SIGNATURE PAGE

Country: China

Project Title: Demonstration Project for Conversion from HCFC-22 Technology to HFC-32 Technology in the Manufacture of Small-sized commercial air-source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd

UNDAF Outcome(s): Key UN conventions promoted; capacity improved fulfill their Obligations

Expected CP Outcome(s): Strengthened national capacity and empowerment of local Stakeholders in environmental management; successful phase out of Ozone-depleting substances being used by enterprises in various Industrial sectors

Expected CP Output(s): Policy makers and general public engaged to support UN conventions Implementation

Implementing partner: Ministry of Environmental Protection

Brief Description

This demonstration project, upon successful completion, will establish the suitability of HFC-32 technology as a viable replacement for HCFC-22 as a refrigerant in the manufacture of commercial air-source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd. The demonstration project will cover product redesign and development, manufacturing equipment modifications and additional equipment, safety and other measures to handle the flammability and high discharge temperatures with HFC-32, laboratory testing and performance evaluation, product trials, prototype testing, production line conversion, technical assistance and training.

If successful, the demonstration project will contribute towards promotion of this technology for unitary and multi-connected commercial air conditioning and heat pump equipment and enable cost-effective conversions at other similar manufacturers in this sub-sector.

Programme Period:	Jau 2011- Jun 2012
Programme Component:	Energy & Environment
Intervention Title:	HCFC phase out in ICR (Tsinghua Tong Fang Demonstration project)
Award ID:	00060893
Project ID:	00076876

Total resources required:	$ 1,229,336
Allocated resources:	
- Government	
- Regular	
- Donor MLF	$ 1,229,336

Agreed by (FECO/MEP): _____ Wen Wurui (Director General)

Agreed by (UNDP): _____ Subinay Nandy (Country Director)

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:	**IMPLEMENTING AGENCY:**
Demonstration project for conversion from HCFC-22 technology to HFC-32 technology in the manufacture of small-sized commercial air-source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd.	UNDP

NATIONAL COORDINATING AGENCY: Foreign Economic Cooperation Office, Ministry of Environment Protection

LATEST REPORTED CONSUMPTON DATA FOR ODS ADDRESSED IN THE PROJECT:

A. Article-7 Data (ODP Tonnes for 2008, as of March 2010):

Annex-C, Group-I substances (HCFCs)	15,387.2

B. Country Programme Sectoral Data (ODP Tonnes for 2008, as of May 2009):

Substance	**Total**
HCFC-22	9,559.6
HCFC-141b	4,415.3
HCFC-142b	1,096.1
HCFC-123	7.3
HCFC-225ca	1.7
HCFC-225cb	0.2

ODS CONSUMPTION REMAINING ELIGIBLE FOR FUNDING (ODP Tonnes) :	N/A
CURRENT YEAR BUSINESS PLAN:	Included

PROJECT DATA			
Sector:	Industrial and Commercial Refrigeration and Air Conditioning (ICR)		
Sub-sector:	Commercial Air Conditioning (chillers/heat pumps)		
ODS use in sector (2008* metric tonnes):			42,000
ODS use in sub-sector/application (2008* metric tonnes):			1,200
Project impact (metric tonnes):			61.9
Project duration:			18 months
Project Costs:	Incremental Capital Costs (including contingencies):	US$	839,996
	Incremental Operating Costs:	US$	389,340
	Total Costs:	US$	1,229,336
Local ownership:			100%
Exports to non-A5 countries:			0%
Requested grant:			**1,229,336**
Cost-effectiveness (US$/kg-ODS):			19.86
Implementing agency support costs:		US$	92,200
Total cost to Multilateral Fund:		US$	1,321,536
Status of counterpart funding (Yes/No):			Yes
Project monitoring milestones included (Yes/No):			Yes

**Preliminary estimates based on ongoing surveys.*

PROJECT SUMMARY

This demonstration project, upon successful completion, will establish the suitability of HFC-32 technology as a viable replacement for HCFC-22 as a refrigerant in the manufacture of commercial air-source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd.

The demonstration project will cover product redesign and development, manufacturing equipment modifications and additional equipment, safety and other measures to handle the flammability and high discharge temperatures with HFC-32, laboratory testing and performance evaluation, product trials, prototype testing, production line conversion, technical assistance and training.

If successful, the demonstration project will contribute towards promotion of this technology for unitary and multi-connected commercial air conditioning and heat pump equipment and enable cost-effective conversions at other similar manufacturers in this sub-sector.

Prepared by: UNDP in consultation with FECO and industry **Date:** January 2011

PROJECT OF THE GOVERNMENT OF THE PEOPLES REPUBLIC OF CHINA

Demonstration project for HFC-32 technology in the manufacture of small-sized commercial air-source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd.

Objective

The objective of this proposed demonstration project is to establish the suitability of HFC-32 technology as a viable replacement for HCFC-22 as a refrigerant in the manufacture of small-sized commercial air-source water chillers/heat pumps at Tsinghua Tong Fang Artificial Environment 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 2008 estimated HCFC consumption in the sector based on ongoing surveys was about 42,000 metric tonnes.

Small-sized commercial air-source chillers/heat pumps are typically used in commercial establishments such as hotels, restaurants, shops and offices, both for cooling and heating, with low energy consumption and no water use. The self-contained design requires no separate plant or machine room. With the current emphasis on energy conservation and environment protection, the market for these products experiences rapid growth. Based on preliminary data from ongoing surveys, the production of such small-sized air-source chillers/heat pumps in 2008 in China was about 110,000 units, with a total HCFC-22 consumption of about 1,200 metric tonnes in about 12-15 enterprises.

Enterprise Background

Tsinghua Tong Fang Artificial Environment Co. Ltd. was established in 1989 and is located in Zhongguancun Science and Technology Zone, Beijing. The enterprise is a state-owned company, specializing in research and development, manufacturing and sale of the environmental products and systems. In the air conditioning field, the company actively carries out research and development of environmental control products, green construction, energy efficiency in buildings and renewable energy technologies. The enterprise employs 554 persons, which includes 84 managerial staff and 81 technical and research staff. The enterprise has five national product inspection centers, laying the foundation for sound research and development in this field.

Over the past decade, Tsinghua Tong Fang Artificial Environment Co. Ltd., with 54 patents, has successfully developed several product lines, including air-source/water-source/ground-source heat pump units, heat pump water heaters, central-station air handling units, fan-coil units and air purifiers. The enterprise has accumulated rich experience in the development and application of heat pump products. The technology level and quality of the products manufactured by Tsinghua Tong Fang Artificial Environment Co. Ltd. are highly appreciated by consumers and other manufacturers in the industry. The low ambient temperature air-source heat pump units manufactured by the enterprise are classified at the International Leading Level by the Ministry of Construction. The range of heat pump units manufactured by Tsinghua Tong Fang Artificial Environment Co. Ltd. is also classified at Leading Level domestically. Most products manufactured by the enterprise meet or exceed the National Standard on Energy Efficiency. In 2009, the enterprise manufactured and sold 4,073 units of small-sized commercial air-source chillers/heat pumps and consumed 61.9 metric tonnes of HCFC-22.

Tsinghua Tong Fang Artificial Environment Co. Ltd. is the national leader in heat pump technology. The enterprise comprises a unique amalgam of industry, academia and research, and is abreast of the latest scientific progress on technology and environment.

The enterprise has developed its own "core technology", "core products" and "core systems" with independent intellectual property rights. Considering the market position of Tsinghua Tong Fang Artificial Environment Co. Ltd. for heat pump technology and also its excellent technical and managerial capacity, it is considered to be the appropriate candidate for carrying out a demonstration project for this application in China.

Capacity Data

Tsinghua Tong Fang Artificial Environment Co. Ltd. currently manufactures a range of heating and cooling products, with production capacity valued at about US$ 3 billion and manufactured on six production lines for various products as tabulated below:

Production Line	Products	Capacity Range	Installed Capacity	Actual production	Average refrigerant charge (kg)	HCFC-22 consumption (2009-tonnes)	Application
Water/ground source heat pumps/chillers	Water-source heat pumps	150 - 3000 kW	700 units	227	90	26.9	Heating/cooling in large buildings such as offices, malls, hotels
	Ground-source heat pumps	120 - 3000 kW		29	75		
	Chillers	400 - 2000 kW		54	80		
Large air-source heat pump/chillers	Screw	260 - 500 kW	700 units	34	75	2.55	
Medium air-source heat pump/chillers	Scroll	60 - 200 kW	1500 units	399	40	15.96	Heating/cooling in medium-sized buildings
Small air-source heat pump/chillers	Scroll	10 - 60 kW	5000 units	4073	15.2	61.9	Heating/cooling in small commercial spaces up to 1000 sqm
Air handling units	Central station air handling units	2000 to 20000 cum/hr	5000 units	NA	NA	NA	Large and medium sized buildings
Fan coil units	Various sizes	340 - 2380 cum/hr	5000 units	NA	NA	NA	Small buildings and individual spaces
Total						**107.31**	

Product Data

Of these, one production line with a capacity of 5,000 units annually (as highlighted above) is for manufacturing small-sized commercial air-source chillers/heat pumps in the range of 10 to 60 kW. This production line was installed in 1999. The total production in 2009 was 4,073 units, with HCFC-22 consumption of 61.9 metric tonnes at an average HCFC-22 charge of 15.2 kg per unit. These units are manufactured in three models/configurations as below:

	60kW	30kW	13 kW
Unit Configuration			
HCFC-22 charge (kg)	24	12	5.1

This product range (small-sized air-source heat pump/chillers) has been selected for this project considering the relative small amount of refrigerant charge volumes, allowing flexibility for selection of alternative technologies.

Production line and process data

The production line comprises of four sections; heat exchanger processing, sheet metal processing, assembly and quality inspection. The detailed description of the main baseline equipment for each of these sections is tabulated below.

Heat-exchanger processing

No	Process	Equipment	Model/type
1	Aluminum foil feeding	Roll de-coiling and feeding	ZX-J31G-63
2	Fin plate punching	High-speed finned tube punching line and tube straightening-bending machine	Custom-built
3	Fin hanging		
4	Fin threading		
5	Vertical tube expanding	Vertical tube expander	Custom-built
6	End cover installation	N/A	N/A
7	Tube bundle and u-tube brazing	Brazing equipment	N/A
8	Nitrogen testing	From tanks	N/A
9	Cleaning and finishing	Washing	N/A
10	Inspection and warehousing	N/A	N/A

Sheet-metal processing

No	Process	Equipment	Model/type
1	Blanking and cutting	CNC plate shears	MS8-6*3200
2	Punching	CNC punch	RT-300
		Deep throat punch	JH11-100
3	Plate bending	CNC plate bending machine	PRM3013
4	Riveting	TOX machine	N/A
5	Inspection	N/A	N/A

Product assembly

No	Process	Equipment	Model/type
1	Face plate laying	Assembly line	Custom-built
		Twin beam traversing crane	QD-10
2	Compressor and heat exchanger installation	N/A	N/A
3	Frame installation	N/A	N/A
4	Minor parts fabrication	3-D tube bending machine	SB-80NCMP
5	Prefabricated parts installation	N/A	N/A
6	Piping and accessories fitting	N/A	N/A
7	Distributor accessories fitting an		
8	Welding and brazing	N/A	N/A
9	Fan-motor installation	N/A	N/A
10	Nitrogen pressure testing	Tanks	N/A
11	Evacuation	Roots vacuum pumps	JZJX150
12	Refrigerant charging/recovery	Charging equipment	RC-1510
		Recovery machine	MDR2290
13	Leak testing	Halogen leak detector	H25-IR

Quality inspection, testing and finishing

No	Process	Equipment	Model/type
1	Minor structural parts fitting	N/A	N/A
2	Operating condition testing	Test rig	Custom-built
3	Product clean-up and finishing	N/A	N/A
4	Visual inspection	N/A	N/A
5	Packing and warehousing	N/A	N/A

The enterprise has been proactive on corporate social responsibility, including environmental impacts of its technology and products, covering energy conservation, energy efficiency and emission reductions. It works closely with government, industry associations and research institutions for environment-friendly and efficient technologies.

Technology

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

Technical factors
- Acceptability of processing characteristics
- Functionality in end-product
- Proven and mature technology
- Sustainability

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 (including energy efficiency)

Some of the zero-ODP alternatives for HCFC-22 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	Supermarket refrigeration in a secondary loop and in stationary and mobile air conditioning systems	Major redesign of system components needed. Investment costs are prohibitive
Hydrocarbons	<15	Small-capacity domestic and commercial refrigeration equipment	Flammability issues. Not widely used in large capacity systems
R-32	675	Small and medium-capacity commercial refrigeration and air conditioning applications	Single component refrigerant. Mildly flammable. Higher working pressures than HCFC-22. Higher refrigeration capacity per unit charge. Main component of R-410A
R-134a	1,300	Domestic, commercial refrigeration medium-temperature applications	Not efficient in low-temperature systems and industrial refrigeration applications. Needs synthetic lubricants
R-407C	1,520	Most air conditioning applications	Properties closely match R22. Temperature glide, synthetic lubricants needed, slightly less efficient than R22. Non-azeotropic mixture creates issues.
R-410A	1,710	Most air conditioning applications	Near azeotropic blend of R-32 and R-125. Higher pressures, better cooling capacity, low temperature glide, high GWP, synthetic lubricants needed
R-404A	3,260	Low temperature applications	High GWP, less efficient at medium temperatures, synthetic lubricants needed
R-507	3,900	Low temperature applications	Azeotropic non-flammable blend of HFC-125 and HFC-143a. Refrigerating capacity comparable to R-502. Good heat transfer characteristics at low temperatures

R-32 (HFC-32) is a single component refrigerant with zero ODP, GWP 675 (which is a third of that of R-410A) and is the main component of R-410A. Its working pressure is higher than R-410A, with good heat transfer properties, volumetric refrigerating capacity and theoretical energy efficiency. The charge amount of HFC-32 is about 60-80% of R-22 for the same refrigerating capacity, depending on the application. R-32 is expected to achieve better overall performance than R-410A. R32 is commercially available and mature, with favorable price as compared to R-410A, though slightly higher than HCFC-22

However, R-32 is mildly flammable therefore safety measures will need to be introduced in manufacturing, installation and maintenance. In accordance with EN378-1:2008, for machine room and open-to-air air-conditioning units using R-32, the charge of R-32 should be limited to 40.4 kg. R-32 can only be used as working fluid in air-conditioning equipments fulfilling this standard.

Tsinghua Tong Fang Artificial Environment Co. Ltd. has carefully considered and applied the above-mentioned factors and has concluded that R-32 technology is most suited for application to its heat pump products, due to its expected technical performance and significant potential benefit with respect to global warming impact as compared to HCFC-22 and also due to potential energy efficiency gains through system improvements. In addition, the enterprise has also carefully studied the international regulatory and market scenario, and notes that R-32 may potentially have wide acceptability in this particular market segment.

The following key challenges with the R-32 technology will need to be addressed through product and process optimization:

- Higher discharge temperatures and pressures, which surpass the limits of the design based on the current HCFC-22 technology for both materials and components
- Flammability of HFC-32
- Limited experience with R-32 technology as a standalone refrigerant for commercial, mass-produced equipment

Being the leader in heat pumps sub-sector in China with adequate technical and managerial capacity, Tsinghua Tong Fang Artificial Environment Co. Ltd. is considered to be the appropriate candidate for carrying out a demonstration project for this application in China.

Rationale for Technology Demonstration

In accordance with the Decision XIX/6 para 9 of the Meeting of Parties to the Montreal Protocol, parties were encouraged to promote the selection of alternatives to HCFCs that minimize environmental impacts, in particular impacts on climate, as well as meeting other health, safety and economic considerations. Thus, while selecting alternatives for HCFCs, factors other than zero ODP, as mentioned above, need to be considered.

In order to select a substitute route that is suitable for China and meets the above standards, FECO/MEP called upon experts and representatives from industry associations, domestic and foreign enterprises, research institutes and universities to set up an expert committee for HCFC alternative technologies for the ICR sector. The committee is responsible for evaluating the trends of alternatives at home and abroad, as well as research and analysis of costs, and to provide inputs for preparation of the HPMP for the ICR sector in China.

The expert committee evaluated in particular, R-410a, R-134a, R-32 and R-290 from the standpoint of performance, environmental impact, safety and cost-effectiveness. The experts recommended R-32 for replacing R22 in small-size commercial air-conditioners based on the following considerations:

- R-32 is a mature refrigerant with a large knowledge base on its properties
- R-32 is produced domestically and has assured commercial availability as reasonable prices
- R-32 is a single substance with good heat transfer capacity, volumetric refrigerating capacity and theoretical energy efficiency.
- For the same refrigeration capacity, the charge quantity for R-32 is 60-80% of that of R-22 depending on the application
- R-32 has GWP of 675, about a third of that of R-410A.

Many industry associations, research institutes and enterprises have done extensive research on R-32. According to current studies, R-32 has good applicability within certain product ranges and charge quantities. Its high efficiency and less charge quantity make it more competitive than R410a, R134a and R507 in terms of emission

reduction and environmental benefits. However, there are two main challenges in applying R-32 technology: R-32 is mildly flammable and there is not much experience with application of R-32 as a standalone refrigerant.

Considering these potential challenges, the Expert Committee advised to introduce R-32 technology on a demonstration basis, to small-sized commercial air-source water chiller/heat pump, having charge quantities small enough to be within the maximum safe limits. Such a demonstration would focus on addressing the flammability and high-discharge temperature issues. The experience gained from such a technology demonstration would be of significant use to multi-connected as well as unitary air conditioners with similar charge amounts and the technology could then be ready for wider adoption and eventual scaling up to other applications. Further, since this sub-sector (small-sized commercial air-source heat pumps) is concentrated within about 15 enterprises, the outcome of the demonstration can be relatively easily replicated, thus facilitating HCFC reductions in this sub-sector and perhaps other sub-sectors, for compliance with the 2013-15 targets.

Project Description

- The following inputs/changes are envisaged in the production process under this project: Overall system redesign of three models of commercial air-source chillers/heat pumps (13 kW, 30 kW and 60 kW), redesign of key components (compressors, expansion valves, heat exchangers, unit structure, electrical and control systems) and redesign of the process
- Conversion of the production line
- Prototype trials, testing and production
- Process and safety training
- Technical assistance
- Analysis and documentation of results

The key technical changes are summarized as below:

System, Components and Process Redesign

HFC-32 is by no means a drop-in substitute for HCFC-22. Due to the different thermodynamic performance of HFC-32 with respect to HCFC-22, the overall system, components and process would need to be redesigned for adaptation with HFC-32. This would be carried out for three models (60kW, 30kW and 13 kW) described earlier. The redesign work will include design and calculations, simulation and control software, remodeling of the compressors, expansion valves, finned tube heat exchanger, water-side heat exchanger, unit structure, electrical systems, prototype manufacturing, test runs, compilation of production process, blueprint and complete bill of materials.

Conversion of the Production Line

Heat Exchanger Processing	Due to the lower charge and higher pressure with HFC-32, the finned tube diameter will need to be reduced from 9.52 mm to 7 mm. Accordingly the finned tube punch dies and tube expander will need to be changed. The tube straightening/bending machine (fin threading) will need to be modified. A new brazing line for the heat exchanger suited for HFC-32 will need to be introduced. Since HFC-32 is flammable, the grease left on the heat exchanger will need to be removed for fire safety. For this, degreasing and dehydrating equipment will need to be introduced.
Sheet Metal Processing	The sheet metal processing dies will need to be changed, including dies for end-plate hole punching and dies for end-plate rim bending and dies for rim bending.
Product Assembly	Due to the flammability of HFC-32, the charging area will need to be isolated, with adequate ventilation, fire safety and alarm systems and explosion-proof fittings. The existing Halogen leak detectors cannot be used with HFC-32, because it contains no Halogen. Therefore Helium leak detectors will need to be introduced.
Quality inspection, testing and finishing	The safety inspection of electrical systems will need to be enhanced by introducing appropriately sensitive devices with protective features. The inspection area will need to be isolated with adequate ventilation, fire-safety and alarm systems and explosion-proof fittings. The existing test rig for HCFC-22 based products can be used with HFC-32, however, it will need modifications such as test room ventilation and fire-safety, high-pressure sensor and sensor for monitoring HFC-32 concentration levels.

Prototype production trials and testing
A pilot-level quantity of the selected models will need to be subjected to prototype production, trials and testing to establish the process and fine-tune as needed and establish product performance through testing. The results would be fed back into the process and product design, to ensure smooth conversion.

Process and safety training
Process and safety training will need to be provided to the manufacturing, installation and maintenance personnel. A total of 233 manufacturing personnel will be trained on HFC-32 properties, applications and safety precautions, process adjustments, installation and calibration of dies and on operating parameters for the selected models to be converted. The training will be imparted for a total of 86 training hours. In addition, 80 installation and maintenance personnel will be trained on product operation and performance, installation, calibration and maintenance protocols and safety precautions. The training will be provided for 30 training hours.

Technical Assistance
Technical assistance from national and international experts will be provided throughout the conversion process for various aspects of the conversion, such as component specifications and selection, technical and regulatory aspects, technical inputs for procurement, etc.

Analysis and documentation of results
The results of the demonstration would need to be analyzed and documented, for wider dissemination. This would be done through a report as well as through technical workshops.

Project Costs

Incremental Capital Costs
The total incremental capital costs amount to US$ 839,996. Details are provided in Annex-I.

Incremental Operating Costs
The total agreed incremental operating costs calculated for one-year duration amount to US$ 389,340. More details are provided in Annex-I.

Total Project Costs
The agreed total project costs amount to US$ 1,229,336

Financing

The requested MLF grant is **US$ 1,229,336**, which represents eligible incremental costs, not including agency support costs.

Implementation

Project Monitoring Milestones

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												
Completing product design					X	X												
Conversion of refrigerant recover system							X	X										
Refrigerant leak-detection system							X	X	X	X								
Refrigerant charging system							X	X	X	X								
Comprehensive testing equipment										X								
Tube punch and bending dies										X	X	X						
Prototype units										X	X	X	X					
Power supply conversion for production line											X	X	X	X				
Verification of production line and testing lab														X				

conversion																	
Tube bending and expansion machines										X	X	X	X				
Punch dies for fins										X	X	X	X	X			
Trial production																X	X

Payment Schedule

Schedule (Predicted Date)	Payment Conditions	Amount (US$)	Accumulated Amount (US$)
1st Payment (January 31 2011)	Upon signing of the contract	300,000	300,000
2nd Payment (August 31 2011)	Three prototype units are built and tested	400,000	700,000
3rd Payment (December 31 2011)	Product assembly line and testing facilities converted and verified	200,000	900,000
4th Payment (June 30 2012)	Technical commissioning completed successfully and relevant personnel trained	284,750	1,184,750

Management

The project will be under the overall management and coordination of the Foreign Economic Cooperation Office, Ministry of Environment 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 executer, 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, equipments and consulting services as per the budget allocation table, modification of production lines and product testing devices, etc., trial operation of production lines, 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 next 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 verification 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 executer 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 2012.

Impact

The successful implementation of this demonstration project will provide an environmentally safe and cost-effective alternative for enabling replication of this technology in similar applications in this sub-sector in China and facilitate HCFC reductions for compliance with the 2013/2015 control targets.

The project if successful will result in direct reductions of 61.9 metric tonnes of HCFC-22 usage at Tsinghua Tong Fang Artificial Environment Co. Ltd. Over a 15-year life-span of the small-sized air-source chiller/heat pumps manufactured by the enterprise, the direct and indirect emission reductions amounting to about **170,000 CO_2-eq tonnes** will be achieved, thus contributing to protection of both the ozone layer and the climate system.

ANNEX-I
Incremental Cost Calculations

Incremental Capital Costs

No	Cost Head		Amount (US$)
1	**System, component and process redesign**		**45,888**
	Redesign	Product redesign (US$ 23,529)	
	Software	Outsourced simulation and control software (US$ 22,059)	
2	**Prototype testing**		**77,941**
	Prototype materials	Cost of materials/process for 3 prototypes (US$ 36,765)	
	Testing	Third party laboratory testing (US$ 41,176)	
3	**Production line conversion**		**519,127**
	Heat exchanger processing (US$ 275,736)	Dies for 7 mm diameter tubes (US$ 144,854)	
		Modification of tube bending machine (US$ 55,882)	
		New vertical tube expanding machine (US$ 75,000)	
		Degreasing furnace	
	Sheet Metal Processing (US$ 7,353)	Die for end-plate hole-punching (US$ 2,941)	
		Die for end-plate rim-bending (US$ 2,941)	
		Die for rim-bending (US$ 1,471)	
	Product Assembly (US$ 224,273)	Suction gun Helium leak detector (US$ 73,529)	
		Charging room isolation/fire protection (US$ 75,303)	
		Two R-32 concentration sensors (US$ 1,471)	
		R-32 automatic charging machine (US$ 66,176)	
		Refrigerant recovery machine for R-32 (US$ 7,794)	
	Quality inspection, finishing and testing (US$ 11,765)	Testing equipment for safety performance (US$ 10,294)	
		Two R-32 concentration sensors (US$ 1,471)	
4	**Prototype production trials and testing**		**72,808**
	Testing	Modification of performance test rig (US$ 10,676)	
		Isolation of test rig room/fire protection (US$ 45,588)	
	Trial production	Cost of trial production for 3 units (US$ 16,544)	
5	**Process and safety training**		**10,000**
	Manufacturing	Training for 233 manufacturing personnel for 86 training hours (US$ 7,000)	
	Installation and maintenance	Training for 86 installation and maintenance personnel for 30 training hours (US$ 3,000)	
6	**Contingency**	for enterprise	**7,766**
7	**Technical assistance**		**45,000**
	Report on project results & Technology Dissemination	Monitoring/Evaluation/Verification; Technical Commission/ Project Acceptance; Technology dissemination, etc. (US$ 15,000)	
	National experts	Throughout project implementation (US$ 10,000)	
	International experts	Throughout project implementation (US$ 20,000)	
8	**ISS for FECO**		**36,880**
9	**ISS for UNDP***		**24,586**
Total			**839,996**

Incremental Operating Costs

Considerations:

1. HCFC-22 price is US$ 2.20/kg
2. HFC-32 price is US$ 2.94/kg
3. HFC-32 charge quantity for the three models is 16 kg (for 60 kW), 8.4 kg (for 30 kW) and 3.5 kg (for 13 kW)

Incremental Operating Cost Source	Incremental Costs/Savings (US$/unit)		
	60 kW unit	30 kW unit	13 kW unit
Compressors	236.00	118.00	96.00
Finned tube heat exchangers	(19.00)	(9.50)	(4.50)
Tube-in-tube/plate heat exchangers	(13.50)	(6.80)	(3.10)
Refrigerant	(5.90)	(2.90)	(1.00)
Electrical components (ex-proofing)	88.40	78.20	75.60
Net costs (savings)	**286.00**	**177.00**	**163.00**
Agreed	**73.93**	**45.75**	**42.13**

Incremental Operating Costs	Amount (US$)
60 kw unit: US$ 151.19/unit X 1,858 units/year	280,917
30 kw unit: US$ 75.56/unit X 858 units/year	64,827
13 kw unit: US$ 32.13/unit X 1,357 units/year	43,596
Total	**389,340**

Total Project Costs

Cost Head	Amount (US$)
Incremental Capital Costs (including contingencies)	839,996
Incremental Operating Costs	389,340
Total	**1,229,336**