	100.4	21.9	9.6		
Water chillers (heat pump)	Large scale	7.1	8.5					13.1	9.2			15.7	9.6	9.9	34.2
	SMEs	10.4	8.5					19.6	9.2			21.9	9.6	15.2	34.2
Heat pump water heater	Large scale	7.1	8.5					13.1	9.2	13.2	100.4	15.7	9.6	9.9	34.2
	SMEs	10.4	8.5					19.6	9.2	19.0	100.4	21.9	9.6	15.2	34.2
Unitary air conditioner	Large scale	7.1	8.5												
	SMEs	10.4	8.5												

187. Based on the CE, the cost for conversion of 110 equipment manufacturing lines is calculated as US \$184,245,000. Stage II will also include the conversion of three compressor manufacturing lines, including one scroll compressor line converting to HFC-32, one reciprocating compressor line to CO₂ and one semi-hermetic screw compressor line to NH₃, with a total cost of US \$10,160,000.

188. The Government requested IOC threshold at the values of US \$3.8/kg and US \$6.3/kg plus 25 per cent increase for low-GWP technologies, and used the average CE for six low-GWP technologies.

189. The total funding for investment activities, as originally requested, amounts to US \$103,305,000, consisting of US \$97,133,000 for the conversion of 110 equipment manufacturing lines and US \$6,172,000 for the conversion of three compressor lines, to phase out 6,500 mt of HCFC-22, with an average CE of US \$15.89/kg, as shown in Table 5.

Table 5. Funding as originally requested for investment activities

Sub-sectors	Enterprise	HCFC-22 (mt)		CE value (US \$/kg)				Cost of phase-out (US \$)	
		HFC-32	Low-GWP*	HFC-32		Low-GWP*		HFC-32	Low-GWP*
				ICC	IOC	ICC	IOC		
Freezer and refrigeration, and condensing unit	Large scale	100	1,000	4.70	2.00	12.10	4.75	670,000	16,850,000
	SMEs	0	900	10.40	3.80	14.26	4.75	0	17,109,000
Water chillers (heat pump)	Large scale	700	630	4.70	2.00	12.90	7.875	4,690,000	13,088,250
	SMEs	300	370	10.40	6.30	18.90	7.875	5,010,000	9,907,000
Heat pump water heater	Large scale	0	250	4.70	2.00	13.00	7.875	0	5,218,750
	SMEs	50	200	10.40	6.30	18.90	7.875	835,000	5,355,000
Unitary air conditioner	Large scale	1,500	0	4.70	2.00			10,050,000	0
	SMEs	500	0	10.40	6.30			8,350,000	0
Sub-total for equipment lines		3,150	3,350	9.40		20.16		29,605,000	67,528,000
Conversion of compressor lines		0	0	n/a		n/a		2,160,000	4,012,000
Sub-total for equipment and compressor		3,150	3,350	9.40		20.16		31,765,000	71,540,000
Total for investment activities		6,500		15.89				103,305,000	

* including HC, HFO, CO₂, NH₃, NH₃/CO₂ cascade, NH₃/CO₂ with CO₂ as heat transfer fluid

TA activities

190. In stage II, 2,320 mt (127.60 ODP tonnes) of HCFCs is planned to be phased out by SMEs, despite the great challenge in motivating SMEs to participate conversion. Therefore TA will be provided to assist SMEs in developing cost-competitive products to maintain market competitiveness after conversion.

191. TA activities will focus on five aspects: technology improvement and problem solving; strengthening the management and monitoring capabilities of stakeholders; revising technical standards in the ICR sector; updating information on technology and policy development; and conducting publicity and awareness-raising activities. A total of 2,322.00 mt (122.99 ODP tonnes) of HCFC consumption will be phased out through the implementation of TA activities.

Technology research to remove barriers to the application of alternative technology (US \$1,600,000)

192. Technology research and development is proposed to target issues in product design and new requirements for components when using alternatives; safety issues relating to the use of flammable and toxic refrigerants; and how to improve product performance to meet standards.

Revision of technical standards (US \$1,260,000)

193. In stage I, the national safety standard was revised to allow flammable refrigerants to be used in the sector. In stage II, product standards will be revised accordingly.

Technical consultant services (US \$500,000)

194. National consultants will be selected to support project selection, review project proposals, and develop technical documents, as well as conduct monitoring and verification of project progress.

Technical communication and seminars (US \$600,000)

195. Technical workshops and seminars will be organized to disseminate information on the development of alternative technologies, ongoing research, and prospects for different alternatives. An international consultant will provide expert advice to assist in technology development and conversion activities.

Training workshops for enterprises (US \$300,000)

196. Training and awareness-raising workshops will be organized to inform ICR enterprises about the project implementation procedures (e.g. procurement, financial management, and environmental impact evaluation); implementation schedule; project monitoring, commissioning and reporting requirements.

Public Awareness (US \$500,000)

197. Public awareness activities will be conducted to disseminate information on experience gained and the results of stage I conversion and TA projects; and promote alternative technologies and products.

Demonstration of products using alternative technologies (US \$2,500,000)

198. Demonstration projects are planned to collect data and analyse the performance of products using HC, CO₂ and HFOs or blended refrigerants. The result will be disseminated among ICR enterprises to promote the alternative technologies and ensure the sustainability of the phase-out.

Project management mechanism

199. The project management unit (PMU) will coordinate the overall implementation of the ICR sector plan including establishing phase-out policy and ensuring its implementation; preparing terms of reference (TOR) for TA activities and organizing the implementation of TAs; developing and maintaining project information management system; monitoring project progress and preparing progress reports and tranche implementation plan; and assisting in financial audits. The funding requested includes the operating cost of the PMU and consulting services for verification.

200. The China Refrigeration and Air-conditioning Industry Association (CRAA) will assist in coordinating technical support to enterprises, project selection and monitoring, organization of technical seminars and public awareness activities, and collecting sector consumption data.

201. The costs for the implementation of policies and regulations, TA activities, demonstration of products with alternative technologies, and project management were calculated at US \$14,860,000.

Cost of the stage II of the ICR sector plan

202. The overall cost, as originally requested, for the stage II of the ICR sector plan amounts to US \$118,165,000, resulting in an average CE of US \$13.39/kg, as shown in Table 6.

Table 6. Detailed cost breakdown for the stage II ICR sector plan for China

No.	Description	Cost	HCFC		CE
		(US \$)	mt	ODP t	US \$/kg
Investment activities					
1.1	Conversion of 110 equipment manufacturing lines	97,133,000	6,500	357.50	15.89
1.2	Conversion of 3 compressor manufacturing lines	6,172,000			
Sub-total		103,305,000			
Non-investment activities					
2.1	Project coordination, monitoring, implementation and management	7,600,000	2,322	122.99	6.40
2.2	Technical assistance:				
	-Research on alternative technologies	1,600,000			
	-Development of technical standards	1,260,000			
	-Consultant services for financial auditing	500,000			
	-Technical workshops and seminars	600,000			
	-Training workshops	300,000			
	-Public awareness	500,000			
3.1	Demonstration of products with alternative technology	2,500,000			
Sub-total		14,860,000			
Total cost		118,165,000	8,822	480.49	13.39

SECRETARIAT'S COMMENTS AND RECOMMENDATION**COMMENTS**

203. The Secretariat reviewed the stage II ICR sector plan for China in light of progress in stage I, the policies and guidelines of the Multilateral Fund, including the criteria for funding HCFC phase-out in the consumption sector for stage II of HPMPs (decision 74/50), and the 2016-2018 business plan of the Multilateral Fund.

Overarching strategy for stage II

204. The Secretariat noted that the stage II of the ICR sector plan would address 30 per cent of the sector baseline by 2020, while some other sectors proposed a complete phase-out by 2025. UNDP explained that the phase-out strategy in the ICR sector had been developed based on the overall national phase-out strategy, development of the industry and the control of servicing demand after 2030. The target of 30 per cent in the ICR sector is lower than the national target of 35 per cent for stage II because there is a limited number of alternatives available for conversion, and because of the high cost of conversion to low-GWP alternatives in the ICR sector. However, phase-out activities must be implemented in order to phase out HCFCs and switch to low-GWP technologies; otherwise, the industry might develop towards high-GWP technologies or continue to install HCFC-based equipment, which would contribute to the servicing demand after 2030. On this basis, the stage II ICR sector plan has been developed for 2016 to 2020. Stage III is likely to address the phase-out of the remaining consumption in the sector if low-GWP alternatives have been demonstrated and are commercially available.

HCFC consumption and eligibility of enterprises for stage II

205. Although the plan includes an indicative list of enterprises participating in stage II, UNDP informed the Secretariat that the list does not include all the enterprises in the sector, as the sector includes a combination of large and small enterprises. Given the time constraints, the nature of the sector and the size of the country, a comprehensive list of the whole sector is virtually impossible. UNDP further clarified that enterprises that are not on the indicative list can also participate in stage II if they are found to be eligible for funding after verification.

206. It was noted that HCFC consumption in the heat pump, freezer and cold storage subsectors increased between 2008 and 2014, which has offset some HCFC phase-out efforts in stage I. UNDP explained that the increase in HCFC consumption reflected increase in the demand for refrigeration equipment due to investment in infrastructure construction, recognition of the efficiency and environmental benefits of heat pumps in replacing coal boilers to provide hot water and room heating, and the lack of alternatives in some applications (e.g. centrifugal water chillers). Also, it is easy to transfer unitary air-conditioning or chiller production to heat pump production without major changes to the production line.

207. The Secretariat further requested UNDP to estimate the amount of non-eligible consumption to be phased out in stage II. UNDP informed that the non-eligible production capacity established after the cut-off date will not be funded in stage II. With regard to ensuring the funding eligibility of enterprises to be converted according to cut-off date and foreign ownership, UNDP explained that the Government is aware of the eligibility criteria and will verify the eligibility of each manufacturing line during implementation to ensure that non-eligible enterprises are not funded. While the exact amount of HCFCs used by non-eligible enterprises due to the cut-off date is unknown at this moment, an estimate of non-eligible consumption by foreign-owned enterprises was provided, as shown in Table 7.

Table 7. HCFC phase-out in stage II in China

Activity	HCFC-22		HCFC-123		Total	
	mt	ODP t	mt	ODP t	mt	ODP t
Phase-out through conversion of eligible enterprises	6,500	357.50	0	0	6,500	357.50
Phase-out by non-Article 5 enterprises through quota	430	23.65	135	2.70	565	26.35
Phase-out through joint ventures with non-Article 5 share	643	35.37	0	0	643	35.37
Phase-out of eligible consumption through technical assistance, enforcement of regulation, quota controls, public awareness activities	1,114	61.27	0	0	1,114	61.27
Total phase-out in stage II	8,687	477.79	135	2.70	8,822	480.49

Alternative technology selection

208. The alternative technologies proposed include HFC-32 (3,150 mt) and low-GWP technologies (HC, HFO, CO₂, NH₃, NH₃/CO₂ cascade, NH₃/CO₂ with CO₂ as heat transfer fluid) (3,350 mt). The Secretariat noted that grouping HCFC phase-out in six low-GWP technologies makes it difficult to assess the cost of conversion, and requested UNDP to provide the phase-out amount for each technology. After a prolonged discussion and significant efforts from the Government of China (with support from the Industrial Association) and UNDP, an estimated technology distribution for each subsector was provided, as shown in Table 8.

Table 8. Alternative technology profile for stage II phase-out

Sector	HFC-32	NH ₃ /CO ₂ (cascade)	NH ₃ /CO ₂ (CO ₂ as heat transfer fluid)	NH ₃	CO ₂	HC- 290	HFOs	Total (mt)	No. of lines
	mt	mt	mt	mt	mt	mt	mt		
Freezers and refrigeration & condensing units		500	500					1,000	12
		300	400	150				850	20
Water chillers (heat pump)						400	330	730	15
						380	120	500	20
Heat pump water heaters					150			150	3
					120			120	10
Unitary air conditioners	2,300							2,300	17
	850							850	13
Sub-total	3,150	800	900	150	270	780	450	6,500	110
Compressors	-		-	-				-	3
Total	3,150	800	900	150	270	780	450	6,500	113

209. UNDP emphasized that the technology distribution provided is only an estimate. The ICR sector is complicated, given its variety of applications and their customization. While low-GWP technologies will be selected as much as possible, it is important for enterprises to make their own choices for conversion and select the technology based on their own technical capability, experience and products. Given that experience in using NH₃, CO₂, HC and HFOs is still limited, certain flexibility is required when choosing from several low-GWP technologies.

210. With regard to whether HFOs and HC-290 can be introduced at a later stage when the cost of conversion becomes lower, UNDP explained that HFO and HC-290 will be used in chillers, which represents the biggest HCFC-consuming subsector in the ICR sector, and where phase-out is needed to meet compliance targets. For some applications where the use of NH₃ is limited by safety constraints, HFO is the only low-GWP alternative currently available. Deferring the introduction of HFO and HC would allow the market transition to HFC-134a (with a GWP of 1,430). Based on experience in stage I, enterprises are not interested in converting to HFC-134a, as very limited funding was provided, especially for SMEs, and co-funding is high, making it difficult to attract SMEs to participate in stage II. Transition to HFCs would make it difficult to change the market again. Currently, all the sub-sectors have high-GWP alternatives that are much easier to accept. However, the Government of China is proposing to the industry the introduction of environmentally-friendly technology and that high-GWP technology will not be supported in stage II.

Cost-related issues

Comparing the CE in stage I and stage II

211. The average CE of enterprises converted in stage I was US \$6.48/kg (excluding demonstration projects) while the CE of stage II has been estimated at US \$15.89/kg.

212. UNDP explained that, in stage I, a differentiated CE was applied for conversion based on the approved funding, in order to allocate more funding for SMEs with consumption below 50 mt, and for converting to low-GWP technologies. For enterprises converting to R-410A and HFC-134a, low funding was provided, resulting in a CE of US \$3.46/kg for HFC-134a and US \$2.90/kg for R-410A. Furthermore, most conversions in stage I were conducted in large enterprises. However for stage II, it will address more SMEs (which have limited financial capacity for co-funding). A comparison of enterprises in stage I and stage II is provided in Table 9.

Table 9. Enterprises for conversion in stage I and stage II

Consumption in Enterprises	Stage I		Stage II	
	Phase-out in mt	Percentage	Phase-out in mt	Percentage
Less than 50 mt	145.90	2%	2,320	36%
50-100mt	920.90	11%	4,180	64%
above 100 mt	7,393.40	87%		
Total	8,460.20	100%	6,500	100%

213. Most technologies used in stage I were mature technologies, i.e. 81 per cent of consumption was converted to HFC-32, R-410A and R-134a (average GWP of 956), stage II will convert 52 per cent of the consumption to low-GWP technologies (average GWP of 328). Moreover, some low-GWP technologies, such as HC-290 and HFOs are still under development. Therefore, conversion costs are expected to be high at the initial stage of technology adoption. A comparison of alternative technologies selected for stage I and II is shown in Table 10.

Table 10. Alternative technology selected for stage I and II

Technology selection	HFC technology				Low-GWP technology					Total	Average GWP of alternatives*
	R-32	R-410	R134a	CO ₂ /R-134a	NH ₃ /CO ₂	NH ₃	CO ₂	HC-290	HFOs		
GWP value	675	2,088	1,430	1,431	1	0	1	3	7		
Stage II phase-out (mt)	3,150	0	0	0	1,700	150	270	780	450	6,500	328.26
Percentage (%)	48				52					100	
Stage I phase-out (mt)	4,166	2,161	468	66	1,396	171	33			8,460	956.11
Percentage (%)	81				19					100	

*weighted average of the GWP of alternatives assuming the same amount of alternatives will be used.

Funding for compressors

214. One of the items used in the calculation of IOC was related to compressors. However, as stage II includes the conversion of three lines manufacturing compressors, the Secretariat noted that the IOC component for compressors was not eligible in line with decision 26/36²⁰. UNDP reported that the compressor lines converted in stage I, and to be converted in stage II, have a total indirect HCFC phase-out of 1,600 mt (88 ODP tonnes) of HCFC-22, (i.e., 9.3 per cent of the 17,272 mt (945.3 ODP tonnes) of HCFC-22 to be phased out in stages I and II). It was agreed to discount the amount for compressors from the calculation of IOC for conversion of equipment manufacturing lines. It was noted that IOC for most conversions have exceeded the cost threshold in ICR sector, therefore the discount of compressor IOC does not have significant impact on overall IOC.

²⁰ In countries which have received or will seek compensation for compressor conversion, any compensation proposed for downstream manufacturers for incremental operating costs associated with compressors will be discounted according to the ratio of the number of compressors in respect of which compensation for conversion of ODS-based production capacity has been paid or will be paid by the Fund, to the total number of refrigeration units produced in the country concerned using hermetic compressors.

215. With regard to funding eligibility of compressor enterprises due to their foreign ownership, UNDP explained that only five out of the 15 compressor manufacturing lines have foreign ownership; and that during implementation, the eligibility of the enterprise for conversion will be verified and non-eligible enterprises will not be funded.

216. Based on technical advice provided to the Secretariat and an analysis of the cost of enterprises converted in stage I, the agreed costs for conversion of the three enterprises manufacturing compressors are shown in Table 11.

Table 11. Cost of conversion of compressor manufacturing lines (US \$1,000)

Type of compressor	Technology	Number of line	Production unit	Cost for conversion	Funding requested	Funding agreed
Scroll compressor	HFC-32	1	100,000	4,800	2,160	1,920
Reciprocating compressor	CO ₂	1	5,000	2,100	1,600	1,480
Screw compressor	NH ₃ /CO ₂	1	3,000	3,260	2,412	1,950
Total		3		10,160	6,172	5,400

ICC

217. The Secretariat analysed the proposed standard costs listed in Tables 4 and 5 in light of the advice received from a technical expert; the related projects included in stage I of ICR sector plan; and the review of documents available particularly regarding heat exchangers. On this basis, the Secretariat proposed costs for each equipment item as listed in the standard costs table included in the ICR sector plan. In further discussions with UNDP, several costs items were adjusted and agreed. However, no agreement could be reached in other items. Table 12 presents a summary of the costs items for the standard model lines, as originally submitted, as addressed by UNDP and as proposed by the Secretariat.

Table 12: Incremental capital cost for standard model lines of the ICR sector plan (US \$)

Cost item		Originally requested		Revised by UNDP		Secretariat proposed	
		SME	Large	SME	Large	SME	Large
No.	Consumption (mt)	40	80	40	80	40	80
Conversion of small chillers to HC-290							
1.1	System, component and process redesign, prototype manufacturing and testing	110,000	110,000	74,000	74,000	74,000	74,000
1.2	Production line conversion*	401,000	649,000	386,000	634,000	313,000	501,400
1.3	Quality inspection, finishing and testing	40,000	80,000	40,000	80,000	25,000	50,000
1.4	Modification of product performance testing equipment	70,000	70,000	70,000	70,000	70,000	70,000
1.5	Trial production	40,000	55,000	30,000	30,000	30,000	30,000
1.6	Process, safety and after-sales training	50,000	70,000	25,000	25,000	25,000	25,000
1.7	Safety and ventilation system (charging, random test and repair, product storage area, 3 sets)	165,000	220,000	165,000	220,000	75,000	100,000
Sub-total		876,000	1,254,000	790,000	1,133,000	612,000	850,400
Cost effectiveness (US \$/kg)		21.90	15.68	19.75	14.16	15.30	10.63
Conversion of small chillers to HFOs							
2.1	System, component and process redesign, prototype manufacturing and testing	182,000	182,000	100,000	100,000	100,000	100,000
2.2	Production line conversion*	188,000	305,000	183,000	288,000	97,000	134,000
2.3	Quality inspection, finishing and testing	25,000	50,000	25,000	50,000	25,000	50,000
2.4	Modification of product performance	69,000	69,000	69,000	69,000	45,000	45,000
2.5	Trial production	61,000	81,000	50,000	50,000	36,000	36,000
2.6	Process, safety and after-sales training	40,000	50,000	25,000	25,000	25,000	25,000
2.7	Safety device	42,000	53,000	42,000	53,000	42,000	53,000

Cost item		Originally requested		Revised by UNDP		Secretariat proposed	
		SME	Large	SME	Large	SME	Large
No.	Consumption (mt)	40	80	40	80	40	80
Sub-total		607,000	790,000	494,000	635,000	370,000	443,000
Cost effectiveness (US \$/kg)		15.18	9.88	12.35	7.94	9.25	5.54
Conversion of heat pump water heaters to CO₂							
3.1	System, component and process redesign, prototype manufacturing and	115,000	115,000	74,000	74,000	74,000	74,000
3.2	Production line conversion*	396,000	619,000	386,000	609,000	295,000	471,000
3.3	Quality inspection, finishing and	20,000	40,000	20,000	40,000	10,000	20,000
3.4	Modification of product performance	80,000	80,000	80,000	80,000	45,000	45,000
3.5	Trial production	70,000	90,000	60,000	60,000	30,000	30,000
3.6	Process, safety and after-sales training	50,000	70,000	25,000	25,000	25,000	25,000
3.7	Safety device	30,000	42,000	30,000	42,000	30,000	42,000
Sub-total		761,000	1,056,000	675,000	930,000	509,000	707,000
Cost effectiveness (US \$/kg)		19.03	13.20	16.88	11.63	12.73	8.84
Conversion of unitary air-conditioners to HFC-32							
4.1	System, component and process redesign, prototype manufacturing and testing	75,000	75,000	75,000	75,000	75,000	75,000
4.2	Production line conversion*	192,000	306,000	192,000	306,000	176,700	279,300
4.3	Quality inspection, finishing and	15,000	30,000	15,000	30,000	15,000	30,000
4.4	Modification of product performance	50,000	50,000	50,000	50,000	45,000	45,000
4.5	Trial production	20,000	30,000	20,000	30,000	20,000	20,000
4.6	Process, safety and after-sales training	20,000	25,000	20,000	25,000	20,000	25,000
4.7	Safety device	42,000	52,000	42,000	52,000	42,000	52,000
Sub-total		414,000	568,000	414,000	568,000	393,700	526,300
Cost effectiveness (US \$/kg)		10.35	7.10	10.35	7.10**	9.84	6.58**
Conversion of Freezers, refrigeration and condensing units to NH₃/CO₂ cascade system							
5.1	System, component and process redesign, prototype manufacturing and testing	115,000	115,000	74,000	74,000	74,000	74,000
5.2	Production line conversion*	390,000	594,000	376,000	553,000	293,050	437,000
5.3	Quality inspection, finishing and	32,000	64,000	32,000	64,000	10,000	20,000
5.4	Modification of product performance	90,000	90,000	90,000	90,000	45,000	45,000
5.5	Trial production	44,000	54,000	20,000	20,000	20,000	20,000
5.6	Process, safety and after-sales training	31,000	41,000	25,000	25,000	25,000	25,000
5.7	Safety device	43,000	53,000	43,000	53,000	43,000	53,000
Sub-total		745,000	1,011,000	660,000	879,000	510,050	674,000
Cost effectiveness (US \$/kg)		18.63	12.64	16.50	10.99	12.75	8.43
Conversion of Freezers, refrigeration and condensing units to NH₃/CO₂ two-stage system (CO₂ as secondary refrigerant)							
6.1	System, component and process redesign, prototype manufacturing and	101,000	101,000	74,000	74,000	74,000	74,000
6.2	Production line conversion*	299,000	471,000	285,000	430,000	224,750	339,250
6.3	Quality inspection, finishing and	26,000	52,000	26,000	52,000	10,000	20,000
6.4	Modification of product performance	70,000	70,000	70,000	70,000	45,000	45,000
6.5	Trial production	42,000	52,000	20,000	20,000	20,000	20,000
6.6	Process, safety and after-sales training	30,000	40,000	25,000	25,000	25,000	25,000
6.7	Safety device	41,000	51,000	41,000	51,000	41,000	51,000
Sub-total		609,000	837,000	541,000	722,000	439,750	574,250
Cost effectiveness (US \$/kg)		15.23	10.46	13.53	9.03	10.99	7.18
Conversion of Freezers, refrigeration and condensing units to NH₃/CO₂ two-stage system (CO₂ as secondary refrigerant)							
7.1	System, component and process redesign, prototype manufacturing and	73,000	73,000	73,000	73,000	73,000	73,000
7.2	Production line conversion*	224,000	360,000	219,000	333,000	156,400	247,050
7.3	Quality inspection, finishing and	21,000	42,000	21,000	42,000	10,000	20,000
7.4	Modification of product performance	62,000	62,000	62,000	62,000	45,000	45,000

Cost item		Originally requested		Revised by UNDP		Secretariat proposed	
		SME	Large	SME	Large	SME	Large
No.	Consumption (mt)	40	80	40	80	40	80
7.5	Trial production	30,000	40,000	20,000	20,000	20,000	20,000
7.6	Process, safety and after-sales training	28,000	37,000	25,000	25,000	25,000	25,000
7.7	Safety device	39,000	48,000	39,000	48,000	39,000	48,000
Sub-total		477,000	662,000	459,000	603,000	368,400	478,050
Cost effectiveness (US \$/kg)		11.93	8.28	11.48	7.54	9.21	5.98

*This item includes cost for modification of heat exchanger manufacturing tools, compressor body processing (cascade systems), pressure test, refrigerant supply station, charging machine, recovery equipment, leak detectors, helium leakage detection (HC-290), vacuum machine, modification of assembly line and ultrasound sealing (HC-290).

**Only US \$4.00/kg is requested for large enterprises converting to HFC-32, therefore this value was used for the calculation of requested cost by UNDP and the Secretariat.

218. Based on the above standard costs for each production line, the cost of conversion of 110 equipment lines and three compressor lines included in stage II of the ICR is summarized in Table 13.

Table 13. Summary of ICC for the conversion of enterprises included in the ICR sector plan (US \$)

Activity	Originally submitted	Originally requested	Revised and requested	Proposed by Secretariat
110 equipment lines	74,990,000	66,734,000	62,846,875	52,636,713
Three compressor lines	10,160,000	6,170,000	5,400,000	5,400,000
Total cost	85,150,000	72,904,000	68,246,875	58,036,713

IOC

219. The Secretariat noted that the Government of China has requested an additional 25 per cent of IOC above the cost threshold of US \$3.8/kg for refrigeration and US \$6.3/kg for air-conditioning converting to low-GWP technologies, and advised UNDP that the 25 per cent increase for converting to low-GWP technologies apply only to the foam sector and not to the ICR sector. However, UNDP and the Government of China disagree with the interpretation of decision 74/50 with regard to whether an additional 25 per cent for converting to low-GWP technologies should be eligible for the IOC in refrigeration and air-conditioning sector and sought guidance of the Executive Committee.

220. In order to rationalize IOC, the Secretariat suggested reducing the CE from the threshold by 5-10 per cent for some technologies due to the cost saving from the large scale of phase-out. However, this approach was not agreed to by UNDP. The total IOC as originally requested, as proposed by the Government of China and by the Secretariat used in the calculation of IOC of the ICR sector plan is presented in Table 14.

Table 14. Cost effectiveness and total IOC for stage II

Application	Technology	Phase-out (mt)	CE (US \$/kg)			
			Originally calculated	As requested	Threshold	Proposed by Secretariat
Water chillers/heat pumps	HC-290	780	17.70	7.88	6.30	5.99
Water chillers/heat pumps	HFOs /HFO blends	450	17.70	7.88	6.30	6.30
Heat pump water heater	CO ₂	270	38.40	7.88	6.30	5.67
Unitary air-conditioner large enterprise	HFC-32	2,300	8.50	2.00	6.30	2.00
Unitary air-conditioner SME	HFC-32	850	8.50	6.30	6.30	5.67
Freeze and refrigeration and condensing units	NH ₃ /CO ₂ (cascade)	800	25.00	4.75	3.80	3.61

Application	Technology	Phase-out (mt)	CE (US \$/kg)			
			Originally calculated	As requested	Threshold	Proposed by Secretariat
Freeze and refrigeration and condensing units	NH ₃ /CO ₂ (CO ₂ as secondary refrigerant)	900	25.00	4.75	3.80	3.61
Freeze and refrigeration and condensing units	NH ₃	150	25.00	4.75	3.80	3.42
Total IOC (US \$1,000)		6,500	105,164	30,563	36,325	25,108

TA activities

221. It was agreed that the PMU cost for the ICR sector plan would be considered separately and would not be included in the cost of the ICR sector plan.

222. The Secretariat enquired about how 2,322 mt would be reduced through TA activities. UNDP explained that this would be phased out mainly by the conversion of foreign-owned enterprises and voluntary conversion by other enterprises. Some of the phase-out in joint-venture enterprises would be monitored by the project verification. The remaining consumption in the VRV/VRF sub-sector might be phased out voluntarily by the industry, as the development of a ban on HCFC use in this subsector is planned in stage II. TA activities such as public awareness, training and technology promotion, and the outcomes from the research and development on low-GWP technologies will motivate some enterprises to undertake voluntary conversion. The Government will monitor HCFC consumption in large enterprises through the government system, while the production of HCFCs will be controlled through the quota for domestic consumption, which limits the sales of HCFCs to the domestic market. With the above comprehensive monitoring and control measures, it is expected that the phase-out of 2,322 mt could be achieved through TA.

223. In responding to a query on the US \$1,600,000 for technology research, UNDP responded that, further research on HFC-32, CO₂ and NH₃ technologies will promote these alternatives for other applications, improve their operational performance and lower the cost of conversion.

224. With regard to the US \$500,000 for consultant services, UNDP explained that the services are for evaluating conversion proposals to ensure that these projects are technically sound and implementable.

225. With regard to seminars, training and international trips, UNDP advised that some technologies introduced in stage II were developed and used by other countries; a major component in conversion of enterprises involves technology transfer, training and international cooperation; training to SMEs will help them to understand the procedures for project implementation, financial management, procurement requirements, and reporting. Demonstration projects will be for different products and markets, including HC-290 chillers, CO₂ and HC-290 heat-pump water heaters.

226. After further discussions between the Secretariat and UNDP, the total cost for TA was agreed at US \$4,550,000, as shown in Table 15.

Table 15. Agreed cost for TA activities for ICR sector plan

Description of TA activities	Cost (US \$)	
	Originally requested	Agreed
Alternative technology research	1,600,000	1,200,000
Technical standards	1,260,000	800,000
Consultant services	500,000	200,000
Technical communication and seminars	600,000	200,000
Training workshops	300,000	50,000
Public awareness	500,000	100,000
Demonstration of products with alternative technology	2,500,000	2,000,000
Total	7,260,000	4,550,000

Costs for stage II of the HPMP

227. The overall total cost for stage II of the ICR sector plan excluding costs related to PMU, following the discussions and adjustments, is presented in Table 16.

Table 16. Final cost of the stage II ICR sector plan

Activity	Phase-out (mt)	Cost (US \$)			
		Originally calculated	Originally requested	Revised UNDP requested	Proposed by the Secretariat
Conversion of 110 equipment lines	6,500	184,245,000	97,133,000	93,401,875	77,744,313
Conversion to 3 compressor lines		10,160,000	6,172,000	5,400,000	5,400,000
Sub-total of investment activities		194,405,000	103,305,000	98,801,875	83,144,313
Technical assistance	2,322	7,260,000	7,260,000	4,550,000	4,550,000
Sub-total excluding PMU	8,822	201,665,000	110,565,000	103,351,875	87,694,313
CE excluding PMU (US \$/kg)		22.86	12.53	11.72	9.94
PMU (US \$)	0	7,600,000	7,600,000	7,600,000	7,600,000
Total including PMU (US \$)	8,822	209,265,000	118,165,000	110,951,875	95,294,313
CE including PMU (US \$/kg)		23.72	13.39	12.58	10.80

Impact on the climate

228. Stage II will phase out 8,822 mt (480.49 ODP tonnes) of HCFCs. Of this amount, 3,350 mt will be converted to low-GWP technologies and 3,150 mt to HFC-32, with a total emission reduction of 25,040,317 tCO₂eq. For the 2,322 mt of phase-out through TA, regulations and awareness-promoting activities, the alternatives to be used are unknown, and therefore the climate impact cannot be calculated. However, through the promotion of low-GWP technologies and public-awareness activities, it is expected that more low-GWP technologies will be used for conversion. The emission reduction from implementation of the stage II ICR sector plan is shown in the Table 17.

Table 17. Climate impact of the stage II ICR sector plan* (tCO₂eq)

Activities		Conversion of manufacturing lines						TA	
Applications	Small chillers (A)	Small chillers (B)	Heat pump water heaters (C)	Unitary ACs (D)	Cascade systems (E)	Two-stage systems (F)	Large freezers (G)	Various (H)	
Baseline technology	HCFC-22	HCFC-22	HCFC-22	HCFC-22	HCFC-22	HCFC-22	HCFC-22	HCFC-22	
Alternative technology	HC-290	HFO	CO ₂	HFC-32	CO ₂ /NH ₃	CO ₂ /NH ₃	NH ₃	Various	
Charge of HCFC-22 (kg/unit)	10	200	10	8	1,000	1,000	1,000	n/a	
Yearly consumption (mt)	780	450	270	3,150	800	900	150	2,322	
Yearly output (unit)	78,000	2,250	27,000	393,750	800	900	150	n/a	
Cooling capacity (KW)	18-25	450-600	25-35	15-20	80-300	120-450	120-900	Various	
Life span of equipment	15	15	15	15	15	15	15	15	
Baseline	Direct impact	1,416,168	3,340,170	488,700	5,719,140	5,938,080	1,629,000	271,500	3,968,865
	Indirect impact	33,582,450	8,571,095	n/a	46,979,253	n/a	n/a	n/a	n/a
	Sub-total	34,998,618	11,911,265	488,700	52,698,393	5,938,080	1,629,000	271,500	3,968,865
After conversion	Direct impact	1,644	1,726	270	1,900,040	800	900	150	4,594,309
	Indirect impact	32,301,277	9,017,140	n/a	43,874,112	n/a	n/a	n/a	n/a
	Sub-total	32,302,921	9,018,866	270	45,774,152	800	900	150	4,594,309
Emission reduction	Direct impact	1,414,524	3,338,444	488,430	3,819,100	5,937,280	1,628,100	271,350	(625,444)
	Indirect impact	1,281,173	(446,045)	n/a	3,105,141	n/a	n/a	n/a	n/a
	Sub-total	2,695,697	2,892,399	488,430	6,924,241	5,937,280	1,628,100	271,350	(625,444)
Total reduction		20,212,053							

*climate impact for technology A, B, D was calculated using MCII; climate impact for technology C, E, F, G was calculated using the GWP value of substances; For technical assistance activities (H), an average GWP of five HFC-based alternatives was used including HFC-134a, R-404A, R-407C, R-410A, HFC-32.

Co-financing

229. Based on the project as submitted, the cost of the conversion of 113 manufacturing lines (including three compressor lines) in the stage II of the ICR sector plan was estimated at US \$185.26 million, of which US \$103.31 million was requested from the Multilateral Fund, with the difference of US \$91.10 million provided by the enterprises manufacturing refrigeration equipment.

RECOMMENDATION

230. The Executive Committee might wish to consider the plan for phase-out HCFCs in industrial and commercial refrigeration sector in China in light of the Secretariat's comments contained in document UNEP/OzL.Pro/ExCom/76/25.

PROJECT EVALUATION SHEET – MULTI-YEAR PROJECTS
China

(I) PROJECT TITLE	AGENCY
HCFC phase out plan (stage II) room air-conditioning manufacturing (RAC) and heat pump water heaters (HPWH)	UNIDO

(II) LATEST ARTICLE 7 DATA (Annex C Group I)	Year: 2014	16,838.53 (ODP tonnes)
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(III) LATEST COUNTRY PROGRAMME SECTORAL DATA (ODP tonnes)							Year: 2014		
Chemical	Aerosol	Foam	Fire fighting	Refrigeration		Solvent	Process agent	Lab use	Total sector consumption
				Manufacturing	Servicing				
HCFC-123				12.9	7.1				20
HCFC-124					2.1				2.1
HCFC-141b	64.3	5,155				484			5,703.3
HCFC-142b		604.5		6.5	33.7				644.7
HCFC-22	121.9	1,644.5		5,582.5	3,118.8				10,467.7
HCFC-225ca						0.8			0.8

(IV) CONSUMPTION DATA (ODP tonnes)			
2009 - 2010 baseline:	19,269.0	Starting point for sustained aggregate reductions:	18,865.44
CONSUMPTION ELIGIBLE FOR FUNDING (ODP tonnes)			
Already approved:	3,445.19	Remaining:	15,420.25

(V) BUSINESS PLAN		2016	2017	2018	2019	2020	Total
UNIDO	ODS phase-out (ODP tonnes)	120.0	120.0	120.0	120.0	120.0	600.0
	Funding (US \$)	18,443,000	18,443,000	18,443,000	18,443,000	18,443,000	92,215,000

(VI) PROJECT DATA			2016	2017	2018	2019	2020	Total
Montreal Protocol consumption limits								
Maximum allowable consumption (ODP tonnes)								
Project costs requested in principle (US \$)	UNIDO	Project costs						
		Support costs						
Total project costs requested in principle (US \$)								
Total support costs requested in principle (US \$)								
Total funds requested in principle (US \$)								

(VII) Request for funding for the first tranche (2016)		
Agency	Funds requested (US \$)	Support costs (US \$)
UNIDO	TBD	TBD

Funding request:	Approval of funding for the first tranche (2016) as indicated above
Secretariat's recommendation:	For individual consideration

PROJECT DESCRIPTION

231. On behalf of the Government of China, UNIDO as the designated implementing agency, has submitted to the 76th meeting stage II of the room air-conditioning manufacturing (RAC) and heat pump water heaters (HPWH) sector plan (RAC sector plan) of the HCFC phase-out management plan (HPMP) at a cost of US \$140,972,435, plus agency support costs of US \$9,868,070 for UNIDO, as originally submitted. The implementation of stage II of the RAC sector plan will assist China in meeting the Montreal Protocol compliance targets of 35 per cent reduction by 2020.

232. The first tranche for stage II of the RAC sector plan being requested at this meeting amounts to US \$24,617,000, plus agency support costs of US \$1,723,190 for UNIDO, as originally submitted.

Status of implementation of stage I of the RAC sector plan

233. Stage I of the RAC sector plan was approved at the 64th meeting at a total cost of US \$75,000,000, plus agency supports costs for UNIDO, as part of stage I of the HPMP, to phase out 10,670 metric tonnes (mt) (586.9 ODP tonnes) of HCFC-22 and meet 10 per cent reduction target of the sector in 2015.

234. Stage I of the RAC sector plan included the conversion of 26 RAC production lines to non-HCFC alternative technologies; three manufacturing lines for HC-290 compressors; technical assistance (TA) activities; project monitoring and regulatory measures. Conversions of all lines will be completed by 2018.

Summary progress report on the implementation of stage I activities²¹

ODS policy and regulation framework

235. The Ministry of Environmental Protection (MEP) issued a Circular on Strict Management of HCFC Production, Sale and Consumption in 2013 to ensure achievement of the freeze target in 2013 and 10 per cent reduction in 2015. The circular established quota permits for enterprises (including RAC) consuming more than 100 mt of HCFCs per year. In addition, the MEP issued a notice to ban the construction of new manufacturing lines using HCFCs in October 2009.

Conversion activities

236. Contracts to convert 17 manufacturing lines from HCFC-22 to HC-290 and eight lines from HCFC-22 to R-410A have been signed. An additional RAC or HPWH manufacturing line will be contracted in 2016 for the conversion from HCFC-22 to HC-290 as per decision 75/57²². Eleven production lines have been converted with the rest being at different stages of the conversion.

²¹ A comprehensive progress report was included in the last tranche request for stage I of the HPMP for China submitted to the 75th meeting (paragraphs 29 to 35 of document UNEP/OzL.Pro/ExCom/75/41).

²² UNEP/OzL.Pro/ExCom/75/85.

TA activities

237. The following activities have been implemented:

- (a) Research to identify technical barriers in the use of HC-290 in RAC units, including tests on HC-290 compressors; on refrigerant charge reduction; assessment of performance of micro-channel heat exchangers for heat pump systems; experiments to improve the performance of HC-290 room air-conditioners; and a study on refrigerant distribution equipment to optimize the HC-290 AC design;
- (b) Research on R-161 refrigerant in larger capacity RAC, compressor and accessories development, and safety-related issues;
- (c) Risk assessment for using R-290 in RAC units, including tests in cases of leakage, and/or fire;
- (d) Development of three standards for flammable refrigerants, including safety codes for manufacturing household and similar air-conditioners; transportation of RAC charged with flammable refrigerants; and safety codes for servicing. One product safety standard was revised to allow the use of HC-290 in RAC appliances; and
- (e) Technical communication workshops on HCFC-22 phase-out; workshops for beneficiaries on the HCFC phase-out strategy; and public awareness activities (e.g. publication of eco-logo for HC-290 RAC).

Project implementation and monitoring unit

238. Under FECO a project implementation and monitoring unit (PMU) was established to implement stage I of the RAC sector plan. FECO is responsible for the overall management and coordination of the RAC sector plan. The Chinese Household Electronic Appliances Association (CHEAA) provides assistance related to the technical and financial aspects of the implementation of the RAC sector plan.

Status of disbursements

239. As of February 2016, of the total funds of US \$75,000,000 approved so far, US \$44,509,717 had been disbursed from UNDP to FECO, and US \$25,923,381 had been disbursed from FECO to beneficiaries. Funding disbursed to beneficiaries accounts for 34.6 per cent of the total funding approved for stage I, and 59.3 per cent of the funding disbursed from UNDP to FECO. An additional US \$15,300,000 will be disbursed to beneficiaries by December 2016. The remaining funding of US \$33,776,619 will be disbursed between 2017 and 2019.

Stage II of the RAC sector planConsumption of HCFC-22

240. In 2015, the estimated consumption of HCFC-22 in the RAC sector was 5 per cent below the consumption allowed under the Agreement between the Government of China and the Executive Committee, as shown in Table 1.

Table 1. HCFC-22 consumption in the RAC and HPWH sector in China (2012-2015)

HCFC-22	2012	2013	2014	2015*
Metric tonnes				
Maximum Allowable Consumption	n/a	74,700	74,700	67,231
Consumption from stage II submission	72,600	68,900	62,000	63,673
Difference	n/a	5,800	12,700	3,558
ODP tonnes				
Maximum Allowable Consumption	n/a	4,108.5	4,108.5	3,697.7
Consumption from stage II submission	3,993.0	3,789.5	3,410.0	3,502.0
Difference	n/a	319	698.5	195.7

*Estimated.

Remaining consumption eligible for funding

241. The remaining consumption of HCFC-22 eligible for funding is 10,015.59 ODP tonnes based on the Agreement between the Government of China and the Executive Committee for stage I of the HPMP and covers XPS foam, ICR, RAC and the servicing sectors. Based on the RAC sector consumption targets in the Agreement and reductions in stage I and from the AC demonstration project approved at the 61st meeting (decision 61/35)²³, the total remaining consumption to be phased out in the RAC sector after stage I should not exceed 63,789 mt (3,508.4 ODP tonnes).

242. Stage II proposes to phase-out 18,675 mt (1,027.1 ODP tonnes) of HCFC-22 in the RAC sector by 2020 and will be deducted from the remaining consumption of HCFC-22 eligible for funding. Of the total phase-out, 8,170 mt (449.4 ODP tonnes) will be funded through the Multilateral Fund and the remaining 10,505 mt (577.70 ODP tonnes) with funding outside the Fund.

Phase-out strategy in the RAC sector for stage II

243. Similar to the stage I strategy, the phase-out of HCFC-22 in the RAC sector would be achieved through a combination of conversion of production lines; regulatory actions; TA activities; and implementation and monitoring.

Regulatory actions and monitoring

244. The regulatory component will support the conversion of RAC and HPWH production lines and will include improvement of the quota management system; revision of energy efficiency and other existing standards, and development of a new technical standard on CO₂; establishment of financial incentives and mechanisms to encourage the application of environmentally friendly alternatives; and establishment of public green procurement. A total of US \$660,000 is requested for establishment of policies and standards.

Conversion of production lines

245. A total of 449.4 ODP tonnes of HCFC-22 will be phased out through conversion of:

- (a) Twenty RAC production lines (442.8 ODP tonnes) to HC-290;
- (b) Five residential HPWH production lines (6.6 ODP tonnes), of which two lines will be converted to R-744 and three to HC-290; and

²³ UNEP/OzL.Pro/ExCom/61/58.

- (c) Four compressor lines, of which three will be converted to supply the RAC sector using HC-290 and one using R-744 for HPWH units.

246. With regards to other alternatives, R-161 might be used for appliances with higher cooling capacities. Other alternatives (e.g. HFC-410A) are also considered as transitional technology to meet the export market requirement and the targets of stage II of the HPMP.

247. Incremental capital costs (ICC) were calculated based on the costs of a standard production line taking into account the retrofit or replacement of production equipment, safety devices, and tests. The proposed cost of each production line is the total cost of the conversion of all lines presented in Table 2:

Table 2. Proposed ICC of conversion of RAC, HPWH and compressor production lines.

Production line	Alternative	Consumption		Cost/line (US \$)	Number of lines	Capacity (units/year)	Total ICC (US \$)
		mt	ODP t				
RAC	HC-290	8,050	442.8	2,711,639	20	350,000	54,232,780
Residential HPWH	HC-290	72	4.0	351,538	3	20,000	1,054,614
Residential HPWH	R-744	48	2.6	365,903	2	20,000	731,806
Sub-total					25		56,019,200
Compressors	HC-290			3,145,451	3	1,700,000	9,436,353
Compressors	R-744			1,112,891	1	200,000	1,112,891
Sub-total					4		10,549,244
Total							66,568,444

248. The incremental operating costs (IOC) of conversion of RAC and HPWH production lines were calculated based on the price difference between HCFC-22 and the alternative refrigerant, replacement of lubricant and design modifications, safety measures for conversion to HC-290, and electronic expansion valve and inverter pumps for conversion to R-744. With the modifications proposed the IOC increased by US \$18.27 per unit for appliances using HC-290 and by US \$280.88 per unit²⁴ for appliances using R-744. However, as per decision 60/44²⁵, the threshold of US \$6.3/kg is applied, bringing the total IOC to US \$51,471,000.

249. Stage II also proposes to purchase 4,000 servicing tools for the use of flammable refrigerants, of which 2,500 will be used to train the servicing technicians employed by the appliances manufacturers and 1,500 tools will be distributed to 50 training centres established under refrigeration servicing sector plan. The proposed cost of this component is US \$7,200,000.

TA activities

250. TA activities have been proposed in stage II at a total cost of US \$7,338,000:

- (a) Selection of production lines and verification (US \$1,298,000);
- (b) Research and assessment of alternative technologies, including risk assessment with a focus on flammability; development of application technologies (e.g. natural refrigerants in high-ambient temperatures, research on product reliability, energy efficiency, and performance); tests and studies to support potential revision of international standards; expert meetings on analysis and assessment of alternative technologies; and information collection (US \$4,325,000);

²⁴ The average HCFC-22 charge for RAC is 1.15 kg/unit and 1.20 kg/unit for HPWH.

²⁵ UNEP/OzL.Pro/ExCom/60/54.

- (c) Technical cooperation and communication strategy including workshops and participation in international meetings; and study tours to countries with advanced technologies with natural refrigerants (US \$1,000,000); and
- (d) Public awareness activities, including market promotion of products, and the eco-logo published in stage I (US \$715,000).

Implementation modality

251. As the national implementation agency, FECO will be responsible for the overall project management and coordination of stage II of the RAC sector plan and will develop and coordinate the adoption of policies and enforce the quota system; establish and operate a project management database; establish incentives for the introduction of alternatives; select eligible enterprises and entities with the support of CHEAA; verify the achievement of HCFC-22 phase-out targets and performance indicators; organize financial and technical verifications; conduct public awareness and training programmes; and prepare progress, verification and completion reports.

252. UNIDO is responsible for the overall implementation of the RAC sector plan and will sign a performance-based contract with FECO to monitor the implementation of stage II; review annual reports prepared by FECO; provide technical support, policy advice and managerial support; and conduct verification of achievement of targets and performance indicators.

253. CHEAA will continue to assist UNIDO and FECO by providing policy recommendations for introduction of environmentally friendly technologies; supporting the enterprises; assisting FECO to select beneficiaries; selecting alternative technologies, and supporting technology transfer and implementation of investment projects; and establishing and operating an industrial database on HCFC consumption, alternatives technologies and phase-out activities.

Total cost of stage II of the RAC sector plan of the HPMP

254. The total cost of stage II of the RAC sector plan to be funded through the Multilateral Fund has been estimated at US \$140,972,435, as originally submitted (excluding agency support costs). The proposed activities will result in the phase-out of 1,027.1 ODP tonnes of HCFC-22 with an overall cost effectiveness of US \$7.55/kg (or US \$17.25/kg based on only consumption of 449.4 ODP tonnes). Detailed activities and cost breakdown, as originally submitted, are shown in the Table 3.

Table 3. Summary of proposed activities and cost of stage II of the RAC sector plan for China

Component	HCFC-22 consumption		CE (US \$/kg)	Total cost (US \$)
	mt	ODP tonnes		
Conversion of RAC and HPWH production lines	8,170.0	449.4	13.16	107,490,190
Conversion of compressor lines	0	0		10,549,245
Procurement of servicing tools	0	0		7,200,000
Sub-total	8,170.0	449.4	15.33	125,239,435
TA	0	0		7,998,000
PMU	0	0		7,735,000
Sub-total	0	0		15,733,000
Total	8,170.0	449.4	17.25*	140,972,435

* Excludes phase-out of 10,505 mt for which funding from the Fund is not requested.

SECRETARIAT'S COMMENTS AND RECOMMENDATION

COMMENTS

255. The Secretariat reviewed stage II of the RAC sector plan in light of stage I, the policies and guidelines of the Multilateral Fund, including the criteria for funding HCFC phase-out in the consumption sector for stage II of HPMPs (decision 74/50), and the 2016-2018 business plan of the Multilateral Fund.

Phase-out strategy and implementation modality

256. The Secretariat noted with appreciation the submission of an ambitious and well-thought proposal that focuses on the introduction of low-GWP alternatives. The Secretariat also noted that with respect to estimating the costs of conversion, the same approach used in stage I was used in stage II, namely, that costs are estimated based on a model line and that specific manufacturing lines that will undergo conversion are only identified (and compensated) via a bidding process during the implementation of stage II. The Secretariat considers this a reasonable approach given that there are several hundred HCFC-22 production lines in the RAC sector with a baseline consumption of over 60,000 mt of HCFC-22. UNIDO clarified that compensation for a line is calculated based on the cycle time²⁶, and that information on foreign ownership, year of establishment, baseline equipment, consumption, records of the production, and any other necessary information will be collected and verified prior to the issuance of contract.

257. More than half of the phase-out (i.e., 10,505 mt) under stage II will be achieved without assistance from the Fund. UNIDO clarified that any non-eligible items related to the conversions would be considered under this component; that the Government of China wishes to only provide financial support for the adoption of low-GWP alternatives; and that every manufacturer would contribute to the reduction target through the implementation of quota limitations. It is anticipated that absent of any policy, the majority of the phase-out for which funding is not requested would be based on conversions to HFC-410A. The proportion of existing RAC manufacturing capacity established before the cut-off date is 85 per cent; and the average Article 5 ownership is 76 per cent and 73 per cent for RAC and compressor manufactures, respectively.

258. Conversions in the HPWH sub-sector were not included in stage I, but are included in stage II. This sector has seen substantial growth in 2009, two years after the cut-off date, leading to questions about its inclusion in stage II. UNIDO clarified that the HPWH manufacturing predominantly originated from RAC production lines due to the similarity of the manufacturing processes, and that an HCFC-production line established before the cut-off date that is converted to manufacture another type of product after that date should still be eligible for funding provided there was no capacity increase; that HPWH manufacturing was included when the maximum allowable consumption for the RAC sector (4,108.5 ODP tonnes) was established; and confirmed that non-eligible lines will not be funded under the HPMP. The distinction between HPWH considered under the RAC and ICR sectors is the former are for residential purposes (between 70 and 500 litres of hot water per hour), while the latter are for industrial purposes (capacity between three and 100 kW), and there are no lines manufacturing both residential and industrial HPWHs. In light of these explanations, the Secretariat reviewed the inclusion of this sub-sector in the RAC sector plan, noting that the replacement of water boilers, which are currently principally coal-fuelled, by HPWH would likely contribute to improvements in local air quality. This sub-sector is likely to see continued if not accelerated growth in the near- to mid-future, and absent interventions that growth is likely to be filled by equipment using high-GWP HFCs. As such, interventions in this sub-sector are likely to have environmental benefits.

²⁶ Time needed by the line to make one unit.

259. The Secretariat also noted that over 16 per cent of the total amount of funding requested is for activities that have no reduction in consumption eligible for funding.

Cost-related issues

RAC conversion to HC-290

260. The proposed costs to convert a line to HC-290 under stage II (US \$2,711,638) are lower than under stage I (US \$3,199,959) because the former does not include conversion costs related to the heat exchanger.²⁷ The model lines considered under stage II have a higher capacity (350,000 units/year) than under stage I (250,000 units/year); however, the average charge per RAC unit in stage II is lower than in stage I (1.15 kg/unit rather than 1.2 kg/unit).

261. The Secretariat reviewed in detail the proposed ICC for conversion of one RAC production line to HC-290 and suggested considering the purchase of installation tools separately from the line conversion and together with the servicing tools, and to associate a reduction in remaining eligible consumption at US \$4.80/kg to those costs. Taking into consideration the actual ICC from the demonstration project for conversion at Midea²⁸ and from the conversion at Chunlan²⁹, and based on advice from an independent technical expert, the Secretariat proposed a number of reductions to different cost components.

262. In light of the Secretariat's proposal, the Government of China adjusted the cost of several items, including the conversions needed for tests undertaken on the production line versus the operating performance tests; a reduction in the number of installation kits (from 450 to 350), a reduction in the cost of Lokring tools; and a reduction to 5 per cent (from 7.5 per cent) for the requested delivery, insurance and installation. With regards to the Secretariat's approach, UNIDO emphasized that the lack of proper procedures and tools during the installation and servicing is a substantial barrier to the uptake of HC-290 units in the market. UNIDO indicated that the costs per line could be higher than those at Midea, given the lower capacity of that line and possible savings related to safety-expenses associated with a new rather than a converted line, and those at Chunlan, since the capacity of 301,411 units/year reflects 1.67 shifts and its capacity based on one shift would be 180,000 units/year.

263. In light of the explanation provided by UNIDO, the Secretariat considers that installation tools are a component of the line conversion, and agrees that charging machines for use with flammable refrigerants should be included in the installation tool kits. The Secretariat proposes that 200 (rather than 270) tool kits should be sufficient and that a 10 per cent reduction per kit be applied given the large number of kits involved. On this basis, installation tools would be funded at US \$209,700 per line (rather than US \$407,750). Table 4 presents the summary of the discussion on the ICC for the RAC line to HC-290.

²⁷ All beneficiaries in stage I were supported with the heat exchanger production lines. As the potential beneficiaries in Stage II are likely to be the same ones as in Stage I, no further conversion of the heat exchanger production lines are expected to be required.

²⁸ Approved at the 61st meeting (decision 61/35) and final report submitted to the 73rd meeting (UNEP/OzL.Pro/ExCom/73/17/Add.1) reflecting a total ICC of US \$1,367,739, excluding heat exchanger and installation tools. The line has a capacity of 200,000 units/year and was converted to HC-290.

²⁹ Enterprise converted under stage I to HC-290 with a capacity of 301,411 units with a total ICC of US \$ 1,021,060, excluding heat exchanger and installation tools, as reflected in a technical verification report submitted to the 75th meeting.

Table 4. Summary of the discussion on the ICC for RAC line to HC-290 refrigerant

Equipment	Cost (US\$)			
	As submitted	Revised UNIDO	Proposed Secretariat	Difference
Assembly line equipment	1,246,343	1,346,343*	724,000	622,343
Operating performance test equipment	259,000	100,000**	100,000	0
Recovery station	10,000	10,000	7,500	2,500
Installation tools	591,750	407,750***	209,700	198,050
Other (e.g., delivery, insurance, installation)	158,032	93,205	-	93,205
Contingency	226,513	195,730	83,150	112,580
Engineering, start up, training	220,000	220,000	140,000	80,000
Total	2,711,639	2,373,027	1,264,350	1,108,677

* Performance test was moved to this category with a reduced cost from US \$159,000 to US \$100,000.

** Performance test was moved from this category.

*** Instead of ex-proof vacuum pumps, charging machines for flammables are requested in the revised proposal.

HPWH conversion to HC-290

264. Upon request for clarification on the rationale to convert to two technologies. UNIDO clarified that the targeted markets for HC-290 and R-744 are different due to their different characteristics since R-744 can generate higher water temperatures, and R-744 has a higher energy efficiency than HC-290 and HCFC-22.

265. In reviewing the actual production (over 40,000 units/enterprise) and consumption (over 50 mt per enterprise) of HPWH, the Secretariat proposed to consider the capacity per manufacturing line at 25,000 units/year (rather than 20,000 units/year), which would reduce the number of manufacturing lines to be converted from 5 to 4, and adjusted the costs for the charging machine, leak detectors, recovery station, and the ventilation and safety system, and for test equipment, resulting in a cost of US \$272,750 per line. UNIDO explained that the proposed capacity was based on the on-site survey conducted during the preparation of the HPMP, and that multiple conversions within one company are not foreseen. UNIDO proposed to only reduce the delivery, insurance and installation costs to 5 per cent, resulting in a cost of US \$345,163 per line. Table 5 presents the summary of the discussion on the ICC for the HPWH line to HC-290.

Table 5. Summary of the discussion on ICC for HPWH line to HC-290 refrigerant

Equipment	Cost (US\$)			
	As submitted	Revised UNIDO	Proposed Secretariat*	Difference
Assembly line equipment	185,000	185,000	160,000	25,000
Operating performance test equipment	65,000	65,000	40,000	25,000
Recovery station	5,000	5,000	2,500	2,500
Other (e.g., delivery, insurance, installation)	19,125	12,750	-	12,750
Contingency	27,413	27,413	20,250	7,163
Engineering, start up and training	50,000	50,000	50,000	0
Total	351,538	345,163	272,750	72,413

* Capacity of 25,000 units/year.

HPWH conversion to R-744

266. The Secretariat sought further clarification on the need to convert the existing test systems, noting that the higher operating pressures of R-744 may require only minor changes (e.g., new pressure transducers and the installation of pressure relief valves), rather than the new systems proposed; the need for a numerical control machine; and a rationale of the costs for engineering, start up and training. Based on the information it had available, the Secretariat proposed an adjusted cost of US \$132,500 per line, which also reflects adjusted costs for the charging machine and leak detectors.

267. UNIDO clarified that conversion of the test systems is required because of the design pressure of R-744 and because of changes in the design of R-744 HPWH; the very low boiling point of R-744 requires a separate cooling circuit for the charging machine to ensure precise charging; given the higher operating pressures R-744 are more prone to leak and require a higher sensitivity than HC-290 detectors; the numerical control machine is a precision machine tool for pipe connections necessary because of the need for more precise machining of parts to be welded given the higher operating pressures; and that higher engineering, start-up and training costs are expected given the higher pressures and more complicated components. UNIDO agreed to reduce the delivery, insurance and installation costs to 5 per cent, resulting in a cost of US \$359,478 per line. Table 6 presents the summary of the discussion on the ICC for the HPWH line to R-744.

Table 6. Summary of the discussion on ICC for HPWH line to R-744

Equipment	Cost (US\$)			
	As submitted	Revised UNIDO	Proposed Secretariat*	Difference
Assembly line equipment	222,000	222,000	70,000	152,000
Operating performance test equipment	35,000	35,000	5,000	30,000
Other (e.g., delivery, insurance, installation)	19,275	12,850	-	12,850
Contingency	27,628	27,628	7,500	20,128
Engineering, start up and training	62,000	62,000	50,000	12,000
Total	365,903	359,478	132,500	226,978

* Capacity of 25,000 units/year.

Compressor conversion to HC-290

268. Based on advice from an independent technical expert, the Secretariat proposed to adjust the costs related to the electric motor (from US \$1,390,000 to US \$1,042,500) and life and load tests (from US \$650,000 to US \$335,000), and proposed adjustments for other items based on 85 per cent of the actual ICC from the demonstration project for conversion at the manufacturer Meizhi³⁰. On this basis, the Secretariat proposed an adjusted cost of US \$2,115,283 per line.

269. UNIDO clarified that the electric motor has to be redesigned due to changes in the size of the rotor and stator, that the load test must be modified to allow for the flammability properties of HC-290, and that equipment for compressor manufacturing is typically custom-made and hence more expensive. UNIDO agreed to reduce the delivery, insurance and installation costs to 5 per cent, resulting in a cost of US \$3,080,220 per line. UNIDO also proposed to reduce the requested funding based on the Article 5 ownership of four potential beneficiaries of 83.75 per cent. The Secretariat notes, however, that the average Article 5 ownership of six potential beneficiaries is 73.1 per cent. Table 7 presents the summary of the discussion on the ICC for the compressor line to HC-290.

Table 7. Summary of the discussion on ICC for compressor to HC-290

Equipment	Cost (US\$)			
	As submitted	Revised UNIDO	Proposed Secretariat	Difference
Manufacturing equipment	1,914,261	1,914,261	1,495,176	419,085
Performance testing equipment	695,000	695,000	373,264	321,736
Other (e.g., delivery, insurance, installation)	195,695	130,463	-	130,463
Contingency	280,496	280,496	186,844	93,652
Engineering, start up and training	60,000	60,000	60,000	0
Total	3,145,451	3,080,220*	2,115,283**	964,937

* Article 5 ownership of four compressor manufacturers at 83.75 per cent.

** Average Article 5 ownership of six compressor manufacturers is 73.1 per cent.

³⁰ Approved at the 61st meeting (decision 61/35) and final report submitted to the 73rd meeting (UNEP/OzL.Pro/ExCom/73/17/Add.1) reflecting a total ICC of US \$3,040,099.

Compressor conversion to R-744

270. The Secretariat proposed adjusted costs for the welding machine (from US \$220,000 to US \$150,000) and leak detector (from US \$270,000 to US \$200,000), resulting in an adjusted cost to convert a compressor manufacturing line to R-744 of US \$883,394. In light of the capacity of 200,000 units/year, the Secretariat considers that only 25 per cent of this cost is eligible given that conversion of two HPWH manufacturing lines to R-744 with a capacity of 25,000 units/year, resulting in eligible costs of US \$220,848.

271. UNIDO clarified that R-744 compressors require high sensitivity of the welding machine and a combined pressure and leak test for the manufacturing due to the very high working pressure, and emphasized that it is essential to have a small compressor line fully converted to enable the conversion to R-744. UNIDO proposed to reduce the delivery, insurance and installation costs to 5 per cent, and to apply an average Article 5 ownership of four potential beneficiaries of 83.75 per cent. Table 8 presents the summary of the discussion on the ICC for the compressor line to R-744.

Table 8. Summary of the discussion on ICC for compressor line to R-744

Equipment	Cost (US\$)			
	As submitted	Revised UNIDO	Proposed Secretariat	Difference
Manufacturing equipment	822,765	822,765	682,765	140,000
Performance testing equipment	92,352	92,352	92,352	0
Other (e.g., delivery, insurance, installation)	68,634	45,756	-	45,756
Contingency	98,375	98,375	77,512	20,863
Engineering, start up and training	30,765	30,765	30,765	0
Total	1,112,891	1,090,013**	883,394*	206,619

* Article 5 ownership of four compressor manufacturers at 83.75 per cent.

** Average Article 5 ownership of six compressor manufacturers is 73.1 per cent. One quarter of funding level considered eligible assuming capacity of 200,000 units/year and conversion of two HPWH lines with capacity of 25,000 units/year.

Servicing tools

272. The Secretariat noted the requests of US \$7,200,000 for servicing tools and US \$11,835,000 for installation tools. In light of decision 74/50 (which provides for US \$4.80/kg for the servicing sector), the Secretariat suggested a lower level of funding be considered with an associated reduction in remaining eligible consumption at US \$4.80/kg. UNIDO agreed to reduce the number of tool sets and their costs and adjusting the components (i.e., the vacuum pump was replaced by an explosion-proof vacuum pump and a service charging machine was added), resulting in a total cost of US \$5,994,000. In addition UNIDO indicated that the Government agreed to associate phase-out with the funding provided for service tools at US \$4.80/kg on the understanding that it is offset against the voluntary phase-out agreed by the Government. The Secretariat does not consider it meaningful to associate this phase-out with the voluntary phase-out proposed by the Government as that phase-out will be associated with foreign ownership, conversions to high-GWP alternatives, and other factors.

273. Noting the information provided by UNIDO and that the servicing tools could also be used for servicing the new equipment after installation, the Secretariat suggested a total level of funding for servicing tools of US \$3,996,000 (based on 2,000 servicing tool sets at a 10 per cent reduction in the cost per kit given the large number to be purchased), with an associated reduction of 832.5 mt of HCFC-22. This additional phase-out would be in addition to the voluntary phase-out proposed by the Government, and would represent the equivalent phase-out of approximately two RAC lines. Table 9 presents the summary of the discussion on cost of servicing tools.

Table 9. Summary of discussion on the costs for servicing tools in the RAC sector plan

Tools	Cost (US \$)								
	As submitted			Revised UNIDO			Proposed Secretariat*		
	#	Cost/tool	Amount	#	Cost/tool	Amount	#	Cost/tool	Amount
Leak detectors	4,000	450	1,800,000	2,700	810,000	1,215,000	2,000	450	810,000
Pressure gauges	4,000	450	1,800,000	2,700	270,000	405,000	2,000	150	270,000
Mechanical vacuum gauge	4,000	90	360,000	2,700	162,000	243,000	2,000	90	162,000
2-stage rotary vacuum pump	4,000	80	320,000	n/a	-	n/a	n/a	n/a	n/a
Ex-proof vacuum pump	n/a	n/a	n/a	2,700	720,000	1,080,000	2,000	400	720,000
Lokring® pressing equipment	4,000	730	2,920,000	2,700	1,314,000	1,971,000	2,000	730	1,314,000
Charging machine	n/a	n/a	n/a	2,700	720,000	1,080,000	2,000	400	720,000
Total			7,200,000			5,994,000			3,996,000*

* Additional associated phase-out of 832.5 mt (45.79 ODP tonnes).

Incremental operating costs (IOC)

274. As submitted, the IOC for the conversion to HC-290 was US \$18.27/unit (US \$15.89/kg) and US \$280.88/unit (US \$234.04/kg) for the conversion to R-744. Additional clarification was sought on the costs related to the seal of electric parts, which accounts for almost 90 per cent of the IOC. Noting the very high IOC for R-744, concerns were raised about the financial sustainability of the proposed conversion. The Secretariat also questioned that the inverter water pump (70 per cent of the IOC) was not incremental as it will allow for better control of the water flow rate, increasing the efficiency of the unit, but irrespective of the refrigerant. The Secretariat also noted that the cost of the electric expander valve (22 per cent of the IOC) appears high and would decrease with mass production.

275. Regarding the IOC for HC-290, UNIDO clarified that rather than using explosion proof electronic components, it was more cost-effective to seal those components, which involved a fire retardation box and wire, sealing cement, and a sealed electric relay. UNIDO also indicated that there may be additional costs associated with valves, installation and servicing, which were not specified as the IOC threshold is US \$6.30/kg. Regarding the IOC for R-744, UNIDO clarified that there is increased acceptance to environmentally-friendly products, that mass production is likely to reduce costs. The inverter water pump is needed due to the higher water temperatures (up to 90 C) that can be achieved with R-744. HCFC-22 units cannot heat water to such high temperature and consequently do not need the inverter pump.

276. The Secretariat noted that the requested IOC of US \$6.30/kg is in accordance with decision 74/50; however, a portion of the IOC was associated with the compressor. In accordance with decision 26/36, the Secretariat proposes a five per cent reduction to the IOC, bringing it to US \$5.98/kg. The total IOC would thus be US \$48,897,450 instead of US \$51,471,000. UNIDO agreed with the Secretariat's proposal while noting that the IOCs would help reduce the cost of HC-290 units and thus facilitate the promotion of HC-290 RAC, which would contribute to the HCFC phase-out and a reduction in the use of HFCs.

TA component and PMU

277. The Secretariat discussed with UNIDO the proposed costs for TA, noting that the technical communication activity does not seem incremental and may be duplicative of other activities proposed in stage II; research and assessment of alternative technologies has already been carried out in stage I; and that any intellectual property that results from research funded through the Multilateral Fund should be the property of the Fund.

278. The Secretariat considers that a set of TA activities that facilitate the conversion of the RAC sector to low-GWP alternatives, including for those enterprises that will convert without funding from the Fund, can be justified. For example, a commitment for green government procurement, e.g., that only energy efficient and low-GWP RAC equipment will be purchased by the government, might be one mechanism that could be considered. On this basis, the Secretariat considers that US \$4,500,000 could be an appropriate funding level for TA activities to facilitate the conversion of the RAC sector to low-GWP alternatives.

279. UNIDO clarified that it is difficult for the Government of China to commit to procure only HC-290 RACs through public procurement as long as other higher GWP substances are allowed to be used under the Montreal Protocol. The Government of China does not encourage HFC-410A because of its high GWP. At the same time, it is being treated as a transitional technology in the HCFC phase-out. The Government will seek to encourage the use of low-GWP and energy efficient alternatives and will make every effort to eliminate the barriers on HC-290 promotion. The contracts between FECO and the beneficiaries stipulate that the intellectual property should belong to FECO, and FECO will allow its use freely in accordance with Chinese law. The Secretariat considers that any intellectual property that results from activities funded through the Multilateral Fund should be the property of the Fund.

280. In light of the Secretariat's comments, UNIDO proposed to reduce the requested funding for study tours and international meeting participation from US \$1,000,000 to US \$340,000 and to reduce that for research and assessment from US \$4,325,000 to US \$3,885,000, resulting in a revised TA funding level of US \$6,898,000.

281. It was agreed that the PMU cost would be discussed along with the PMU cost for all sector plans in the context of the overarching strategy.

Total cost

282. A summary of the overall costs of stage II of the RAC sector plan in China, as submitted, as revised by UNIDO and as proposed by the Secretariat is presented in Table 10.

Table 10. Overall cost of the RAC sector plan

Production line	Phase-out (mt)	Submission			Secretariat			Revised		
		Cost/line (US \$)	Lines	Total ICC (US \$)	Cost/line (US \$)	Lines	Total ICC (US \$)	Cost/line (US \$)	Lines	Total ICC (US \$)
RAC and HPWH production lines conversion										
RAC, HC-290	8,050	2,711,639	20	54,232,772	1,264,350	20	25,287,000	2,373,027	20	47,460,540
HPWH, HC-290	72	351,538	3	1,054,614	272,750	2 ^a	545,500	345,163	3	1,035,489
HPWH, R-744	48	365,903	2	731,806	132,500	2	265,000	359,478	2	718,956
Sub-total	8,170	n/a	25	56,019,190	n/a	24	26,097,500	n/a	25	49,214,985
Compressor lines conversion										
Compressors, HC-290 ^b	n/a	3,145,451	3	9,436,353	2,115,283	3	4,638,816	3,080,220	3	7,739,053
Compressors, R-744 ^c	n/a	1,112,891	1	1,112,891	883,394	1	161,440	1,090,013	1	912,886
Sub-total	n/a	n/a	4	10,549,245	n/a	4	4,800,256	n/a	4	8,651,939
IOC	n/a			51,471,000			48,897,450			48,897,450
Total conversion cost				118,039,435			79,795,206			106,764,374
Servicing tools				7,200,000			3,996,000 ^d			5,994,000 ^e
TA				7,998,000			4,500,000			6,898,000
Total w/o PMU				133,237,435			88,291,206			119,656,374
PIM				7,735,000			7,735,000 ^f			7,735,000
Grand total w PMU				140,972,435			96,026,206			127,391,374
CE (US \$/kg)				17.25			10.67 ^g			15.59
CE (US \$/kg) including phase-out with no funding requested				7.55			4.92 ^g			6.82

a. The Secretariat proposed 2 lines instead of 3.

b. Total ICC are adjusted based on Article 5 ownership (Secretariat's proposal uses 73.1 per cent, i.e. the average Article 5 ownership of six potential beneficiaries, while China proposed to reduce the requested funding level based on an Article 5 ownership of four potential beneficiaries of 83.75 per cent).

c. Total ICC are adjusted based on Article 5 ownership (Secretariat's proposal uses 73.1 per cent, i.e. the average Article 5 ownership of six potential beneficiaries, while China proposed to reduce the requested funding level based on an Article 5 ownership of four potential beneficiaries of 83.75 per cent); the Secretariat further adjusted total ICC as it considers only one quarter of funding level eligible.

d. Additional associated phase-out of 832.5 mt (45.79 ODP tonnes).

e. China proposes to associate phase-out (at US \$4.80/kg) that would be offset against the voluntary phase-out already agreed by the Government.

f. To be discussed along with PMU cost for all sector plans in the context of the overarching strategy. The Secretariat does not recommend the amount indicated.

g. Includes additional 832.5 mt associated with servicing tools. Includes PMU at the requested level for calculation purposes. Level to be discussed.

Impact on the climate

283. The conversion of the 20 RAC manufacturing lines to HC-290 would avoid the emission to the atmosphere of some 18,880 million tonnes of CO₂ equivalent per year. In addition, China is proposing to phase out 10,505 mt at RAC enterprises without assistance from the Fund. It is expected that the vast majority of those conversions will be to R-410A. On that assumption, the conversion of approximately 26 RAC manufacturing lines to HFC-410A would avoid the emission to the atmosphere of some 112 million tonnes of CO₂ equivalent per year. The conversion of 4 HPWH lines to HC-290 and R-744 is estimated to avoid the emission to the atmosphere of some 217 million tonnes of CO₂ equivalent per year. Table 11 presents the climate impact calculated using the Multilateral Fund Climate Impact Indicator (MCII).

Table 11. Climate impact of conversion projects* in RAC sector (tCO₂eq)

Conversion	Funded RAC lines	Unfunded RAC lines**	HPWH
Baseline technology	HCFC-22	HCFC-22	HCFC-22
Alternative technology	HC-290	R-410A	HC-290, R-744
Charge of HCFC-22 (kg/unit)	1.15	1.15	1.20
Yearly consumption (mt)	8,050	10,465	120
Yearly output per production line (unit)	350,000	350,000	25,000
Number of production line	20	26	4
Export to non-Article 5 countries (%)	0	36	0
Cooling capacity (KW)*	3.5	3.5	n/a

Conversion		Funded RAC lines	Unfunded RAC lines**	HPWH
Life span of equipment		12	12	12
Baseline	Direct impact	14,615,580	19,000,254	217,200
	Indirect impact	133,660,160	168,013,352	n/a
	Sub-total	148,275,740	187,013,606	217,200
After conversion	Direct impact	16,960	19,957,002	120
	Indirect impact	129,378,730	166,944,024	n/a
	Sub-total	129,395,690	186,901,026	120
Reduction	Direct impact	14,598,620	(956,748)	217,080
	Indirect impact	4,281,430	1,069,328	n/a
	Sub-total	18,880,050	112,580	217,080
Percentage of reduction (%)		12.73	0.06	99.94
Total emission reduction		19,209,710		

* Calculated using MCII for a 12 year life time of equipment.

** Assuming all manufacturing lines will be converted to R-410A

RECOMMENDATION

284. The Executive Committee may wish to consider the plan for the room air-conditioning sector in China in light of the Secretariat's comments contained in document UNEP/OzL.Pro/ExCom/76/25.

PROJECT EVALUATION SHEET – MULTI-YEAR PROJECTS

China

(I) PROJECT TITLE	AGENCY
HCFC phase-out plan (stage II) solvent	UNDP

(II) LATEST ARTICLE 7 DATA (Annex C Group I)	Year: 2014	16,838.53 (ODP tonnes)
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(III) LATEST COUNTRY PROGRAMME SECTORAL DATA (ODP tonnes)								Year: 2014	
Chemical	Aerosol	Foam	Fire fighting	Refrigeration		Solvent	Process agent	Lab use	Total sector consumption
				Manufacturing	Servicing				
HCFC-123				12.9	7.1				20.0
HCFC-124					2.1				2.1
HCFC-141b	64.3	5,155				484			5,703.3
HCFC-142b		604.5		6.5	33.7				644.7
HCFC-22	121.9	1,644.5		5,582.5	3,118.8				10,467.7
HCFC-225ca						0.8			0.8

(IV) CONSUMPTION DATA (ODP tonnes)			
2009 - 2010 baseline:	19,269.0	Starting point for sustained aggregate reductions:	18,865.44
CONSUMPTION ELIGIBLE FOR FUNDING (ODP tonnes)			
Already approved:	3,445.19	Remaining:	15,420.25

(V) BUSINESS PLAN		2016	2017	2018	2019	2020	After 2020	Total
UNDP	ODS phase-out (ODP tonnes)	120.0	0	140.0	0	140.0	0	400.0
	Funding (US \$)	5,252,727	0	6,128,182	0	6,128,182	0	17,509,091

(VI) PROJECT DATA			2016	2018	2020	2023	2025	Total
Montreal Protocol consumption limits								
Maximum allowable consumption (ODP tonnes)								
Project costs requested in principle (US \$)	UNDP	Project costs						
		Support costs						
Total project costs requested in principle (US \$)								
Total support costs requested in principle (US \$)								
Total funds requested in principle (US \$)								

(VII) Request for funding for the first tranche (2016)		
Agency	Funds requested (US \$)	Support costs (US \$)
UNDP	TBD	TBD

Funding request:	Approval of funding for the first tranche (2016) as indicated above
Secretariat's recommendation:	For individual consideration

PROJECT DESCRIPTION

285. On behalf of the Government of China, UNDP as the designated implementing agency, has submitted to the 76th meeting the solvent sector plan as part of stage II of the HCFC phase-out management plan (HPMP) at the amount of US \$57,500,000, plus agency support costs of US \$4,025,000 for UNDP, as originally submitted. The implementation of stage II of the solvent sector plan will completely phase-out the consumption of HCFCs in the sector by 2026 and assist China in meeting the Montreal Protocol compliance targets of 35 per cent reduction by 2020 and 67.5 percent by 2025.

286. The first tranche for stage II of the HPMP being requested at this meeting amounts to US \$3,443,868, plus agency support costs of US \$241,071 for UNDP, as originally submitted.

Status of implementation of stage I of the HPMP for the solvent sector

287. Stage I of the solvent sector plan was approved at the 65th meeting, at a total cost of US \$5,000,000, plus agency support costs for UNDP. The target reduction for stage I in the solvent sector was 69.0 ODP tonnes (627.3 mt) of HCFCs. An overview of the results achieved so far is included below.

Summary progress report on the implementation of stage I activities³¹

ODS policy and regulation framework

288. The Ministry of Environmental Protection (MEP) issued a Circular on Strict Management of HCFC Production, Sale and Consumption in 2013 to ensure achievement of the freeze target in 2013 and the 10 per cent reduction in 2015. The circular established quota permits for enterprises (including the solvent sector) consuming more than 100 mt of HCFCs per year.

Conversion of enterprises

289. Stage I of the solvent sector plan focused on the conversion of six medical device enterprises to KC-6³², two metal cleaning enterprises to hydrocarbon- (HC) based cleaning process and one electronic cleaning enterprise to isopropanol/alcohol. All nine enterprises have completed their conversions phasing out 67.13 ODP tonnes (610.29 mt) of HCFC-141b; (six enterprises had received national acceptance, while the remaining three are expected by mid-2016). In addition, the demonstration project at Zhejiang Kindly Medical Devices has been completed with an additional phase-out of 3.06 ODP tonnes (27.82 mt) of HCFC-141b. In total, 70.20 ODP tonnes of HCFC-141b was phased out during stage I of the solvent plan (i.e., 1.19 ODP tonnes above the target).

Technical assistance (TA) activities

290. The technical assistance activities included workshops to discuss alternatives, on-site verification of conversion, a study tour to gain experience on alternative technologies, policy enforcement measures, training on the use of alternative technologies phased-in, and development of a management information system to track HCFC phase-out and provide project data and progress reports.

³¹ A comprehensive progress report was included in the last tranche request for stage I of the HPMP for China submitted to the 75th meeting (paragraphs 15 to 20 of document UNEP/OzL.Pro/ExCom/75/41).

³² Iso-paraffin and siloxane.

Project implementation and monitoring unit (PMU)

291. The PMU has provided support to the national ozone unit (NOU) through visiting enterprises to review projects; developing technical specifications; organizing meetings for evaluation and recommendation to issue service agreements; public awareness; and ensuring financial control of the funds according to UNDP rules and regulations.

Status of disbursements

292. As of February 2016, of the total funds of US \$5,000,000 approved so far, US \$4,500,000 had been disbursed from UNDP to FECO, and US \$4,032,344 had been disbursed from FECO to beneficiaries. Funding disbursed to beneficiaries accounts for 80 per cent of the total funding approved for stage I, and 89 per cent of the funding disbursed from UNDP to FECO. An additional US \$787,700 will be disbursed to beneficiaries by December 2016.

Stage II of the solvent sector planConsumption of HCFC-141b

293. The solvent sector is comprised of 400 enterprises and characterized by emissive uses of HCFCs for degreasing and other applications for disposable medical devices (DMD) (40 per cent), metal degreasing (20 per cent), electronics degreasing (20 per cent) and solvent formulation (20 per cent). The sector uses mainly HCFC-141b with a few enterprises using HCFC-225ca/cb.

294. In 2014 the consumption of HCFC-141b in the solvent sector reported in the country programme (CP) data was 2 per cent, below the consumption allowed under the Agreement between the Government of China and the Executive Committee, as shown in Table 1. In 2015, the consumption has been estimated at 455.2 ODP tonnes.

Table 1. HCFC-141b consumption in the solvent sector in 2012-2015

Solvent sector	2012	2013	2014	2015*
Metric tonnes (mt)				
HCFC-141b	4,755.00	4,230.00	4,400.00	4,127.00
HCFC 225ca	16.22	28.73	33.25	45.00
HCFC-225cb	19.83	0.00	0.00	0.00
Total (CP data report)	4,791.05	4,258.73	4,433.25	4,172.00
Maximum allowable consumption	n/a	4,492.70	4,492.70	4,172.00
Difference	n/a	233.97	59.45	0.00
ODP tonnes				
HCFC-141b	523.05	465.30	484.00	454.00
HCFC-225ca	0.41	0.72	0.83	1.12
HCFC-225cb	0.65	0.00	0.00	0.00
Total (CP data report)	524.11	466.02	484.83	455.17
Maximum allowable consumption	n/a	494.20	494.20	455.17
Difference	n/a	28.18	9.37	0.00

*Estimated consumption

Remaining eligible consumption for finding

295. After implementation of stage I, the remaining consumption of HCFC-141b eligible for funding is 455.2 ODP tonnes based on the Agreement between the Government of China and the Executive Committee for stage I of the HPMP. Stage II proposes to phase-out 455.2 ODP tonnes (i.e., 454.04 ODP tonnes of HCFC-141b and 1.13 ODP tonnes of HCFC-225) of HCFC used in the solvent sector by 2026,

of which 401.53 ODP tonnes will be funded through the Multilateral Fund, with interim reductions as shown in Table 2.

Table 2. Reduction schedule for HCFC-141b in the solvent sector

Description	Stage I		Stage II					Total
	2013	2015	2018	2020	2023	2025	2026	
Consumption limit (mt)	4,530.63	4,173.00	3,624.51	2,944.91	1,359.19	500.00	0	n/a
Consumption limit (ODP tonnes)	494.22	455.17	395.38	321.24	148.27	55	0	n/a
Reduction (mt)	272.73	357.63	548.49	679.60	1,585.72	859.19	500	4,803.36
Reduction (ODP tonnes)	30.00	39.05	59.79	74.14	172.97	93.27	55	524.22
Reduction from starting point (per cent)	-	10	20	35	70	88	100	n/a
Funded reduction (ODP tonnes)		69.05					455.17	524.22

Phase-out strategy in the solvent sector for stage II

296. Similar to stage I, the strategy to phase-out HCFC-141b and HCFC-225 used in the solvent sector will consist of investment activities to convert the solvent using enterprises including small- and medium-sized enterprises (SMEs), regulatory actions; TA activities in support of the phase-out; and implementation and monitoring.

297. Reduction targets from the HCFC baseline for compliance are proposed as follows: 20 per cent by 2018; 35 per cent by 2020; 70 per cent by 2023; 88 per cent by 2024, and 100 per cent by 2026. The Government is also committing to the phase-out of all other HCFC consumption in the solvent sector that is not eligible for funding through the technical assistance activities.

Regulatory actions and monitoring

298. Regulatory actions that will facilitate the introduction of HCFC alternatives including flammable and/or toxic alternatives will be implemented for the solvent sector including the requirement for an import quota license for HCFC-225 starting in 2016; a ban on HCFC consumption in the solvent sector by 2026; and mandatory registration management by local environmental bureaus for all enterprises consuming less than 100 tonnes of HCFCs per year. A list of key recommended HCFC alternatives and standards for their safe handling and operation specifications will be prepared to support these initiatives.

Conversion of solvent using enterprises

299. The sector plan foresees the phase-out of 4,172 mt (455 ODP tonnes) of HCFCs used for DME cleaning, metal cleaning, electronics cleaning, and solvent formulation. Table 3 presents an estimate of the distribution of HCFC consumption in each sub-sector for 2014.

Table 3. Sub-sector distribution of HCFC consumption for 2014 in the solvent sector

Sub-sector	Consumption	
	Metric tonnes (mt)	ODP tonnes
DMD	1,650.0	181.50
Electronics cleaning	825.4	90.79
Metal cleaning	825.4	90.79
Solvent formulation	825.4	90.79
Other uses for cleaning (HCFC-225ca/cb)	45.0	1.13
Total	4,172.0	455.20

300. Through a survey conducted in 2015, 178 enterprises out of 297 provided information on their operations. The survey concluded that the DMD sub-sector accounted for 40 per cent of overall consumption of HCFCs, while the other three sub-sectors accounted for 20 per cent each. In addition, 10 per cent of HCFC consumption for the electronics cleaning and solvent formulation, 12 per cent for DMD, and 15 per cent for metal cleaning are ineligible for funding. This ineligible consumption will be provided technical assistance to facilitate their conversion.

Technology selection and cost calculation

301. The selection of the alternative solvents for the investment projects considered the impact on worker’s health and safety; GWP value of the alternatives; impacts on the process and production capacity of the enterprises; and cost-effectiveness. On this basis alternatives were selected for each application as shown in Table 4.

Table 4: Alternatives to HCFC-141b used as a solvent in China

Sub-sector	Purposes	Alternatives
DMD	Deposit silicone coating on needle tip and in wall of outer syringe barrel	KC-6, alcohol-soluble silicone, solvent-free silicone, HFES
	Degreasing	KC-6, HFES, trans-1,2-dichloroethylene
Metal cleaning and electronics cleaning	Degreasing	Hydrocarbon solvents, HFES, trans-1,2-dichloroethylene, HFOs
Solvent formulation	Formulated degreasing solvents	HFES, HFCs, HFOs, chlorinated solvents

302. The cost of the investment activities had been estimated based on the conversion costs of a sample of 48 enterprises in the four sub-sectors (i.e., 29 DMD enterprises (13 of which are SMEs), 11 metal cleaning enterprises (three of which are SMEs), four electronics cleaning enterprises and four solvent formulation enterprises). This model calculated the incremental capital costs (ICC) based on standard costs for replacing or retrofitting equipment in the baseline, trials, testing and training; and equipment and system safety for enterprises converting to HC-based cleaning processes. Incremental operating costs (IOC) were calculated based on cost of each alternative.

303. For the DMD conversion to KC-6 (slightly flammable and toxic) costs included a new ultrasonic degreasing equipment, replacing manual with mechanized cleaning, upgrade of the ventilation system, and explosion-proofing of equipment. For the metal cleaning and electronics cleaning applications, conversion to HFE (20 per cent) or HC (80 per cent) included upgrade of the ventilation system, upgrade of the alarm system, gas detectors, sprinklers, and explosion proof of equipment. For the solvent formulation application, conversion was based on new formulations with HFES, where a formula was used to calculate IOC.

304. This resulted in cost-effectiveness values (US \$/kg) for each sub-application which was then used to estimate the overall funding required for conversions in each sub-sector. For the solvent formulation sector, the resulting cost was US \$34.26/kg, but only half that cost was used to calculate the requested funding, as shown in Table 5.

Table 5. Total cost of the conversion in the solvent sector

	Actual consumption (mt)	Eligible consumption (mt)	Cost (US \$)			CE (US \$/kg)
			ICC	IOC	Total	
DMD (KC-6)	1,650.80	1,452.70	16,197,605	1,583,443	17,781,048	12.24
Metal cleaning (HC)	825.40	701.59	10,394,020	3,544	10,397,564	14.82
Electronics cleaning(HC) 80 per cent	825.40	594.29	8,721,218	2,959	8,724,177	14.68

	Actual consumption (mt)	Eligible consumption (mt)	Cost (US \$)			CE (US \$/kg)
			ICC	IOC	Total	
Electronics cleaning (HFE) 20 per cent		148.57	808,219	1,876,441	2,684,660	18.07
Solvent formulation-HFE/HCs	825.40	742.86	0	12,725,192	12,725,192	17.13*
Total/Average	4,127.00	3,640.01	36,121,062	16,191,579	52,312,641	14.37

*CE was calculated at US \$34.26/kg, and China is requesting only US \$17.13/kg

**HCFC-225 will be phased-out (45 mt) without additional funding

TA activities

305. In support of the conversion of enterprises using HCFC-based solvents, the following technical assistance activities, at a cost of US \$2,187,359, will be implemented:

- (a) Capacity building for authorities to manage HCFC-141b phase-out in the solvent sector through training workshops, consultation meetings and dissemination of technical information (US \$150,000);
- (b) Review and revise policies regarding HCFC phase-out in the solvent sector focusing on guidance for the use of alternative solvents and safety requirements (US \$360,000);
- (c) Research to improve application and efficiency of alternatives, develop guidelines for and promote the safe use of the alternatives (US \$397,359);
- (d) Assist enterprises in project implementation and provide supervision, evaluation, project review, inspection and commissioning (US \$500,000);
- (e) Strengthen the management capacity of 20 local environment protection departments/industrial associations on HCFC phase-out in the solvent sector (US \$600,000);
- (f) Share knowledge and experience to promote HCFC phase-out in SMEs and enterprises with HCFC not eligible for funding (US \$180,000).

Implementation modality

306. The PMU established under stage I of the solvent sector plan will continue to be operational in stage II, it will assist in the implementation, monitoring, verification, and follow-up, of activities: it will coordinate with all stakeholders, and organize training workshops for FECO and other relevant agencies to ensure full cooperation with the HCFC phase-out. The financial arrangements for the solvent sector plan would be similar to that in stage I. The cost of the PMU is requested at US \$3,000,000.

Total cost of stage II of the HPMP

307. The total cost of stage II of the solvent sector plan has been estimated at US \$57,500,000, as originally submitted (excluding support costs), to phase-out of 455.2 ODP tonnes of HCFC (454.1 ODP tonnes of HCFC-141b and 1.12 ODP tonnes of HCFC-225ca) by 2026, representing a cost-effectiveness of US \$14.37/kg, as shown in Table 6.

Table 6. Summary of proposed activities and cost of stage II of the HPMP for China

Sub-sector	Technology	Actual consumption		Eligible consumption		Funds requested (US \$)	CE (US \$/kg)
		mt	ODP tonnes	mt	ODP tonnes		
DMD	KC-6	1,650.8	181.59	1,452.7	159.80	17,781,048	12.24
Metal cleaning	HC	825.4	90.79	701.59	77.17	10,397,564	14.82
Electronics cleaning	HC	825.4	90.79	594.29	65.37	8,724,177	14.68
	HFE			148.57	16.34	2,684,660	18.07
Solvent formulation	HFE/HCs	825.4	90.79	742.86	81.71	12,725,192	17.13*
Total		4,127.0	454.1	3,640	400.40	52,312,641	14.37**
Technical assistance						2,187,359	
Project Management Unit						3,000,000	
Funds requested to the Multilateral Fund						57,500,000	

*CE was calculated at US \$34.26/kg, and China is requesting only US \$17.13/kg

**Calculated based on eligible consumption of the enterprises

SECRETARIAT'S COMMENTS AND RECOMMENDATION

COMMENTS

308. The Secretariat reviewed stage II of the HPMP for China in light of stage I, the policies and guidelines of the Multilateral Fund, including the criteria for funding HCFC phase-out in the consumption sector for stage II of HPMPs (decision 74/50), and the 2016-2018 business plan of the Multilateral Fund.

Phase-out strategy

309. The Government is committing to completely phase-out all HCFC consumption in solvent uses by 2026. UNDP indicated that the initial commitment in stage I was to completely phase-out the use of HCFC-141b only in the DMD sector by 2025, and achieve full phase-out by 2030. However, through stage II, the Government is proposing the complete phase-out of HCFCs in the solvent sector, which is supported by a ban on its use for the solvent sector, commencing 1 January 2026, after all the enterprises have converted.

Cost-related issues

310. The Secretariat noted that the approach to use standard costs for the calculation of the overall incremental costs of the conversion of the solvent enterprises may introduce uncertainties in the assessment of such costs and expressed concerns that while these are based on actual prices of alternatives, they may not be representative to extrapolate costs for the whole sector.

311. UNDP noted that this had been the approach taken for stage I, and is considered the most-efficient way to provide assistance to all enterprises and provide flexibility to consider eligible enterprise but with very small consumption. The calculation of the costs took into account the properties of the alternatives (i.e., flammability and toxicity) and thus the need for safety related equipment and costs; technical needs for conversion, (e.g., replacing degreasing machines with ultrasonic equipment or inclusion of solvent recovery systems in the process).

312. Further to a discussion where the Secretariat prepared a detailed analysis of the proposed costs in the solvent sector and compared them with other previously approved projects in the solvent sector in China, an agreement was reached to reduce the cost of some items in the baseline equipment, which

consequently decreased the ICC per application. In addition, given the current knowledge and uncertainties on the prices of the alternatives, some IOC were also adjusted. The total agreed ICC and IOC for stage II of the HPMP amounts to US \$47,205,858 with an overall CE of US \$11.3/kg, as shown in Table 7.

Table 7. Original ICC, IOC and agreed ICC, IOC total

Sub-sector	Technology	Original CE (US \$/kg)			Agreed CE (US \$/kg)		
		ICC	IOC	CE	ICC	IOC	CE
DMD	KC-6	11.14	1.10	12.24	10.37	0.38	10.75
Metal cleaning	HC	14.82	0.00	14.82	14.06	-0.87	13.19
Electronics cleaning	HC	14.68	0.00	14.68	13.50	-0.87	12.63
	HFE	5.44	12.63	18.07	5.35	9.48	14.83
Solvent formulation	HFE/HCs	0.00	17.13	17.13*	0.00	17.00	17.00
Total CE based on eligible phase-out				14.37			12.97*
Total CE based on actual phase-out				12.54			11.31

* CE was calculated at US \$34.26/kg, and China is requesting only half of the calculated cost

TA activities

313. UNDP explained that the technical assistance activities are necessary to support phase-out activities of the solvent sector. Training for solvent users, particularly the SMEs are essential to ensuring that the selected alternatives are applied correctly; for many of these enterprises, consideration of occupational health and safety issues are a priority; therefore, knowledge sharing and dissemination of information is required.

314. Taking into account the potential overlap with the PMU for some of the consultancy services included in the technical assistance costs, China agreed to reduce the technical assistance component from US \$2,187,000 to US \$1,485,000.

PMU

315. UNDP clarified that there were no overlaps in the work of the PMU and the specific projects and activities in the solvent sector. The PMU will provide the overall coordination of the project, oversee the bidding and procurement process, and will be involved in day to day operations of the specific conversion to ensure that these are being implemented on time.

316. Noting that the Secretariat had raised the issue of project management costs related to sector plans in the context of the overall stage of the HPMP, it was agreed that the current PMU costs, based on a 6 per cent of the investment project costs, be maintained and maybe adjusted in light of decisions of the Executive Committee.

Agreed ICC/IOC for stage II of the solvent sector plan in China

317. The agreed overall cost of the activities proposed for the solvents sector in stage II of the HPMP for China amounts to US \$51,523,210 (excluding agency support cost), as shown in Table 8.

Table 8. Agreed cost for stage II of the solvent sector for China

Sub-sector	Technology	Actual consumption		Eligible consumption		Funds agreed (US \$)			CE (US \$/kg)
		mt	ODP tonnes	mt	ODP tonnes	ICC	IOC	Total cost	
Disposable medical devices	KC-6	1,650.8	181.59	14,452.7	159.80	15,062,833	552,017	15,614,849	10.75
Metal cleaners	HC	825.4	90.79	701.6	77.17	9,862,707	-610,351	9,252,356	13.19
Electronics cleaners	HC	825.4	90.79	594.3	65.37	8,024,169	-517,032	7,507,136	12.63
	HFE			148.6	16.34	794,528	1,408,369	2,202,897	14.83
Solvent formulation	HFE/HCs	825.4	90.79	742.9	81.71	0	12,628,620	12,628,620	17.00
Phase-out of HCFC-225		45.0	1.13	45.0	1.13	-	-	-	-
Total		4,172.0	455.2	3,685	401.53	33,744,236	13,461,622	47,205,858	11.31*
Technical assistance								1,485,000	
PMU								2,832,351	
Total cost								51,523,210	

*Calculated based on actual phase-out to be achieved in stage II

Impact on the climate

318. The conversion of the remaining HCFC-141b and HCFC-225 in the solvent sector would avoid the emission into the atmosphere of 2,621,055 thousand tonnes of CO₂ equivalent per year, as shown in Table 9.

Table 9. Impact on the climate PU foam projects

Substance	GWP	Tonnes/year	CO ₂ -eq (tonnes/year)
Before conversion			
HCFC-141b and HCFC-225	725	4,175	3,026,875
Total before conversion			
After conversion			
KC-6, HC	~20	1,155	23,100
HFE	320	1,196	382,720
Impact			2,621,055

Co-financing

319. No co-financing from beneficiary enterprises is expected for stage II of the solvent sector of the HPMP. The Government through the FECO has committed to monitor the implementation of activities under the policy and regulatory component of the HPMP. Of the total 4,172.0 mt (455.2 ODP tonnes) to be phased out through the solvent sector plan, 488.18 mt (54.1 ODP tonnes) will be phased out without assistance from the Multilateral Fund. On the basis of the CE of US \$11.31/kg (as agreed), the contribution to the Fund associated with the phase-out would be US \$5,521,315.

RECOMMENDATION

320. The Executive Committee may wish to consider the sector plan for phase-out of HCFC-141b and HCFC-225 in the solvent sector in China in light of the Secretariat's comments contained in document UNEP/OzL.Pro/ExCom/76/25.

PROJECT EVALUATION SHEET – MULTI-YEAR PROJECTS
China

(I) PROJECT TITLE	AGENCY
HCFC phase out plan (stage I) servicing sector, including enabling	Germany, Japan, UNEP (lead)

(II) LATEST ARTICLE 7 DATA (Annex C Group I)	Year: 2014	16,838,53 (ODP tonnes)
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(III) LATEST COUNTRY PROGRAMME SECTORAL DATA (ODP tonnes)								Year: 2014	
Chemical	Aerosol	Foam	Fire fighting	Refrigeration		Solvent	Process agent	Lab use	Total sector consumption
				Manufacturing	Servicing				
HCFC-123				12.9	7.1				20
HCFC-124					2.1				2.1
HCFC-141b	64.3	5,155				484			5,703.3
HCFC-142b		604.5		6.5	33.7				644.7
HCFC-22	121.9	1,644.5		5,582.5	3,118.8				10,467.7
HCFC-225ca						0.8			0.8

(IV) CONSUMPTION DATA (ODP tonnes)			
2009 - 2010 baseline:	19,269.0	Starting point for sustained aggregate reductions:	18,865.44
CONSUMPTION ELIGIBLE FOR FUNDING (ODP tonnes)			
Already approved:	3,445.19	Remaining:	15,420.25

(V) BUSINESS PLAN		2017	2018	2019	2020	Total
Germany	ODS phase-out (ODP tonnes)	2.4	0	3.1	0	5.5
	Funding (US \$)	237,000	0.0	306,000	0.0	543,000

(VI) PROJECT DATA			2016	2018	2020	2023	2025	Total
Montreal Protocol consumption limits								
Maximum allowable consumption (ODP tonnes)								
Project costs requested in principle (US \$)	Germany	Project costs						
		Support costs						
Project costs requested in principle (US \$)	Japan	Project costs						
		Support costs						
Project costs requested in principle (US \$)	UNEP	Project costs						
		Support costs						
Total project costs requested in principle (US \$)								
Total support costs requested in principle (US \$)								
Total funds requested in principle (US \$)								

(VII) Request for funding for the first tranche (2016)		
Agency	Funds requested (US \$)	Support costs (US \$)
Germany/Japan/UNEP	TBD	TBD

Funding request:	Approval of funding for the first tranche (2016) as indicated above
Secretariat's recommendation:	For individual consideration

PROJECT DESCRIPTION

321. On behalf of the Government of China, UNEP, as the lead implementing agency, has submitted to the 76th meeting a sector plan for the servicing sector and enabling programme as part of stage II of the HCFC phase-out management plan (HPMP) at a total cost of US \$22,549,900, consisting of US \$18,890,000, plus agency support costs of US \$2,087,900 for UNEP, US \$1,000,000, plus agency support costs of US \$120,000 for the Government of Germany, and US \$400,000, plus agency support costs of US \$52,000 for the Government of Japan, as originally submitted. The servicing sector plan and enabling programme will phase out 232 ODP tonnes of HCFCs and assist China in meeting the Montreal Protocol compliance target of 35 per cent reduction by 2020.

322. The first tranche for stage II of the HPMP being requested at this meeting amounts to US \$4,091,147, consisting of US \$3,300,000, plus agency support costs of US \$364,747 for UNEP, US \$300,000, plus agency support costs of US \$36,000 for Germany, and US \$80,000, plus agency support costs of US \$10,400 for Japan, as originally submitted.

Status of stage I of the servicing sector plan and enabling activities

323. Stage I of the HPMP for China was approved at its 64th meeting to meet the 10 per cent reduction of HCFC consumption by 2015. This approval included the servicing sector plan and enabling activities at a total cost of US \$5,640,000, plus agency support costs. It is expected that activities included in stage I of the refrigeration servicing sector will continue until 2017.

Summary progress report on the implementation of stage I activities³³

324. As of March 2016, standards and technical codes including handling of flammable refrigerants, and a training textbook for servicing refrigeration equipment had been developed or amended; two national and 17 regional training centres had been established, and approximately 4,000 trainers and refrigeration service technicians had been trained and 500 enterprises certified; a feasibility study to support the certification of technicians had been completed; a study to assess needs of the vocational system with regard to refrigeration servicing is under implementation; the qualification certification scheme for refrigeration servicing companies had been amended to include requirements on good service practices, refrigerants recovery, recycling and reclamation; a demonstration project to strengthen local Environmental Protection Bureaus (EPBs) capacity had been implemented; and outreach and awareness activities on good refrigeration service practices had been conducted.

325. Implementation of enabling activities had included the distribution of 30 refrigerant identifiers to ten customs offices, and training workshops for ODS importing and exporting enterprises; the review and approval of ODS trade applications by the National Management Office of ODS Import and Export had been automated; implementation of six training workshops for local EPBs and other authorities; distribution of manual on ODS policies and regulations and booklets on compliance activities to EPBs; coordination meetings for ministries and commissions under the State Council; and outreach activities on alternative technologies.

326. The PMU has provided support to the National Ozone Unit (NOU) in implementing the activities in the refrigeration servicing sector, through *inter alia* coordinating the training programmes, visiting training centres to ensure completion of activities, preparing implementation plans and work plans, supervising public awareness campaigns; assisting in reporting and monitoring activities; and ensuring

³³ A comprehensive progress report was included in the last tranche request for stage I of the HPMP for China submitted to the 75th meeting (paragraphs 123 to 124 of document UNEP/OzL.Pro/ExCom/75/41).

financial control of the funds according to rules and regulations of the agencies and the Executive Committee.

Status of disbursements

327. As of March 2016, of the total funds of US \$5,240,000 so far approved for the servicing sector, US \$2,837,000 (54 per cent) has been disbursed from UNEP to FECO, and US \$2,422,387 had been disbursed by FECO. The remaining funding of US \$2,403,000 will be disbursed between 2016 and 2017.

Stage II of the servicing sector plan and enabling activities

HCFC consumption in the refrigeration servicing sector

328. The HCFC consumption in the refrigeration servicing sector has been estimated at 67,345 mt (3,704 ODP tonnes) in 2015. Due to the efforts by the industrial and commercial refrigeration and room air-conditioners manufacturing sectors that have introduced HCFC-free equipment into the market, the level of consumption of HCFC-22 has declined (i.e., consumption in 2012 was estimated at 88,327 mt (4,858 ODP tonnes). However, the demand of HCFC-22 for servicing will continue for several years given the fact that the amount of HCFCs charged in RAC equipment has been estimated at 1,000,000 mt, and since 2011 approximately 100,000 mt of HCFCs are being charged in new RAC equipment annually. It is expected that consumption in the refrigeration servicing sector will be largest consumption among all sectors by 2020.

329. The refrigeration servicing sector comprises approximately 110,000 servicing workshops which are scattered throughout the country, with different levels of servicing capabilities and technical skill levels of the technicians, and the majority with limited basic equipment and tools, particularly in the AC sector, where refrigerants are not recovered and recycled. However, in the industrial and commercial refrigeration sector about 80 per cent of the servicing workshops have refrigerant recovery equipment, (compared to 55 per cent before the implementation of stage I).

330. The servicing sector is also characterised by the use of seasonal workers (over a six-month period starting in the spring for installing refrigeration and AC systems) that often lack the necessary training, affecting quality of service. There are only a few vocational training institutions that provide formal courses for technicians. Information dissemination about new HCFC alternative refrigerants, especially flammable, toxic, and/or high pressure, is limited.

Strategy of stage II of the refrigeration servicing sector and enabling activities

331. The overarching strategy of stage II of the refrigeration servicing sector and enabling activities has been developed taking into account the HCFC phase-out targets of the overall stage II of the HPMP for China, and the urgent need for the safe adoption of alternative refrigerants, taking into account flammability and toxicity issues and their operating pressures.

Refrigeration servicing sector

332. The refrigeration servicing sector proposes to reduce both HCFC consumption and emissions of refrigerants; and to strengthen the infrastructure in the country for the safe use of alternative refrigerants by building capacity of service technicians, enhancing refrigerant management, and promoting good service practices and ozone friendly technologies/equipment.

333. The following activities will be implemented:

- (a) Development of new codes/standards for safety requirements during installation and servicing of equipment using flammable and/or toxic refrigerants, and certification of service companies and technicians, and assessment of recycled refrigerants;
- (b) Strengthen the technician certification schemes through improvement of the vocational education system; strengthening safety in the work place through good service practices including safe handling of flammable, and high operating pressures of refrigerants;
- (c) Continue training programmes for refrigeration technicians, supported by the development of new training materials and establishment of additional training centres;
- (d) Promote the qualification and certification of service companies that adopt good service practice in all sub-sectors (including in supermarkets) and encourage all servicing companies to improve their service practices;
- (e) Conduct feasibility studies to support policy development to reduce HCFC emissions through recovery, recycling, and reuse of HCFC;
- (f) Continue enhancement of the capacity of local EPBs for management and monitoring of the activities in the refrigeration servicing sector through additional pilot cities; and
- (g) Outreach activities to disseminate information on good refrigeration service practices and on ozone-climate initiatives to enhance awareness on protecting the ozone layer and the climate.

Enabling programme

334. The enabling activities in stage II will ensure that local authorities have the capacity to implement relevant laws and regulations to encourage HCFC phase-out; strengthen the capacity of law enforcement to manage ODS import/export; prevent and combat illegal trade of HCFCs; facilitate the adoption of alternative refrigerants; and encourage better procurement practices through public awareness campaigns.

335. The following enabling activities will be implemented:

- (a) Build capacity for ten local EPBs authorities through regular meetings;
- (b) Develop a communication and outreach strategy based on the results achieved during implementation of similar activities in stage I; conduct workshops related to the protection of the ozone layer; develop and distribute awareness materials; and support website maintenance;
- (c) Continue to strengthen the HCFC import/export management system through training workshops for customs officers and study tours; and capacity building assistance for four customs districts including *inter alia* training on refrigerant identification and risk analysis, improve database, evaluation and improvement of inspection operations; and
- (d) Project management, coordination, monitoring and financial reporting.

PMU

336. The PMU established under stage I of the refrigeration servicing sector will continue to be operational in stage II. The PMU through FECO will take overall responsibility for the implementation of the activities under the servicing sector plan (including the enabling activities), with technical and policy assistance from UNEP. The activities to be undertaken include progress of implementation, work plans for tranches and preparation of other reports.

Total cost of stage II of the refrigeration servicing sector and enabling activities

337. The total cost of the refrigeration servicing sector and enabling activities included in stage II of the HPMP for China has been estimated at US \$20,290,000, as originally submitted (excluding support costs), as shown in Table 1.

Table 1. Cost of stage II of the servicing sector and enabling activities for China

Component	Description	Unit cost (US \$)	Units	Total (US \$)
Servicing sector				
Policy	Standards/codes	60,000	6	360,000
	Certificate systems for servicing technicians	450,000	1	450,000
	Qualification certification for companies	60,000	5	300,000
	Supporting system	400,000	1	400,000
Sub-total				1,510,000
Training	Training and outreach materials	300,000	1	300,000
	Training from training centers	100,000	50	5,000,000
	Communication and competition of skills among training centers	50,000	2	100,000
	Overseas training	6,000	60	360,000
	Training through channel of RAC manufactures	100	40,000	4,000,000
	Coordination, monitoring, evaluation of the training programme	200,000	1	200,000
Sub-total				9,960,000
Initiative	Supermarket refrigerant management initiative	100,000	10	1,000,000
Sub-total				1,000,000
Outreach	Outreach	60,000	5	300,000
Sub-total				300,000
Pilot City	Policy	50,000	4	200,000
	Incentive for servicing provider/end user	150,000	4	600,000
	Outreach	100,000	4	400,000
	Refrigerants reclaiming and treatment system	100,000	4	400,000
	Qualification certification for technicians	50,000	4	200,000
	Other activities designed by pilot cities	50,000	4	200,000
Sub-total				2,000,000
PMU		1,200,000	1	1,200,000
Sub-total for the servicing sector				15,970,000
Enabling activities				
Capacity building for local authorities				2,100,000
Communication and outreach strategy				750,000
Strengthening import/export management of HCFCs				1,150,000
PMU				320,000
Sub-total for enabling components				4,320,000
Total cost				20,290,000

SECRETARIAT'S COMMENTS AND RECOMMENDATION

COMMENTS

338. The Secretariat reviewed stage II of the HPMP for China in light of stage I, the policies and guidelines of the Multilateral Fund, including the criteria for funding HCFC phase-out in the consumption sector for stage II of HPMPs (decision 74/50), and the 2016-2018 business plan of the Multilateral Fund.

Phase-out strategy for stage II of the servicing sector

339. The 2014 CP data reports a HCFC consumption of 3,161 ODP tonnes in the servicing sector (consisting of: 3,118 ODP tonnes of HCFC-22, 33.7 ODP tonnes of HCFC-142b, 7.1 ODP tonnes of HCFC-123, and 2.12 ODP tonnes of HCFC-123). This consumption was approximately 20 per cent below the (estimated) HCFC baseline of 3,898 ODP tonnes for this sector, while the estimated consumption of 3,734 ODP tonnes in 2015 was approximately 4 per cent below.

340. In stage II for the refrigeration servicing sector the Government of China is committing to phase-out 4,227 mt (232 ODP tonnes) of HCFC-22; however, the overarching strategy indicated a phase-out of 734 ODP tonnes of HCFC-22. UNEP clarified that the tonnage included in the overarching strategy was indicative, and did not denote a commitment from the Government to phase out that amount. While specific levels of HCFC consumption and phase-out targets have been established for the manufacturing sectors, these consumption levels and phase-out targets are not established for the refrigeration servicing sector. UNEP further explained that the HCFC consumption in the servicing sector is calculated as the balance from the overall HCFC consumption levels (calculated on the basis of the amounts produced, imported and exported), and the consumption levels of each of the manufacturing sectors (i.e., HCFC consumption not allocated to the manufacturing sectors is considered as the consumption for refrigeration servicing sector). Therefore the estimated level of consumption may not necessarily reflect the actual situation on the ground.

Proposed activities in stage II

Refrigeration servicing sector plan

341. Implementation of stage I activities in the refrigeration servicing sector were delayed due to the limited structure and institutional arrangements that were in place, in particular, the identification and selection of training centres, and the engagement of partners and key stakeholders. Noting that similar activities will be implemented in stage II, UNEP explained that the institutional infrastructure is now in place; training centres established under stage I have contracted will new centres will be established; and all main partners participating in activities related to the refrigeration servicing sector are on board. Accordingly, implementation delays will be minimised as the implementation modality is already defined.

342. In consideration of the potential overlap of activities related to training of technicians and procurement of service tools included in both stage II of the RAC and ICR manufacturing sectors with those under the refrigeration servicing sector, UNEP explained that the tools and training under the manufacturing sectors are specifically for installation and servicing of the new equipment based on HC-290 refrigerant and will be provided to the servicing companies that are owned by manufacturing enterprises, while the activities under the refrigeration servicing sector relate to reducing consumption and emissions of HCFC-22 already installed in the country. Cognizant of the need to ensure a comprehensive approach for the refrigeration servicing sector and avoid potential overlaps, UNEP further explained that training and qualification of service companies under the refrigeration service sector plan will be coordinated and monitored with similar activities proposed in the RAC and ICR sector plans.

343. Upon a request for additional information on the policies that will be developed during stage II, UNEP explained that it will include specific codes for servicing and maintenance of refrigeration equipment focusing on reducing leaks and thus minimising emissions of refrigerants; standards on assessing the quality of recovered and recycled refrigerant, and conditions for its use; and setting limits on leakage rates particularly during the servicing of equipment based on flammable or toxic refrigerants. UNEP also differentiated between technician qualification and technician certification, noting that these are two independent systems managed by separate ministries (i.e. Ministry of Human Resources and Social Security, and Ministry of Work Safety), and the need to work with both of them in parallel to ensure that requirements under the Montreal Protocol are integrated into each.

344. UNEP also indicated that the activity proposed for the pilot city will build on the success of the Shenzhen project, and endeavour to continue these efforts in other cities; the supermarket initiative will provide practical experience for the food cold chain to integrate good service practices to improve the management of HCFCs in this sector.

Enabling activities

345. Addressing a concern on minimising overlaps between the capacity building under current implementation using from balances from completed CFC phase-out projects with that proposed under stage II, UNEP clarified that the component in stage II will commence only in 2018 once the activities from previously funded projects have been completed; therefore, no overlap is foreseen. The major challenge for capacity building is related to the large number of EPBs that need to be supported, and the need to design training activities for all officials that will ensure the long-term sustainability of the activities being implemented.

346. With regard to the communication strategy, UNEP indicated that the main objective is to outreach to several stakeholders (e.g., individual consumers, corporate consumers and retailers and the media) on issues concerning the ozone science, actions being undertaken to protect the ozone layer and the links between ODS phase-out and associated impact on the climate

PMU

347. In justifying the request of US \$1,200,000 for the PMU, UNEP explained that the cost was calculated at approximately 8 per cent of the overall cost of the refrigeration servicing sector (excluding the enabling activities), noting that the PMU will be responsible for part of the daily operation of the project management office. As the management, coordination and monitoring of the training activities of 50 training centers is above the capacity of the PMU based on its current set up, contracting an executing agency will ensure the efficient and effective delivery of the training programmes, as it will coordinate the operation of the training centers, identify the trainees, collect feedback for improvements, and facilitate exchange of experiences among the training centers.

348. Noting that the Secretariat had raised the issue of project management costs related to sector plans in the context of the overall stage of the HPMP, it was agreed that the current PMU costs based on 8 per cent of the total project costs be maintained.

Conclusion

349. The funding requested for the servicing sector and the enabling programme (US \$20,290,000 excluding agency support costs) is in line with decision 74/50 (i.e., funding for the servicing sector at US \$4.80/kg). The activities proposed in the servicing sector and enabling programme are designed to respond to the needs of the Government of China, and their implementation will contribute to the reduction of HCFC consumption in the refrigeration servicing sector, and strengthen the local

infrastructure to enable the use of low-GWP refrigerants, thereby supporting efforts of Government to phase out HCFC use in the sector.

Impact on the climate

350. The proposed activities in the servicing sector, which include better containment of refrigerants through training and provision of equipment, will reduce the amount of HCFC-22 used for refrigeration servicing. Each kilogramme of HCFC-22 not emitted due to better refrigeration practices results in a savings of approximately 1.8 CO₂-equivalent tonnes. Although a calculation of the impact on the climate was not included in the HPMP, the activities planned by China, in particular its efforts to promote low-GWP alternatives, refrigerant recovery and reuse, indicate that the implementation of the HPMP will reduce the emission of refrigerants into the atmosphere therefore resulting in benefits on the climate. However, at this time, a more accurate quantitative assessment on the impact on climate cannot be conducted. The impact might be established through an assessment of implementation reports by, *inter alia*, comparing the levels of refrigerants used annually from the commencement of the implementation of the HPMP, the reported amounts of refrigerants being recovered and recycled, the number of technicians trained and the HCFC-22 based equipment being retrofitted.

RECOMMENDATION

351. The Executive Committee may wish to consider the sector plan for the servicing sector and the enabling programme in China in light of the Secretariat's comments contained in document UNEP/OzL.Pro/ExCom/76/25.

PROJECT EVALUATION SHEET – NON-MULTI-YEAR PROJECT

CHINA

PROJECT TITLE(S)

BILATERAL/IMPLEMENTING AGENCY

(a) Demonstration project for ammonia (NH ₃) semi-hermetic frequency convertible screw refrigeration compression units in the industrial and commercial refrigeration industry at Fujian Snowman Co., Ltd.	UNDP
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NATIONAL CO-ORDINATING AGENCY	MEP/FECO
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LATEST REPORTED CONSUMPTION DATA FOR ODS ADDRESSED IN PROJECT

A: ARTICLE-7 DATA (ODP TONNES, 2014, AS OF APRIL 2016)

HCFCs	2,219.48
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B: COUNTRY PROGRAMME SECTOR DATA (ODP TONNES, 2014, AS OF APRIL 2016)

HCFC-22	2,200.00
HCFC-123	12.98
HCFC-124	0.00
HCFC-141b	0.00
HCFC-142b	6.50
HCFC-225a	0.00

HCFC consumption remaining eligible for funding (ODP tonnes)	2,162.50
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CURRENT YEAR BUSINESS PLAN ALLOCATIONS		Funding US \$	Phase-out ODP tonnes
(a)		n/a	n/a

PROJECT TITLE:	
ODS use at enterprise (ODP tonnes):	n/a
ODS to be phased out (ODP tonnes):	n/a
ODS to be phased in (ODP tonnes):	n/a
Project duration (months):	18
Initial amount requested (US \$):	1,234,693
Final project costs (US \$):	
Incremental capital cost:	1,097,931
Contingency (10 %):	0
Incremental operating cost:	0
Co-funding	819,338
Total project cost:	1,097,931
Local ownership (%):	100
Export component (%):	0
Requested grant (US \$):	1,097,931
Cost-effectiveness (US \$/kg):	n/a
Implementing agency support cost (US \$):	76,855
Total cost of project to Multilateral Fund (US \$):	1,174,786
Status of counterpart funding (Y/N):	Y
Project monitoring milestones included (Y/N):	Y

SECRETARIAT'S RECOMMENDATION	Individual consideration
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PROJECT DESCRIPTION

Background

352. At the 75th meeting, UNDP submitted a demonstration project for ammonia (NH₃) semi-hermetic frequency convertible screw refrigeration compression units in the industrial and commercial refrigeration industry at Fujian Snowman Co., Ltd., at a total cost of US \$2,412,263, plus agency support costs of US \$168,858, as originally submitted^{34,35}. Further to a discussion at a contact group that was established to consider all projects to demonstrate low-GWP technologies submitted to the 75th meeting, the Executive Committee decided to defer consideration of the seven demonstration projects including the compressor project for China, to the 76th meeting (decision 75/42).

353. On behalf of the Government of China, UNDP has re-submitted to the 76th meeting the above-mentioned demonstration project, at a total cost of US \$1,234,693, plus agency support costs of US \$86,429. The project proposal submitted is contained in Annex I to the present document.

Project objective

354. In recent years, the annual growth rate of industrial and commercial refrigeration (ICR) equipment in China is more than 10 per cent, with an associated increase in demand for HCFC-22 (i.e., the current annual consumption of HCFC-22 in small- and medium-sized ICR equipment has been estimated at 4,500 metric tonnes (mt) (247.5 ODP tonnes). Usually HCFC-22-based refrigeration equipment is located in densely populated areas; due to safety regulations, NH₃-based refrigeration equipment must be placed away from populated areas, as the refrigerant charge is more than 100 kg. The development of NH₃ semi-hermetic screw refrigeration compressors with refrigerant charge of less than 50 kg will allow for the use of NH₃ in small- and medium-sized ICR equipment (such as freezers, cold storage rooms in supermarkets and food processing facilities) in densely populated areas and reduce refrigerant leakage.

355. On this basis, the demonstration project proposes to establish the suitability of NH₃ semi-hermetic frequency convertible screw refrigeration compression units with carbon dioxide (CO₂) as the secondary refrigerant used in small- and medium-sized ICR systems. The alternative technology will be tested and standardized in a factory-controlled environment.

356. The use of screw compressors for NH₃/CO₂ refrigeration systems has not been tested in China³⁶. The participating enterprise, Fujian Snowman Co., Ltd., manufactures compressors, ice-making equipment, water-cooling equipment, ice storage, and cooling systems, and has research and development capacity. The production lines for ice makers and ice storage will be modified to implement the project.

Project implementation

357. The demonstration will cover product and process design, development of the prototype of the NH₃-based compression unit, construction of the testing device for performance evaluation, and training. Documentation of the results and dissemination of technology will also be carried out.

358. The proposed technology will be demonstrated in three compressor models with different refrigerant charge and volumetric displacement, as shown in Table 1. The three models will undergo laboratory tests only (end-user testing is not included in the project).

³⁴ UNEP/OzL.Pro/ExCom/75/41.

³⁵ Funding for the preparation of this project was approved at the 74th meeting in the amount of US \$24,000, plus agency support costs of US \$1,680, on the understanding that its approval did not denote approval of the project or its level of funding when submitted (decision 74/26).

³⁶ Technical expert confirmed that such technology is used in Sweden.

Table 1. Specifications of the NH₃/CO₂ refrigeration system

Model	Theoretical volumetric displacement (m ³ /hr)	NH ₃ charge (kg)	CO ₂ charge	HCFC-22 charge replaced (kg)
SSSCA50 (SRS-12L)	262*	17	30	75
SSSCA60 (SRS-1008L)	221**	22	35	90
SSSCA210 (SRS-1612LM)	652	48	60	194

* Applications above -35 degrees Celsius.

** Applications below -35 degrees Celsius.

359. The project is expected to be completed in 18 months.

Project cost

360. The total project cost has been estimated at US \$1,917,269, of which US \$1,234,693 is being requested from the Multilateral Fund and the remaining US \$682,576 will be co-funded by the enterprise, as shown in Table 2. A letter of commitment to implement the project has been received from Fujian Snowman Co., Ltd.

Table 2. Project cost by activity (US \$)

Description		Total	Requested	Co-financing
Product and process design	System design	147,730	147,730	0
	Process design	44,319	44,319	0
	Compressor design	156,495	0	156,495
	Heat exchange analysis software	78,247	78,247	0
Compression unit performance test device construction	Electric leakage detector	3,130	0	3,130
	Detector	4,695	0	4,695
	Helium detector	66,041	0	66,041
	Compression unit performance test	438,184	438,184	0
	Pressure vessel strength test device	187,973	0	187,973
Prototype production	NH ₃ compressor	295,775	295,775	0
	NH ₃ oil separator	28,169	28,169	0
	CO ₂ liquid-storage tank	56,338	56,338	0
	Heat exchanger	21,127	0	21,127
	Starting cabinet (inverter)	42,254	0	42,254
	Electric control cabinet	4,695	0	4,695
	Valve parts, pipe, flanges	31,299	0	31,299
	Metal hose (testing)	9,390	0	9,390
	CO ₂ pump	28,169	28,169	0
	CO ₂ (0.9999)	56,338	0	56,338
	NH ₃	2,034	0	2,034
	Frozen oil	1,095	0	1,095
	Helium	3,443	0	3,443
	Nitrogen	235	0	235
Training	Training on product and process design	117,762	117,762	0
	Welder training	7,825	0	7,825
	Material fee	7,825	0	7,825
Market promotion	Market promotion	76,682	0	76,682
Total		1,917,269	1,234,693	682,576

SECRETARIAT'S COMMENTS AND RECOMMENDATION

COMMENTS

361. The project proposal submitted to the 75th meeting³⁷ included the conversion of the compressor manufacturing line to produce 3,000 NH₃ semi-hermetic frequency convertible screw refrigeration compressors, while the proposal submitted to the 76th meeting only focuses on the demonstration of NH₃ semi-hermetic frequency convertible screw compressor technology for NH₃/CO₂ integrated refrigeration systems. If the demonstration is successful, the conversion of the manufacturing lines could be carried out during implementation of stage II of the HPMP for China.

362. For ease of reference, the results of the discussions between the Secretariat³⁸ and UNDP on the demonstration project submitted to the 75th and 76th meetings are summarized below:

- (a) With regard to the conversion of one production line at the enterprise, UNDP explained that, through the demonstration project, the enterprise will retrofit an open compressor line to produce a few prototypes of semi-hermetic compressors for testing and technology validation. If the prototypes prove successful and the test results are satisfactory, the production line could be retrofitted by adding production equipment and testing equipment to manufacture 3,000 units per year of NH₃/CO₂ refrigeration systems funded under stage II of the HPMP;
- (b) With regard to the request for a new performance-testing device instead of modifying the existing testing laboratory for open-type compressors, UNDP explained that the laboratory in the baseline is for testing compressors with theoretical displacement above 300 m³/hr, while the two new models to be developed have theoretical displacement below 300 m³/hr. Modifying the existing laboratory would cost even more than constructing a new one. On this issue, the Secretariat noted that the level of co-financing this cost has been increased from 37 to 43 per cent;
- (c) With regard to the potential risk for adoption of the proposed technology, given that it will be more expensive than the HCFC-22-based technology, UNDP explained that currently the majority of alternative technologies in the HCFC-22-based refrigeration sector are more expensive. Although the cost of the new NH₃/CO₂ technology will be high at the beginning, it is expected that it will decrease with mass production of systems. Moreover, the new NH₃/CO₂-based system will have improved energy efficiency. With technology promotion and dissemination, as well as the increasing demand for low-GWP and energy-efficient alternatives, the new product will eventually be accepted by the market;
- (d) UNDP explained that the high costs of the demonstration project are due to the introduction of a new technology which involves major development work and testing; the hermetic system is more costly than open-type systems; and the high-pressure of CO₂ requires more costly materials. The cost of CO₂ used for prototyping, is high as repetitive tests will be conducted, noting that the charge of CO₂ is between 30-60 kg in one unit (thus requiring approximately 6,000 kg at US \$9.40/kg). On this issue the Secretariat noted that this cost will be co-funded by the enterprise; and

³⁷ UNEP/OzL.Pro/ExCom/75/41.

³⁸ The Secretariat sought expert advice on various aspects of the project, including the innovative nature of the proposed technology, the design of the process and the costs.

- (e) With regard to the intellectual property right (IPR) of the compressor design, UNDP explained that, as Snowman has invested heavily in research and development of the NH₃ compressor and is co-funding a significant part of the demonstration project including compressor design, it should hold the IPR for the compressor design. Other enterprises that wish to use the design would need to enter into a commercial arrangement with Snowman. The Secretariat advised that the demonstration project is mainly (57 per cent) funded by the Fund; the purpose of the demonstration is to validate the technology for replication in enterprises in Article 5 countries to allow the manufacture of NH₃ compressors. Any royalty payment required for compressor design would put an economic barrier on the technology dissemination, therefore, defeat the purpose of demonstration. There is no agreement reached on the IPR issue.

363. The demonstration project would not have a direct phase-out of HCFC-22, as the project is to develop a new semi-hermetic compressor to be used in NH₃/CO₂-refrigeration system. However, Snowman is proposing to convert its ice-maker production line with an annual capacity of 3,000 units to the NH₃/CO₂-based technology. The ice-maker units have an associated consumption of 23 mt (1.27 ODP tonnes) of HCFC-22. In addition, the production of the NH₃/CO₂-refrigeration system would replace HCFC-22 system to phase out 359 mt if the demonstration project is successful. On this basis, this HCFC-22 consumption could be associated with the demonstration project. Upon request to deduct tonnage associated with the demonstration project, UNDP explained that the reduction can only be realized if the demonstration is successful and when the conversion of ice making machine manufacturing line in Snowman is completed as a part of stage II of HPM. Accordingly, there should not be any reduction of consumption at this stage.

364. With regard to a further rationalizing the cost of the project³⁹ (noting that the total cost of the project originally submitted to the 75th meeting was US \$2,412,263), UNDP adjusted the costs of several project components (i.e., reduction of the costs for heat-exchanger design by US \$25,000; performance-testing device construction by US \$40,000; CO₂ pump by US \$5,000; and a helium leakage detector by US \$200,000). As a result, the total cost for the demonstration project remains unchanged, while the funding requested from the Multilateral Fund has been adjusted to US \$1,097,931, and the co-financed has been increased to US \$819,338. The Secretariat's technical expert had confirmed that the funding levels requested for product and process design, modification of the production line and training of personnel are justified.

Conclusion

365. The Secretariat considers that this project complies with the guidelines for low-GWP alternative demonstration projects as established by decision 72/40. The demonstration project has been closely linked with the phase-out activities proposed in the HPMP for China. If proven successful, the project will provide a technology solution to replace HCFC-22 in small- and medium-sized ICR equipment with refrigerant charge below 200 mt. The technology has never been tested in an Article 5 country and will provide a viable alternative with zero ODP, low-GWP and improved energy efficiency for small- and medium-sized refrigeration applications, including supermarket and cold-chain stores. The IPR for compressor design insisted by the beneficiary enterprise could be a barrier for technology dissemination.

³⁹ Through decision 74/21(c), bilateral and implementing agencies were requested to rationalize the costs of the demonstration projects to enable the approval of a larger number of demonstration projects under the available funding of US \$10 million, in line with decision 72/40, and to further explore other sources of additional funding.

RECOMMENDATION

366. The Executive Committee may wish to consider:

- (a) The demonstration project for ammonia (NH₃) semi-hermetic frequency convertible screw refrigeration compression units in the industrial and commercial refrigeration industry at Fujian Snowman Co., Ltd., in the context of its discussion on proposals for demonstration projects for low-GWP alternatives to HCFCs as described in the document on the Overview of issues identified during project review (UNEP/OzL.Pro/ExCom/76/12);
 - (b) Approving demonstration project for ammonia (NH₃) semi-hermetic frequency convertible screw refrigeration compression units in the industrial and commercial refrigeration industry at Fujian Snowman Co., Ltd., in the amount of US \$1,097,931, plus agency support costs of US \$76,855 for UNDP in line with decision 72/40; and
 - (c) Urging the Government of China and UNDP to complete the project as planned in 18 months, and submitting a comprehensive final report soon after project completion.
-

Annex I

76th Meeting of the Executive Committee for the Implementation of the Montreal Protocol

**MULTILATERAL FUND FOR THE IMPLEMENTATION OF THE
MONTREAL PROTOCOL ON SUBSTANCES THAT DEplete THE OZONE LAYER**

PROJECT COVER SHEET - NON-MULTI-YEAR INVESTMENT PROJECTS

COUNTRY: CHINA

PROJECT TITLE:

Demonstration Project for Ammonia Semi-hermetic Frequency Convertible Screw Refrigeration Compression Unit in the Industrial and Commercial Refrigeration Industry at Fujian Snowman Co., Ltd.

IMPLEMENTING AGENCY:

UNDP

PROJECT DATA

Sector:	Industrial and Commercial Refrigeration and Air Conditioning (ICR)		
Sub-sector:	Commercial and Industrial Refrigeration and Freezing Equipment		
ODS use in sector (2013* metric tonnes):			40,805
Project impact (metric tonnes):			382
Project duration:			18 months
Project Costs:	Incremental Capital Costs(including contingencies):	US\$	1,917,269
	Incremental Operating Costs:	US\$	0
	Total Costs:	US\$	1,917,269
Local ownership:			100%
Exports to non-A5 countries:			0%
Request grant		US\$	1,097,931
Counterpart fund		US\$	819,338
Cost-effectiveness (US\$/kg-ODS):			
Implementing agency support costs:		US\$	76,856
Total Cost to Multilateral Fund:		US\$	1,174,787
Status of counterpart funding (Yes/No):			Yes
Project monitoring milestones included (Yes/No):			Yes

**Preliminary data based on ongoing surveys*

PROJECT SUMMARY

This demonstration project, upon successful completion, will establish the suitability of ammonia semi-hermetic frequency convertible screw refrigeration compression unit with the secondary refrigerant of carbon dioxide, as a viable replacement for HCFC-22 technology in the integrated coolant refrigeration systems for commercial and industrial applications at Fujian Snowman Co., Ltd.

The project will cover product redesign and development, prototype production of ammonia semi-hermetic frequency convertible screw refrigeration compression unit, testing and performance evaluation, prototype testing, training and market promotion.

If successful, the demonstration project will contribute towards promotion of this technology for replacing HCFC-22 based refrigeration systems in cold storage and freezing applications and enable cost-effective conversions at other similar manufacturers in this sub-sector.

Further actions on the production lines conversion will be implemented under ICR HPMP based on the successful demonstration of the technology.

Prepared by: UNDP in consultation with FECO and industry

Date: March 2016

PROJECT OF THE GOVERNMENT OF PEOPLES REPUBLIC OF CHINA
Demonstration Project for Ammonia Semi-hermetic Frequency Convertible Screw Refrigeration
Compression Unit in the Industrial and Commercial Refrigeration Industry at Fujian Snowman Co., Ltd.

Objective

The objective of this proposed demonstration project is to establish the suitability of ammonia semi-hermetic frequency convertible screw refrigeration compression unit as a viable replacement for HCFC-22 technology in the manufacture of systems for commercial and industrial applications at Fujian Snowman Co. Ltd.

Sector Background

The Industrial and Commercial Refrigeration and Air Conditioning (ICR) Sector in China has experienced remarkable growth in the past two decades, averaging at about 12% annually, due to the steep growth in the demand for consumer, commercial and industrial products, resulting from rapid overall economic development. This sector is categorized into several sub-sectors, namely: compressors, condensing units, small-sized air-source chillers/heat pumps, commercial and industrial chillers/heat pumps, heat pump water heaters, unitary commercial air conditioners, multi-connected commercial air conditioners, commercial and industrial refrigeration and freezing equipment, mobile refrigeration and air conditioning equipment and refrigeration and air conditioning components and parts. The 2014 estimated HCFC consumption in the sector based on ongoing surveys was about 40,805 metric tons, 98% of that HCFC is HCFC-22.

With the recent changes in Chinese people's lifestyle, the market of frozen food and cool processing is growing very rapidly. Furthermore, with the development of national economy, the petrochemical industry, energy development and other fields are also developing rapidly, bringing more market demand. Bio-pharmaceuticals, mine freezing, hydropower dams, etc. in the field of CBM liquefaction industry refrigerated equipment are also expanding. In recent years, the refrigerated equipment is increasing at the average speed of more than 10%. The majority of refrigeration equipment manufacturing enterprises are small and medium enterprises. According to survey by the industrial association, HCFC-22 refrigerant consumption for refrigeration equipment (including condensing units) level is about 4,000 metric tons annually.

Refrigeration equipment is regarded as one important end-user as stated in Sector Plans for Phase-out of HCFCs in the Industrial and Commercial Refrigeration and Air conditioning Sector in China and it includes food display case, transport refrigeration, icemaker, quick freezers, cold store, refrigerated warehouse, beverage cooling equipment, etc. The main end users are supermarkets, shops, air conditioned refrigeration warehouses, restaurants, food distributors, kitchens of hotel, food process plants, etc. These systems are all medium and small industrial and commercial system which uses HCFC-22 as one important refrigerant. The amount of HCFC consumption is above 25% of ODS consumption. The refrigerant substitute is important for these field products. So the new core technology developed for medium and small industrial and commercial refrigeration is useful for ODS substitute.

Alternative Technology

The following factors need to be considered for selection of the alternative technology:

Technical factors

- Processing characteristics
- Functionality in end-product
- Proven and mature technology
- Energy efficiency

Commercial factors

- Cost-effectiveness
- Reliable availability

Health and safety factors

- Low risk for occupational health
- Low risk for physical safety (flammability, etc.)

Environmental factors

- Direct ozone impacts
- Direct and indirect climate impacts

Some of the zero-ODP alternatives to HCFC-22 currently available for this application are listed below:

Substance	GWP	Application	Remark
Ammonia	0	Industrial refrigeration and process chillers	Flammability and toxicity issues. Material compatibility issues. Regulatory issues.
CO ₂	1	Refrigeration in a secondary loop and in stationary and mobile air conditioning systems, heat pump water heater systems	Major redesign of system components needed. Investment costs are prohibitive
R-404A	3,260	Low temperature applications	High GWP, less efficient at medium temperatures, synthetic lubricants needed

R-404A has high GWP and requires synthetic lubricants, although its thermodynamic properties are suitable for low-temperature applications. Its long-term sustainability from an environmental perspective is considered doubtful.

Ammonia is a traditional natural refrigerant with good environment properties as well as favorable thermodynamic properties. The operating pressures are low. It has low flow resistance and has excellent heat transfer characteristics. Being a single substance, it is chemically stable. It has high refrigeration capacity. It is widely available at affordable prices. However, ammonia is quite reactive; it is toxic and moderately flammable. It is also not compatible with non-ferrous materials.

CO₂ was a commonly used refrigerant in the late 19th and early 20th centuries, however, its use gradually faded out. CO₂ has many favorable characteristics. It has no ODP and GWP of 1; it is inert, non-toxic and chemically stable, is compatible with almost all materials and available widely at affordable prices. For a given refrigeration capacity, the system components with CO₂ are much smaller compared to other refrigerants. However, the main disadvantage with CO₂ is its high operating pressures, which requires special designs for the system and components. CO₂ is also not very efficient at high ambient temperatures.

Fujian Snowman Co. Ltd. has selected ammonia semi-hermetic frequency convertible screw refrigeration compression unit with CO₂ in its design as the technology of choice for its low-temperature coolant integrated refrigeration systems, considering the favorable environmental and thermodynamic properties of these two refrigerant alternatives.

In this project, the main work is about the integrated refrigeration system which used ammonia as refrigeration. One advantage of this system is the ammonia semi-hermetic frequency convertible screw refrigeration compressor used in refrigeration unit which can make the charge is less than 50kg. It is important for the applications in supermarket. The other advantage of this system is the CO₂ as the secondary fluid used in this system. Because of the CO₂ has more cooling capacity carriage and good fluid parameter. The whole system is designed for one refrigeration cycle which is not the same as the cascade system which has two refrigeration cycles.

Enterprise Background

Fujian Snowman Co., Ltd. was established in March 2000, with a registered capital of RMB 600 million. The headquarter is located in MinJiang Industrial Zone, Fuzhou, Fujian Province, and the company covers an area of 300 acres in Binhai and Liren new industrial park of Changle City. The company has developed into the largest professional manufacturer of ice-making system, and it became a professional high-tech enterprise integrated with R&D, designing, manufacturing, sales and engineering unit installation of compressors, ice-making equipment,

cooling water equipment, ice storage system and cooling system. The products are widely used in cold-chain logistics, food processing, ice storage cooling, mine cooling, nuclear power plant construction, water conservancy and hydropower and other fields.

Ice making machine: Fujian Snowman owns more than 100 exclusive patents with proprietary intellectual property rights. It has developed more than 40 types of products, especially the ice making machine sales ranks at top in China.

Screw refrigeration compressor units: The company has developed dozens of new type of high efficiency and energy saving screw refrigeration compressor, its technology has reached the international advanced level.

Compressor manufacture: Packaged systems with open (NH₃), semi-hermetic (HCFC-22) and hermetic screw compressors (HCFC-22) and also reciprocating compressors (HCFC-22). The enterprise has two famous brands of compressor, which are SRM and RefComp.

Industrial refrigeration systems: Fujian Snowman Co., Ltd. is one of the largest manufacturers of integrated industrial refrigeration systems, such as large capacity brine chillers, ice makers, etc. based on screw compressors, with a 40-60% market share.

Fujian Snowman Co., Ltd. is committed to technology innovation, focusing on environment protection, energy efficiency and safety. Over 30-40% of its refrigeration products use natural refrigerants.

In 2015 Fujian Snowman Co. Ltd. manufactured the following HCFC-22 based integrated refrigeration systems:

No	Product Line	Evaporating temperature (°C)	Quantity (Nos.)	HCFC consumption (metric tons)
1	Water Chillers	-5 to +3	50	N/A
2	Ice maker	-30 to -15	400	23
3	Brine Chillers	-40 to 3	11	N/A
4	Ice storage system	-18 to -5	20	1

Rationale for Technology Demonstration

In China, presently, the refrigerated equipment of large quantity of ammonia (usually more than hundreds of MTs) is used far away from more densely populated areas. According Chinese law and regulations, large ammonia based systems (more than 100 kg) are not allowed in the densely populated areas. Therefore, the refrigeration equipment that is used in densely populated sized is mainly used HCFC-22 as a refrigerant. For example, each of the quick freezers, cold stores, refrigerated warehouses in the sub-sector uses up to dozens to hundred kilogram HCFCs; this can be substituted with less than 50kg ammonia in the new refrigeration system. Food display case, cold store, beverage cooling equipment, etc. in the supermarket is one main target of the demonstration project.

The development of NH₃ semi-hermetic screw refrigeration compressors with less than 50kg ammonia which, to our knowledge, is the first commercialized prototype system in the world. Development of this system will make it possible for medium and small sized refrigerated equipment based on ammonia to be used in the densely-populated area, which will gradually reduce the use of HCFC-22. Based on the redesign and production of semi-hermetic compressor, the prototype of whole system can be constructed for the applications in China which can be applied internationally with the technology perfected.

As stated earlier, future market demand in China for food processing and related technologies and for industrial refrigeration is promising. The best operating evaporation temperature bracket for NH₃ refrigeration system is above -35, and this is the normal range for medium and small-scale low-temperature industrial refrigeration applications. Especially, these refrigeration applications use not large units. The investment of cascade has not been high in the country. Thus, one stage NH₃ system that use CO₂ as the secondary refrigerant, can replace HCFC-22 in many applications, which have significant growth potential in the future. The designed system is not the same as the cascade system. One difference is the production system is one refrigeration cycle, but the cascade system has two refrigeration cycles which means it should has two compressors. The investment and operation

cost of cascade system is higher than system designed here because of the cascade system is bigger, which can only be used in bigger applications, e.g., storehouse and huge supermarket, which, in most of the cases, are located in suburban area with sparsely population. The system demonstrated in this project, with very low charging amount, can be used in small system located in crowded area, e.g., 7-11. The other difference is the operation temperature is not the same. The cascade system can get the lowest temperature for the frozen storage. The third difference is the CO₂ as different working fluid. In cascade system, CO₂ is a refrigerant which will have phase change in condenser and evaporator. In ammonia integrated system, CO₂ is secondary refrigerant which has no phase change just carry the cooling capacity to the application field.

Furthermore, most of the large-scale low-temperature refrigeration systems use open-type compressors and open system design, with a significant amount of leakage and low recovery rate of refrigerant during maintenance, thus annual consumption of HCFCs in servicing for such systems is very high. Thus, replacing HCFCs in such applications gains high priority from an environmental standpoint.

While NH₃ semi-hermetic frequency convertible screw refrigeration compression unit has been implemented elsewhere, its application has been sporadic and mainly focused on site-assembled custom-built legacy systems and not on a commercial production scale. China, in general and Fujian Snowman Co. Ltd. in particular, offers an opportunity for standardizing this technology on a commercial scale. This is because Fujian Snowman Co., Ltd. manufactures integrated low-temperature refrigeration systems. Standardizing this technology in a factory-controlled environment will favor its widespread adoption considering the future growth prospects for its application. Thus, demonstration of this technology is considered critical for its early adoption and consequent dissemination of its technical performance. This will contribute to sustainable reductions in HCFC consumption as well as to contribute to protecting the climate system.

Project Description

Fujian Snowman Co., Ltd. specializes in the manufacture of integrated packaged refrigeration systems incorporating twin-screw refrigeration compressors, of open (NH₃) and semi-hermetic (HCFC-22) designs. Nowadays, the charge of NH₃ open twin-screw compressor integrated package refrigeration system is more than 100kg, which are forbidden to use in more densely populated areas by the government. The purpose of this demonstration project is to demonstrate the small system with lower NH₃ charging amount with CO₂ as a secondary refrigerant. The product will be redesigned and constructed to fit the small discharge semi-hermetic frequency convertible screw refrigeration compression unit. In order to expand the application of NH₃ in small and medium industrial and commercial refrigeration field, the type of NH₃ compressor will be changed to semi-hermetic. Considering the requirements of the standards, including the building codes, and the safety, CO₂ will be used as the secondary refrigerant. So, the present demonstration project will cover low-temperature (evaporating temperature above -35) applications, where the current HCFC-22 based designs will be replaced by NH₃ refrigeration system technology, using ammonia semi-hermetic frequency convertible screw refrigeration compression unit.

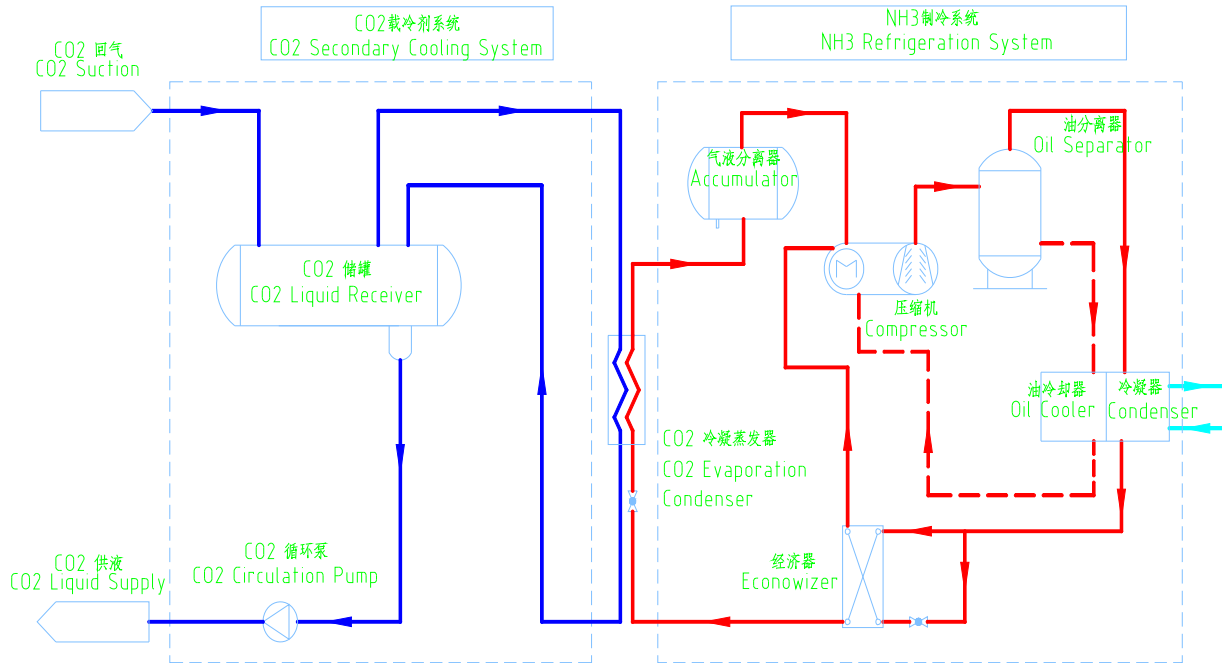
Introduction

The cold storages in China are mostly designed as Direct Expansion coil units where refrigerant is directly circulated in evaporator coil(s) which evaporates and absorbs heat in the fan coil unit. This type of units require large quantity of charge in the system

In order to reduce the quantity of charge in the integrated refrigeration system which can be allowed to be used in cold storage just like supermarket etc, the first step is redesigning and producing the ammonia semi-hermetic frequency convertible screw refrigeration compressor. Then, the refrigeration system would be designed and developed as following type unit: NH₃ as the refrigerant, and CO₂ as heat transfer fluid (which means the secondary refrigerant) to be the alternative solution of HCFC-22 refrigerant in the medium and small freezing and cooling storages. The charge of refrigeration system is less than 50kg, which is safety for some applications. Units of three different sizes will be developed in this project.

Under this demonstration project, in order to produce the new type of compressor that is ammonia semi-hermetic frequency convertible screw refrigeration compressor with ammonia charge less than 50kg. The key components are as following: new compressors design, the new heat exchanger design, construction of compression unit, Manufacturing of prototypes, construction of test device.

As the new production of NH₃ refrigeration system, the relevant schematic diagram is as below:



This system through the development of ammonia semi-hermetic frequency convertible screw compression unit which suits for medium and small freezing and cooling storages, using NH₃ as the refrigerant and CO₂ as secondary refrigerant (heat transfer fluid), would not only phase-out HCFC-22 refrigerant and the reduced NH₃ charge volume (much less than 50kg) in refrigeration system, but also eliminate presence NH₃ in the cold storage side by using CO₂ as carrier (heat transfer fluid) and guarantee the safety of cold storage operation.

Current status of technology development

Fujian Snowman Co., Ltd. has carried out initial development of NH₃ refrigeration systems with semi-hermetic frequency convertible screw compressor for medium and small commercial refrigeration and medium industrial refrigeration applications (the refrigerant quantity is less than 50kg.), with a view to offer factory-manufactured integrated systems. The current status is as below:

- The semi-hermetic frequency convertible screw compressors are specially designed with the advantages of small size, light weight, smooth and safe operation at high speed. It can obtain high volumetric efficiency, low noise and little vibration. The capacity control from 15% to 100% of the capacity can be achieved.
- Oil separator with indigenous design is adopted. The separator has the advantage of efficient separation, which reduces oil content within the carrier refrigeration system. This gives full play to heat exchanger efficiency to ensure highly efficient operation of the refrigeration system.
- Intelligent and automatic controls have been adopted for the carrier (heat transfer fluid) refrigeration system, which can respond automatically to load changes and external conditions. Remote computerized monitoring system is employed. The refrigeration system has complete security protection devices and functions.

Feasibility

While the design of the NH₃ compression refrigeration system is based on conventional principles, the key elements in its operationalization and commercialization are the innovations needed to make the systems efficient, as well as to make them reliable by integrating system components optimally and manufacturing the integrated system in a factory-controlled environment. The present demonstration project will enable wider adoption of standardized, efficient and reliable factory-manufactured integrated medium and small NH₃ refrigeration systems.

Project activities

For the demonstration project, to achieve this goal, the following activities will be carried out: Product and process redesign, construction of test devices for product performance, Manufacturing of prototypes and Personnel training. After the modification, technology dissemination and documentation of the results would be carried out.

Product and process design

At present, the main product of the enterprise is the conventional refrigeration system with HCFC-22 as the refrigerant. There is large difference in product design and production process between NH₃ refrigeration systems with semi-hermetic frequency convertible screw compressor and HCFC-22 based refrigeration systems. To meet this need, the following design will be needed based on production process: three specifications of NH₃ screw compression unit, The main design works as follows: profile design of screw rotor, electrical motor design, compressor design, working drawings and related design assessment and review; The design of ammonia semi-hermetic frequency convertible screw compressor, and the design of special motor for the ammonia semi-hermetic frequency convertible screw compressors, design of test devices for NH₃ refrigeration compression system, design of user demonstrations for the early users of NH₃ refrigeration systems.

The three specifications of NH₃/CO₂ screw compression units for the project are as below:

Model	Theoretical displacement (m³/hr)	NH₃ charge (kg)	CO₂ charge	HCFC-22 substitute(kg)	Status
SSSCA50 (SRS-12L)	262	17	30	75	To be developed
SSSCA210 (SRS-1612LM)	652	48	60	194	To be developed
SSSCA60 (SRS-1008L)	221	22	35	90	To be developed

** Please note that Ammonia charge in the system is less than 50 kg.*

All of the above would be covered in the current project. The design elements would comprise of the following

- The design of ammonia semi-hermetic frequency convertible screw compressor;
- The design of special motor for the ammonia semi-hermetic frequency convertible screw compressors;
- The design of NH₃ related pressure vessel screw frequency convertible compressors;
- The design of NH₃ system of screw frequency convertible compressors unit;
- Electrical control;
- The applied controlling software design.

The process design would comprise of the following:

- Pressure Vessel Manufacturing Process Design
- Forming of pressure vessels, welding process design
- Reconstruction design of container strength test device
- Compression Unit Assembly Manufacturing Process Design
- Compression unit production process design
- Forming, welding process design
- Forming, welding and other process equipment design
- Assembly process, tooling design

- Electrical Control System Manufacturing Process Design
- Electrical control system production process design

Construction of test devices for product performance

As a new refrigeration system, the NH₃ system cannot be tested in the existing performance test laboratory after product commercialization. Further, the product test device of the medium and small NH₃ refrigeration system requires new facility construction. The test devices of NH₃ semi-hermetic compressor housing strength and air load are to be added. In addition the following additions need to be done:

- Pressure vessel strength testing device
- NH₃/CO₂ compression unit performance test equipment
- Assessment of the test device by national professional agency

Manufacturing of prototypes

According to the industrialization requirement of the NH₃ refrigeration system, three specifications of refrigeration systems need to be developed. Before commercialization, the prototype of refrigeration system needs to be manufactured and tested before mass production. As processing parts are numerous and processing precision is strict, the waste rate from casting to completion is very high. Hence, three sets of rough parts need to be produced for each compressor size. One set of rough parts need to be manufactured for other auxiliary equipment. The prototype manufacturing will cover the following:

- Manufacture nine sets of NH₃ semi-hermetic screw compressor prototypes for each specification of SSSCA50(NH₃ 17kg) SSSCA210 (NH₃48kg) and SSSCA60 (NH₃ 22kg)
- Manufacture one set of component matching with the coolant system for each specification.
- Refrigeration system prototype assembly.
- Experimental test on refrigeration system prototypes.

Personnel Training

The design, production, marketing and debugging of the new product are different from those of the conventional refrigeration system. Therefore, business unit training is needed for all sections of the project. The following personnel will be included in the training:

- Related designers, technicians.
- Production management persons, manufacturing workers.
- Product application engineer.
- Technician for installation and debugging, equipment maintenance personnel.
- Related user operators, equipment administrative personnel.

Technology Dissemination

According to user's requirements, design of the first demonstration application engineering for NH₃ refrigeration system with ammonia semi-hermetic frequency convertible screw refrigeration compressor will include scheme compilation, construction drawing design, details compilation of construction materials, instructions of installation and construction, instructions of debug operation.

Market promotion is needed for new technology entry in the market. A detailed work plan is needed in the market promotion as NH₃ refrigeration system with ammonia semi-hermetic frequency convertible screw refrigeration compressor is new to domestic refrigeration industry. The following methods will be used to promote the technology:

- Technical communication with engineering design companies, introduction of product, and promotion and recommendation plan.
- Technical communication with construction companies, product promotion and recommendation, and application technology.
- Application promotion in relevant industry associations.
- Organize product release conference, and display product and application technology.
- Communicate with government environmental protection departments to enhance publicity campaign.
- Advertisement and promotional brochures.
- Participate in exhibitions, such as International Refrigeration Exhibition in China, Chinese Fisheries Exposition, and Chinese Food Processing Exposition; display the product and application technology.
- Provide free technology, debug and maintenance to users of the demonstration project.

Summary

The conversion will be carried out in close consultation with FECO/MEP, industry associations, scientific and technical institutions and the special working group for the ICR sector.

Project Costs

The total project cost amounts to US\$1,917,269. Details are provided in Annex I. Considering ExCom decision 72/40(b), decision 73/27 and other related decisions, the MLF support for the demonstration projects is not enough. Therefore, the enterprise component would be added to bear the remaining cost for the demonstration project as the counterpart fund, which amounts to US\$ 819,338.

Financing

The requested MLF grant is US\$ 1,097,931, which represents eligible incremental costs, without agency support costs.

Implementation

Project Monitoring Milestones

The project milestones and timelines from the date of receipt of funds is given in the table below.

MILESTONE/MONTHS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Start-up of project activities	X																	
Submission of project document for signature	X	X																
Project document signature		X	X															
Preparation and request for bids			X	X														
Award of contracts				X	X	X												
System design and compressor design	X	X	X	X	X	X	X	X										
Stainless vessel processing equipment	X	X	X	X														
Design of testing lab and procurement of material	X	X	X	X														
Processing of casting model and boxes for compressor parts					X	X	X	X										
Installation of testing equipment					X	X	X	X										
Processing of vessel parts for testing equipment					X	X	X	X										
Prototype manufacturing of compressors					X	X	X	X										
System drawings									X	X	X	X						
Fixtures and cutters for NH ₃ compressor									X	X	X	X						
Conversion for Fin-tube processing									X	X	X	X						
Installation and tuning of testing equipment									X	X	X	X						
Assembly of compressors									X	X	X	X						
Retrofitting of testing device for NH ₃ compressor													X	X	X	X		
Verification of testing lab													X	X	X	X		
Completing the prototype system													X	X	X	X		
Market survey and obtaining the certificates																	X	X
Installing air load testing equipment																	X	X
Training and technical assistance																	X	X
Verification																	X	X

Payment Schedule

The following table presents the proposed performance based payment schedule including the counterpart contribution for the project.

Schedule (Predicted date)	Payment Conditions	Amount (US\$)	Accumulated Amount (US\$)
1 st Payment (contract signature)	Upon signing of the contract	329,379	329,379
2 nd Payment (seven months after the contract signature)	Completion of equipment for NH ₃ system	329,379	658,759
3 rd Payment (fourteen months after the contract signature)	Completion of prototype building, and completion of testing equipment	219,586	878,345
4 th Payment (eighteen months after the contract signature)	Completion of training, technology dissemination, and verification of project	219,586	1,097,931

Management

The project will be under the overall management and coordination of the Foreign Economic Cooperation Office, Ministry of Environmental Protection of China. UNDP will be the implementing agency for the project, which will provide international coordination and technical assistance as needed.

The project employs the Performance-based Payment (PBP) mechanism in its implementation. Under the PBP mechanism, the enterprise tasked to carry out the conversion would play the role as a key executor, which is responsible for all the activities related to the conversion (with supervision of the technical expertise team hired by FECO and/or UNDP), including but not limited to: product redesign, procurement of raw material, components, equipment and consulting services as per the budget allocation table, construction product testing devices, etc., and project technical commissioning. The procurement shall be organized fully in line with the marketing principle, so that the goods and services procured are high quality, most reasonable price and suitable for product line conversion to make sure the new alternative technology applied feasibly and successfully. The detailed arrangement on procurement will be defined in the contract between FECO/MEP and the Executor (enterprises).

FECO and UNDP will not be involved in the procurement activities of the enterprise by any means other than make payment to the enterprise in tranches for the costs of procurement and conversion, at agreed payment dates given in the payment schedule, and when milestones prerequisite for the tranche have all been achieved on time.

Verification

- 1) **Periodical Performance Verification.** Before each payment, FECO will invite independent experts to verify whether the performance for each milestone that the payment depends on have been satisfying. The verification reports will be submitted and accepted by UNDP as the main supporting documents for requesting the installment of payment.
- 2) **Technical Assessment.** Before the last installment of payment, FECO and UNDP will invite independent experts to verify whether the selection and application of alternatives in practice are suitable and feasible. The assessment report will be submitted to FECO and UNDP.

M&E

- 1) FECO and UNDP will organize a joint Monitoring and Evaluation mission to the Project executor during this project operation. The mission can be combined with the verification mission accordingly. The M&E schedule will basically follow the timeline of payment schedule.
- 2) NEX Audit will be organized by UNDP during the project implementation upon UNDP's audit arrangement in the project years. For any issue identified during the auditing process, FECO shall take corresponding correction/improvement measures as per the audit findings and recommendation. Meanwhile, the payment may be suspended depending on the nature of the issues concerned until the acceptable/satisfactory results are worked out.
- 3) Quarterly Review and Annual Review Meeting will be organized by FECO; Semi-annual Project Review Reports and a final Project Report will be submitted to UNDP at least 10 days before the review meetings and by the end of project operation in 2016.

Impact

The successful implementation of this demonstration project will provide the demonstration of an environmentally safe and cost-effective alternative for enabling replication of this technology in similar

applications in this sector in China and facilitate HCFC reductions for compliance with the future HCFC control targets.

Following the system demonstration, the product lines of the R22 compressor and compression unit will be considered to be converted to NH₃, which will result in production of new technology based products at production capacity of 3,000 units annually and thus will result in reductions of 359 metric tons of HCFC-22 usage at Fujian Snowman Co. Ltd. (see Annex II). Furthermore, over a 15-year life-span of the refrigeration systems manufactured by the enterprise, the consumption of HCFCs for servicing of those systems is expected to be 226.16 metric tons in the life cycle. The total GHG emission reductions will amount to about 1,041,602.60 CO₂-eq tones, thus contributing to protection of both the ozone layer and the climate.

ANNEX-I

Incremental Cost Calculations

No	Cost Head	Amount	MLF requested	Co-financing	
1	Product and process design	System design	147,730	147,730	-
		Process design	44,319	44,319	-
		Compressor design	156,495	-	156,495
		Heat exchange analysis software	78,247	58,247	20,000
2	Compression unit performance test device construction	Electric leakage detector	3,130	-	3,130
		Detector	4,695	-	4,695
		Helium detector	66,041	-	66,041
		Compression unit performance test equipment	438,184	398,184	40,000
3	Material for the prototype production	Pressure vessel strength test device	187,973	-	187,973
		NH ₃ compressor	295,775	295,775	-
		NH ₃ oil separator	28,169	26,169	2,000
		CO ₂ liquid-storage tank	56,338	54,338	2,000
		Heat exchanger	21,127	-	21,127
		Starting cabinet (inverter)	42,254	-	42,254
		Electric control cabinet	4,695	-	4,695
		Valve parts, pipe, flanges	31,299	-	31,299
		Metal hose (testing)	9,390	-	9,390
		CO ₂ Pump	28,169	23,169	5,000
		CO ₂ (0.9999)	56,338	-	56,338
		NH ₃	2,034	-	2,034
		Frozen Oil	1,095	-	1,095
		Helium	3,443	-	3,443
Nitrogen	235	-	235		
4	Training	Training on process and product design	117,762	50,000	67,762
		Welder training	7,825	-	7,825
		Material fee	7,825	-	7,825
5	Market Promotion	Market Promotion	76,682	-	76,682
		Total	1,917,269	1,097,931	819,338

ANNEX-II

Subsequent Actions:

Ammonia Semi-hermetic Frequency Convertible Screw Refrigeration Compressor Production Line Conversion at Fujian Snowman Co., Ltd

Objective

Based on the demonstration project which is designed to demonstrate and establish the suitability of ammonia semi-hermetic frequency convertible screw refrigeration compressor unit as a viable replacement for HCFC-22 technology and for commercialization of the unit, the capacity of the compressor and compression unit manufacturing will be set up through the following activities namely (a) product line modification and construction, and (b) testing device modification and construction, as well as training at Fujian Snowman Co. Ltd.

It must be noted that this incremental activities that are necessary for commercialization would be implemented as a part of HPMP project and do not form a part of the demonstration project. This implementation structure is adopted so that we can use the demonstration results and develop the project for commercialization.

Project Description

In order to produce the small discharge semi-hermetic frequency convertible screw refrigeration compression unit, the production line will be redesigned, modified and constructed to fit the small discharge semi-hermetic frequency convertible screw refrigeration compressor and compression unit. With the prototype production, safety protection articles and training are needed for manufacturing personnel.

Project activities

The existing product lines of compressor and pressure vessels will be modified to meet the industrial production capacity of three typical specifications of NH₃ refrigeration systems. To achieve this goal, the following activities will be carried out:

- modification and construction of production lines,
- modification and construction of the test devices,
- personnel training and documentation, and
- market promotion.

Design and modification of production line

The low temperature and small refrigerant charge NH₃ refrigeration system is the new product of Fujian Snowman Co., Ltd. The existing production lines cannot all be used for producing NH₃ system components such as semi-hermetic frequency convertible screw compressor, pressure vessel and heat exchanger.

1. Modification of compressor production line

- Modification and construction of the existing manufacturing lines of the NH₃ compressors including rough castings production, rotor machining, housing processing, house strength test, the compressor assembly for the semi-hermetic screw compressor.
- The investment on special process equipment is made for the three specifications NH₃ semi-hermetic screw compressor, including compressor model, fixture and special inspection gauge of the rotor profiles.
- High-strength processing tool is needed because NH₃ compressor housing material, rotor profiles and material, and all components materials are different from conventional products.
- The airtight device is needed to test the compressor in order to decrease the leakage.

2. Modification of compression unit production line

- Pipe processing equipment, wedding tool and grinding tool is needed because NH₃ compression unit is different from the conventional products.

3. Modification of pressure vessel production line

The modification and construction of product line for pressure vessels will include the following:

- Modification and construction of the existing manufacturing lines of the pressure vessels below the pressure of 20kg, including production process link of the added high-pressure low-temperature CO₂ pressure vessel, tube processing and welding for tube expander, welding and assembly for CO₂ evaporator, because CO₂ is as secondary refrigerant;
- Modification of process equipment and controls for production and testing. The materials for the CO₂ pressure vessels of high-pressure low-temperature are different from the conventional components materials. Therefore, the corresponding process equipment and control need to be added during production and test process, such as welding, expanding joint and inspection.
- Modification of testing equipment. The strength test and air tightness test are needed for the high-pressure low-temperature pressure vessel. Welding equipment of stainless steel container and high-pressure low-temperature vessel will be added, as well as welding test plate and assessment method of high-pressure low-temperature vessel.

4. Modification of heat exchanger production line

- Modification and construction of manufacturing line for the existing 14 kg fan heat exchanger, including processing of CO₂ fin heat exchanger, shell sheet metal processing, expansion joint, welding, strength and air tightness testing;
- Additional unit assembly of NH₃ refrigeration system with twin screw compressors, including the assembly of NH₃ refrigeration system and test of the air load factory;

Construction of test devices for product performance

As a new refrigeration system, the NH₃ system cannot be tested in the existing performance test laboratory after product commercialization. Further, the product test device of the medium and small NH₃ refrigeration system requires new facility construction. The test devices of NH₃ semi-hermetic compressor housing strength and air load are to be added. In addition, compression testing device needs to be added.

Personnel Training

The design, production, marketing and debugging of the new product are different from those of the conventional refrigeration system. Therefore, business unit training is needed for all sections of the project. The following personnel will be included in the training:

- Related designers, technicians.
- Production management persons, manufacturing workers.
- Product application engineer.
- Technician for installation and debugging, equipment maintenance personnel.
- Related user operators, equipment administrative personnel.

Project Cost

The total incremental capital costs amount to US\$1,262,481. Details are provided as follows:

No	Cost Head		Amount (US\$)
1	Modification of production lines		725,313
	Compressor (US\$ 568,859)	Mechanical processing cutting tool (US\$ 62,598)	
		Shockproof boring bar (US\$ 62,598)	
		High-precision hydraulic chuck (US\$ 62,598)	
		Another cutting tool (US\$ 31,299)	
		Machining tooling (US\$ 93,897)	
		Rotor milling cutter (US\$ 70,423)	
		Ammonia Motor mould (US\$ 70,423)	
		Vacuum equipment (US\$ 28,951)	
		Airtight device (US\$ 86,072)	
	Compression Unit (US\$ 156,454)	Pipe processing equipment and grinding tool (US\$ 78,247)	
Auxiliary fixture tool(US\$ 23,474)			
Welding equipment (US\$ 54,733)			
2	Test device construction		312,989
Compressor performance test(US\$ 312,989)	Compressor performance test equipment (US\$ 312,989)		
3	Manufacturing of prototype		106,417
	Test labor fee and some test cost (US\$ 106,417)	Installation and test labor fee(US\$ 70,423)	
		Safety protection articles (US\$ 28,169)	
NDT testing costs (US\$ 7,825)			
4	Personnel training		117,762
	Training (US\$ 117,762)	Training (US\$ 117,762)	
Total			1,262,481

Financing

The conversion project will be implemented under the HCFC Phase-out Management Plan in Industrial and Commercial Refrigeration and Air-conditioning Sector in China (Stage I or Stage II). The cost will be determined according to the rules of the HPMP.